Safety, Dose Optimisation and Security: the Quadrature of the Circle

Frank Hardeman and Fernand Vermeersch
Belgian Nuclear Research Centre (SCK•CEN)
Boeretang 200, BE-2400 Mol, Belgium
Corresponding author: frank.hardeman@sckcen.be

Abstract

The growing concern for potential terrorist acts has lead to a number of new ideas about storing radiological and nuclear materials that are not always compatible with existing practices or infrastructures. This is valid in normal, routine circumstances, but may especially pose problems in case of accidents. As such, the management of nuclear safety, radiological protection and security within an evolving world such as a nuclear research centre sometimes looks like implementing the quadrature of the circle. Just a few examples. First: infrastructure related problems: from a security point of view, fuel storages or radioactive sources are better stored in the heart of a well protected zone, while in case of criticality, fire, etc. a more peripheral location is more appropriate. Strong protection infrastructure may lead to difficulties of evacuation in case of emergencies. Second: safety related problems: access limitations to some areas may be a burden in the management of safety interventions, maintenance, etc. Third: administrative contradictions: inventories of fuel storages and high active sealed sources are a cornerstone of inspections and verifications; yet, this information is also a treasure for terrorists aiming at actions to obtain special materials. Fourth: dose management: some of the measures taken to secure sources may lead to an increase in dose (e.g. labelling of old sources). Many more concrete examples of daily experience can be given.

As a conclusion, it is indispensable that some people, both at the level of regulators and operators dispose of a helicopter view on this subject, in order to achieve optimal solutions taking into account all aspects: safety, security and dose optimisation.

Introduction

In many organisations dealing with nuclear and/or radioactive materials, there have been considerable efforts since a long time to implement an adequate policy for avoiding nuclear accidents (nuclear safety), serious accidents with the workforce (mainly industrial safety) and to reduce doses and to limit contaminations (radiation protection). While nuclear and industrial safety got a lot of attention already in the fifties and sixties of previous century, also via the regulation put into place, it took longer before institutes started implementing systematic 'ALARA' policies. A real breakthrough here was obtained mainly in the nineties despite earlier guidance of e.g. the ICRP (ICRP 26, 1977; ICRP 37, 1983; ICRP 55, 1989; ICRP 60, 1991). Breakthrough certainly was supported from the publication "Alara, from theory towards practice" (Stokell et al., 1991).
Security issues received a growing attention in the past few years only, to a large part as a consequence of the 9/11 event leading to new concern, later on followed by new legislation on e.g. the management of sealed sources (EC 2003/122/EURATOM); these have led to many organisational measures such as reinforcement of intrusion

prevention, surveillance, administrative and technical measures to reinforce access control.
In parallel, the 'safety culture' approach developed, mainly based on IAEA guidance in the aftermath of the Chernobyl disaster and the activities of the so called INSAG, the International Nuclear Safety Advisory Group (a.o. INSAG 4, INSAG 15). This safety culture concern has developed first in nuclear power plant, while other nuclear facilities followed later.

The management of prevention of accidents in nuclear facilities requires a holistic approach taking into account safety of facilities, workforce safety, environmental impact, security of materials, safeguards issues. All these aspects require the necessary attention, however, in practice there are many difficulties. This paper focuses on the fields of enhancement of this management, but also on contradictory conclusions to be taken, making a coherent policy to be as searching for the quadrature of the circle. Although we are convinced that the difficulties mentioned certainly are also of relevance for industrial or medical applications with radioactivity, we will focus on nuclear facility related issues.

Safety culture, ALARA culture, security culture

Safety culture has been defined in many papers, but the most frequently used definition can be taken from INSAG 4:

> *Safety culture is defined as "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance"*

Security culture has also been defined in documents of the IAEA, also making an attempt to be in line as much as possible with the definition above of safety culture (e.g. IAEA STI PUB 1347):
*For the purposes of this report, **nuclear security culture** is defined as:*

> *The assembly of characteristics, attitudes and behaviour of individuals, organizations and institutions which serves as a means to support and enhance nuclear security. An appropriate nuclear security culture aims to ensure that the implementation of nuclear security measures receives the attention warranted by their significance.*

ALARA management has less well been defined so far, although it has also been discussed in terms of a state of mind, an attitude, a culture. Work on defining ALARA culture better has already been planned via the European ALARA Network, e.g. during the 10th ALARA workshop in Prague (EAN 2006).

Synergy between Safety, ALARA and Security culture

A number of characteristics of the 3 cultures show synergy, as is highlighted below.

1. An individual dimension: each individual working with radioactive or nuclear materials should show skills and attitudes contributing to the limitation of risks. As an example: a questioning attitude; adequate planning; think before you act. Risk conscious co-workers not only performing a task, but being critical towards what they are told to do and having adequate social relations with their

colleagues to observe non-acceptable behaviour are supporting all three cultures.
2. An organizational dimension: the entire picture should fit: management should be supportive of all aspects, be aware of risks, be setting the right policy priorities. A right balance between risk averted and effort made is important for all three issues.
3. A common objective: avoid harm in a broader sense, a.o. by putting organisational measures into practice to avoid or to limit the consequences of technical failures and human error.
4. A technical component that needs specialised knowledge, investments, adequate maintenance.

Fundamental differences between Safety, ALARA and Security culture

Nature of the risk

The main difference between Safety and ALARA culture on the one hand, and Security culture on the other hand is the nature of risk. While one can assume that normal people strive to avoid accidents and do their best to mitigate them, security related issues clearly have a dimension of malicious intend. This has important consequences for the policy to be implemented. Security issues furthermore have an external dimension, i.e. an event starting outside the fence of the facility: a threat of theft, sabotage, intrusion… originating from the outside. This is much less the case for safety issues (although external events also may lead to difficult circumstances), and much less for ALARA culture. However, security may also have an in-house dimension: malevolent intentions of members of the workforce, contractors, apprentices, students, visitors. In this respect, safety culture and ALARA culture can be considered to be based on trust, coaching, respect and reinforcement of ideas between staff, hierarchy and operators, prevention advisors and managers. Security may lead to distrust, control instead of supervision, and suspicion instead of support.

Probabilistic aspects

Probabilistic arguments are important for assessing the risk of an activity and its acceptability; in terms of design of facilities or judgements in a context of approval processes, this is important. Probability however is not useful in a context of intentional harm.
However, in this respect, safety culture and ALARA culture are not really in line. Nuclear safety often deals with very improbable events, why ALARA often concerns daily tasks and assessments. Nuclear safety rather deals with low probability – high consequence events, while ALARA is mainly regarding high probability – low consequence actions. This has practical implications for e.g. the validity or non-validity of statistical follow-up and other quality assurance related techniques (Llory, 2009) and in the mind set of people. Dealing with very low probability events may lead to lack of awareness or over-confidence (it never went wrong). In case of ALARA, it may rather be negligence (in day-to-day work doses in nuclear facilities often are very small).

Acceptability

The acceptability issue is apparent in many cases. A first example is related to the acceptability of consequences in emergency conditions. While it is appropriate to apply stringent intervention levels for the application of countermeasures related to a

radiological release (e.g. in Belgium 5-15 mSv effective dose is the intervention level for sheltering – Royal Decree 2003), it is much less evident to use these values in case of terrorism. It is obvious that the nuclear industry wants to be top in all safety related issues, but application of these very low values as the upper bound for the maximum acceptable doses in case of e.g. theft of a source appears to be excessively stringent, and imposes protective measures beyond the reasonable, certainly if one compares to the ease by which other means can be used to cause dead to victims (explosives, toxics, weapons of all nature).

In terms of behaviour, it is very uncomfortable if not unacceptable to people to feel being systematically controlled and supervised by colleagues, chefs, guarding personnel. Social control and adequate supervision by hierarchy are well accepted and part of an adequate safety culture, but suspicious control to identify malevolent actions leads to social tensions. The systematic use of personal data, cameras, all types of sensors, checks by intelligence services etc. is also a negative side effect of the security policy that is imposed.

Safety, radiation protection and security require important investments in means, staff, maintenance, administrative support. For many people, it appears much more acceptable and ethically more justifiable to spend this money in safety enhancing measures as compared to measures to counteract malevolent use of radioactivity or nuclear material.

Time dependence

The risk of nuclear, radiological or industrial safety depends on the inherent aspects of the products dealt with; there may be fluctuations over time due to variability in operations (e.g. routine operation or maintenance), variability in potential impact (quantities of products, nature of experiments). This time dependence however depends on in house planning and processes, and if some change in policy is desired to adapt to particular circumstances, this can be anticipated in house.
The security issue is different. The threat of an intrusion or sabotage depends on external situations, and as such is beyond control of the operator. The protective measures required depend not only on the radioactive inventory, but also on the external circumstances (such as presence of terrorists on the territory, events in conflict areas), even at a global level. This dependence on external, hard to predict events makes policy making very difficult.

Reason

The aspect of reason is very obviously part of ALARA-culture. But both the safety and security culture definitions by the IAEA refer to 'reason' as well, albeit formulated a little differently ("warranted by their significance", cf. supra). As stated above, the "significance" of security is very hard to assess, which is a fundamental difficulty in the definition of STI/PUB/1347. As the external risk can hardly be assessed, this situation leads very often to over dimensioning of the security protection put in place. It is very difficult to obtain an adequate balance between the risk of terrorism (radiological consequences) and the efforts put into place for protection, the target often being "zero risk". There is maybe need for an 'ASARA' approach: as secure as reasonably achievable.

Practical difficulties in stimulating the synergy between safety, security and ALARA culture

Practicalities

In many organisations nuclear safety and security are managed by different services or sections, and often radiation protection and/or industrial safety may belong to still different ones. This of course hinders a joint policy, though striving for an integrated approach seems highly recommendable.

Technical competence is also an issue: the knowledge needed to avoid reactor excursions or criticality incidents (nuclear safety) is much different from the knowledge needed for an adequate radiation protection policy (justification and optimisation of exposures), for preventing an industrial safety related event, and has nothing to see at all with knowledge of security related technical measures such as identification of persons, strengths of fences, etc.

Legislation – relation to regulator and authorities

Much legislation is applicable to working in nuclear facilities. Often this legislation originates from different regulators. As an example, even at the European level, Radiation protection and nuclear safety are not well linked to general safety on the workplace and to environmental impact neither. Nuclear security issues mainly originate from IAEA guidance (INFCIRC 225 Rev 4C), with less implication of the European regulator.

In many countries, regulations including licensing and inspections have been attributed to different authorities. This may lead to different visions, and different expectations being imposed on the plant. As a consequence, implementation of an integrated approach is often made difficult.

Some practical cases inspired by daily practice in a nuclear research centre

The examples below do not intend to be exhaustive; they are just examples showing that integration of safety, radiation protection and security policies is often difficult, and that the requirements imposed on people may be contradictory.

Communication and information

Openness is a key feature of an adequate safety culture, and access to information is a cornerstone of modern management, supporting adequate safety and ALARA policies. As an example, it is good safety practice to clearly label radioactive products, to make inventories, to indicate where radioactive products are found. However, from the viewpoint of security, this helps potential terrorists in identifying the areas of interest to them.
Concrete examples are the requirements in the context of sealed sources: it is clearly an advantage in the management of sources to have adequate descriptions and to have a policy of evacuation of sources that are no longer used. On the other hand, the inventories of these sources may be a point of orientation to potential terrorists. Therefore, restrictions on information such as inventories are to be imposed. For a broader discussion, we refer to IAEA STI/PUB/1437. Excessive regulation to enhance the security of e.g. sealed sources may also be against the ALARA principle. High active sealed sources must be checked somehow, but imposing to

possess pictures, to check labels on the source itself etc. may require important interventions having only a marginal impact on enhanced security.

Design of facilities

In terms of limiting the impact of criticality incidents, fires,… in places where nuclear and radioactive materials are stored or used, it is optimal to have some isolated or peripheral rooms. On the other hand, such places are much harder to protect against intrusion, and a central position in the building is often preferred.

Emergency circumstances

In case of technical difficulties in a controlled area, fast access can be important. This can be hindered by authorisation checks or procedures. This is true for normal interventions after technical failures and in real emergency conditions where external emergency workers are called in. A compromise must be sought between hermetic isolation of some rooms, and adequate measures to have people evacuated in emergency situations, knowing that each system to bypass the protection system is an extra opportunity for abuse by terrorists.

Conclusion

The integration of adequate policies to simultaneously enhance safety culture, ALARA or radiation protection culture and security culture is a complex task, which may lead to situations in which one has to invent the quadrature of the circle. Besides some technical arguments, there is a big mental impact on the people, both in the decision making and in the daily application. The contradictory nature of some of the rules that need to be imposed may lead to discomfort and cognitive dissonances (Festinger, 1957).

In order to facilitate this process of enhancing all components of safety, radiation protection and security, there definitely is a need of a helicopter view by international advisory bodies and regulators. It is the merged policy that needs optimisation, and not various pillars safety, security and ALARA culture separately. An ASSARA-approach (As Safe and Secure As Reasonably Achievable) is what we all should be aiming for.

References

EAN 2006 10th Workshop on 'Experience and new Developments in implementing ALARA in Occupational, Patient and Public Exposures, Prague, 12-15 September 2006, accessible via

http://www.eu-alara.net/index.php?option=com_content&task=view&id=62&Itemid=38

EC 2003/122/EURATOM

Council Directive 2003/122/EURATOM(f) on the control of high-activity sealed radioactive sources and orphan sources

Festinger, 1957 L. Festinger, A theory of cognitive dissonance, Stanford University Press, 1957

ICRP 26, 1977 Recommendations of the International Commission of Radiological Protection, Annals of the ICRP, 1, 1977 (now superseded)

ICRP 37, 1983 Cost-Benefit Analysis in the Optimization of Radiological Protection, Annals of the ICRP 10, 2-3, 1983

ICRP 55, 1989 Optimization and Decision Making in Radiological Protection, Annals of the ICRP 20, 1, 1989

ICRP 60, 1991 1990 Recommendations of the International Commission of Radiological Protection, Annals of the ICRP 21, 1-3, 1991 (now superseded)

INFCIRC 225 The Physical Protection of Nuclear Material and Nuclear Facilities

INFCIRC/225/Rev.4 corrected, accessible via:

http://www.iaea.org/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html

INSAG 4, 1991 Safety Culture, A report by the International Nuclear Safety Advisory Group, Safety Series No. 75-INSAG-4, IAEA, Vienna, 1991, STI/PUB/882, ISBN 92-0-123091-5, ISSN 0074-1892

INSAG 15, 2002 Key practical issues in strengthening Safety Culture, A report by the International Nuclear Safety Advisory Group, INSAG-15, IAEA Vienna, 2002, ISSN 1025–2169, STI/PUB/1137, ISBN 92–0–112202–0

Llory 2009 Michel Llory, Comment juger le niveau de sûreté ? Limites des statistiques et conduite d'un diagnostic organisationnel. Contribution to the Topical day on the Enhancement of Safety Culture, SCK•CEN, Mol, Belgium, October 15, 2009.

Royal Decree 2003

Nucleair en Radiologisch Noodplan voor het Belgische Grondgebied – Nuclear and Radiological Emergency Plan for the Belgian Territory, Koninklijk Besluit van 17 oktober 2003 – Royal Decree of 17 October 2003, Belgisch Staatsblad 20 november 2003 – Belgian official journal 20 November 2003 (in Dutch and French)

STI/PUB/1347 Nuclear Security Culture, IAEA Nuclear Security Series No. 7, Implementing Guide, International Atomic Energy Agency Vienna, 2008, STI/PUB/1347, ISBN 978–92–0–107808–7

Stokell et al., 1991 P.J. Stokell, J.R. Croft, J. Lochard, J. Lombard, "Radiation Protection : ALARA from theory towards practice", CEC report EUR 13796 EN, 1991