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IRPA INITIATIVE ON RADIATION PROTECTION CULTURE

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Brussels, 3 december 2010

At a time of significant developments in the use of ionizing radiation in the medical field as well as in the revival of nuclear industry, the radiation protection profession is facing the challenge of enhancing RP culture throughout the world.•The generation who developed safety as applied today is gradually leaving now.

At the IRPA12 Congress in Buenos Aires in October 2008, the Executive Council decided to actively support an initiative for enhancing Radiation Protection (RP) culture among the RP professionals worldwide because embedding Safety at a cultural level within an organization is by far the most effective way of delivering the performance to which we all aspire. As the voice of radiation protection professionals, IRPA has initiated a process and has provided a medium for discussion on this item throughout the world. This first draft presents arguments coming from 3 IRPA workshop organized in Europe, in Asia and in USA.

This preliminary draft document has been divided into 4 parts
- Elements of traits and Elements for a definition of RP culture
- Criteria of success
- Assessment tools
- Engage stakeholders and Role of RP professionals and IRPA Associate Societies

There is no basic difference between sectors (medical, nuclear, industry). About safety culture, radiation protection focuses on people and behaviour (culture) to prevent harm to the worker and others when hazardous equipment is being operated and general safety focuses on the system design to permit hazardous equipment to be used without harming the worker. Radiation Protection culture is necessary to implement safety. Definitions of culture found in literature have in common the view that culture is a central value in society and consists of practices that organizational members share about appropriate behavior.

RP culture needs a **narrative in common language so it's independent of the local and regional contexts which are not in the elements structuring safety culture based on science, values and experience.**

A culture can convey a sense of identity for the organization's members and facilitate commitment to something larger than one's individual self-interest. Culture increases the consistency of employee behaviour; a positive safety culture influences how workers behave in the workplace. That's why the NRC proposed a new definition for safety culture: ***"Nuclear Safety Culture is the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals (e.g., production vs. safety, schedule vs. safety, and cost of the effort vs. safety) to ensure protection of people and the environment.(NRC 2011).***

Research has indicated that within organizations, a better safety culture correlates with a good safety performance. But to have and maintain a RP culture, organizational leaders assisted by all levels of employees, must articulate what is missing and the changes that are required to embed RP and safety into their organization. There must be a shared vision of safety and safety must be a basic value. The behaviors of leaders acting as symbols of this new safety culture are necessary. Thanks to the leadership that managers exhibit through their presence in the field, the coaching of workers and the reinforcement of operational focus are enhanced. This will contribute to point all staff and managers towards operational focus, and more specifically, ongoing plant reliability, human performance, and organizational effectiveness and to develop a "field culture" in addition to the "engineering culture" to anticipate problems and to obtain the commitment of all employees.

To change culture within an established organization, the founding culture must be well understood. Thus, the first premise regarding organizational safety culture is that safety professionals must be aware of and understand their organization's founding culture and the impact it is having in today's operations. That's also important to assess the level of culture into the group, so to set up a programme for identifying and resolving problems (Corrective Action Programme) independent external audit (Transparency).....

In summary to develop a RP culture allows to give visibility to the fundamentals of safety (science and values), to promote radiation risk awareness and shared responsibility among practitioners, operators, management and regulators, to maintain the safety heritage to the next generation, to facilitate its transmission, to improve the quality and effectiveness of safety is based on continuous improvement and to contribute to the general safety.

Four Working Groups have been appointed to the drafting of this document based on the material resulting from the three IRPA Workshops. A period for consultation of the Associate Societies of IRPA and IOMP will run from December until the end of February 2012, in order to get feedback on the "preliminary draft document". On the basis of the Associate Societies' comments, a new version of the draft document will be produced in conjunction with each WG leader.

All societies are kindly invited to participate to the special Session on the IRPA Initiative on Radiation Protection Culture during the IRPA 13 Congress in Glasgow in May 2012. The objective of this Working Session will be to discuss on this draft and to decide about the structure and content of future IRPA Guiding Principles on RP culture to be prepared following the Glasgow Congress.

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NEW PERSPECTIVES FOR RADIATION PROTECTION CONCEPTS IN THE FRAME OF SUSTAINABILITY

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Abstract.
The principles of radiation protection and the systematic approach for radiation risk assessment, risk management and nuclear safety are briefly discussed. Radiation protection is confronted recently with new challenges in the medical sector, with some natural radiation risk paradoxes, with lessons from nuclear reactor accidents, with ongoing long term nuclear waste considerations and is even challenged in its radiation paradigm itself. Meanwhile outside the sector new approaches develop for health and environmental policies. Sustainable development and precaution, almost not referred yet within the nuclear sector, start to offer opportunities.

The criteria and strategies put forward show some similarities with IRPA efforts to integrate normativity (values), to promote stakeholder engagement, to focus on safety-, radiation protection- or ALARA-culture. ICRP efforts to broaden the anthropocentric scope and to continue justification for a number of challenges are also in line with sustainable development.

It is proposed to open the scope in RP and to enlarge assessment approaches in nuclear developments. Defensive strategies, as prepared by UNSCEAR on attribution of risks at low doses, could handicap a precautionary evolution in future and should be directed to improved risk awareness by transparent risk communication. Moreover societal and distributive equity considerations should be taken into account to gain trust and acceptance. Ecosystem approaches could moreover help to establish coherency and to reconsider impact assessment instruments.

KEYWORDS: (protection, ALARA, culture, sustainability, precaution, assessment)

INTRODUCTION

A range of interpretations of the concept of sustainability is emerging in the field of technology, energy, environment and health policies. Up to now the system of regulation of exposure to ionising radiation has paid little attention to these dynamics. The nuclear energy sector and IAEA are mainly referring to sustainability for competitive opportunities related to externalities such as the climatic challenge of carbon based energy technologies.

Sustainable development is often a mere political discourse or a marketing argument as seen in the framing of resource efficiency and long term waste improvement in Gen IV in the European SNE-TP [1].

Sustainable development beyond sector interests and political discourses however considers additional in depth criteria in assessing decisions: these include coherent integration of different problem dimensions, global responsibility and proactive precaution strategies which are not familiar to the nuclear sector. On the contrary ethics, equity and stakeholder involvement, as promoted by IRPA for consideration by radiation protection professionals is becoming a more common process language.

Sustainability assessment approaches are being developed referring to criteria as strategic objectives, discussed in a PhD by E. Laes (Laes 2006) and applied operationally for energy planning purposes by the Belgian Federal Planning Office (BFPO, 2007). These conceptual guidelines for action should be used within an holistic perspective, assessing system impact interactions (Hugé J.et al, 2011) not limited to interaction aspects, such as health effect in radiation protection. To reach such broader objectives, impact assessment processes need to be built on transparency and participation. Finally sustainability assessment should be integrated institutionally. While impact assessment is a generic term referring to processes identifying the future consequences of current or proposed actions, sustainability assessment embraces processes that all have as their broad aim the integration of sustainability concepts into decision-making

[1] Sustainable Nuclear Energy Platform DG Research EC

(Pope, 2006). Indeed, sustainability assessment is not a prescribed process, but rather an orientation of practice (Pope & Dalal-Clayton, 2011). It is not as codified as e.g. environmental impact assessment (EIA) and strategic environmental assessment (SEA). While this allows for a degree of freedom and inventiveness in developing more detailed or more context-specific definitions, methods and applications, it also means that sustainability assessment frameworks exist in many forms, but they are always based on criteria of sustainable development and used in a vast number of cases and contexts.

In a research contract for the Belgian Science Policy Agency nuclear energy developments were assessed qualitatively using the principles of sustainable development and applying a clustered factor pathway analysis. This study on nuclear energy governance (Eggermont et al, 2011) was published just before the Fukushima accident, which has illustrated a number of policy recommendations. Moreover a case study was performed by (Hugé J. et al, 2011), conceptually analysing recent progress in Belgian nuclear waste policies. The stepwise planning for decision making was not only left to a technical expert panel but also to an independent forum of lay citizens, aiming a mere open framing of sustainability.

Particular attention is given in this paper to one of the criteria for sustainable development, precaution, as it is particularly relevant for radiation protection. A development of precaution as strategy for decision making in health and environmental policies is briefly discussed. It was edited by an inter-disciplinary group of the Dutch Health Council (Health Council 2008), discussing also the ALARA approach.

This paper first considers major present challenges for radiation protection after a brief review of the radiation protection approach.

A number of requirements for precaution and sustainability development are then projected on these problem areas looking for new perspectives for radiation protection by broadening its scope.

It is noticed that well developed nuclear assessment tools for safety, health, waste and the environment have interesting strengths in depth and in time scope compared to non nuclear approaches. However a number of applications of ionising radiation became very controversial illustrating the weaknesses in nuclear assessment in a societal context as well as a number of safety culture problems. Safety culture, still lacking in different companies is a condition sine qua non for preventing accidents. More proactive thinking could complete assessment scenario's as part of scientific method while ecosystem approaches could enlarge health considerations. Communication in the nuclear sector has improved but still requires a structured transparency commitment. Engagement of relevant stakeholders, also of patients groups and local and environmental organisations, has enriched the risk problem solving perspectives in the nuclear field through confrontation with a variety of world views. But the challenge of distributive equity and trans-generational ethics has emerged as particularly relevant in nuclear impact assessments.

RADIATION PROTECTION APPROACH

This consists of the ALARA principle, safety, health & environmental risk assessment and a system of justification, optimisation and limits.

The radiation protection approach was historically driven by a hierarchy of operational priorities referring to a subdivision of effects:

1. absolute prevention of deterministic effects
2. potential stochastic effects focussed at higher exposures
3. care for low doses to critical groups (aiming as well to limit health effects for individuals, guaranteeing public health concern of exposed groups and including a high level of RP hygiene preventing spread of radioactivity)
4. supposing that the environment is sufficiently protected if man is.

This approach has assumed since decennia that any dose of radiation could cause stochastic biological effects with some risk of detriment to health. The environmental philosophy (4) is anthropocentric.

This approach historically leads to the ALARA principle, defined as an action rule based on value judgement, in order to manage exposure. This was implemented in a basic system of protection: justification of practices, optimisation of protection, complemented for workers and the public by limits (Eggermont, 2005). Justification and Optimisation illustrate the utilitarian ethics (Feltz, 2008) behind this approach, which moreover introduced a lot of flexibility in risk management for sometimes uncertain effects.

Limits have added some egalitarian ethics in ICRP philosophy, in order to guarantee the protection of the health of individuals. It should be noticed however that no limits apply in 90% of the doses to the public (patients, Rn exposure), and even for the majority of workers exposed in NORM industries.

Justification has a generic and a specific dimension. As Health & Environmental governance is rapidly changing and increasingly guided by corporate interests, generic justification is delegated by policy makers to agencies or expert advisory councils for health and environment which make a kind of (medical) technology assessment. Those experts are struggling with complexity, uncertainty and value judgements, which can be interpreted differently. Their legitimacy is questioned. (Anderson, 2008) calls experts 'the priests of enlightenment' as they have lost their virgin status due to their growing problems with conflict of interests, due to the delimitation of their expert mandate and due to their expert culture. It is noticed that perception of lay citizens versus experts is polarising while a need to focus awareness is coming up in all risk domains including radiation protection.

Justification is increasingly applied for particular practices such as CT for children, bodyscan for security reasons, radioactivity in lamps (Belgian Health Council, www.css-hgr.be) and also for nuclear energy in particular conditions, contrary to earlier ICRP proposals for RP purposes (Eggermont, 2005).

Specific justification essentially belongs to the professional responsibility of each expert at each level of radiation protection. It allows for instance the medical practitioner not to apply patient limits for sake of patient benefit. But then the optimisation of protection comes on the foreground not only regarding technology but regarding the whole trans-disciplinary process of patient treatment. Full process insight became very complicated in medical imagery. An integration of radiation protection in quality assurance was necessary. Ethical requirements, risk awareness and safety cultural requirements together with adequate patient communication and even involvement have complemented the risk decision making process in recent years in order to achieve better health care of sustainable nature.

Justification and optimisation exerted much more impact than required traditionally by an authorisation process or even in expert behaviour. They go far beyond strict radiation protection, integrating different aspects of responsibility with a balancing of risks and benefits in particular. Optimisation is vital in nuclear risk management . Its cultural dimension is reconsidered now by IRPA but could be more supported by science based communication models such as RISCOM (Andersson, 2008).

The dose concept as risk indicator is a performant but rather abstract concept, lacking transparency for lay citizens. Since biological targets of exposure seem able to suffer without energy deposition in the target molecule the concept is criticised (bystander effect). Effective dose was not set up for a range of present uses (patient dose in radiology, environmental exposure pathways of low energy). Considering moreover individual predisposition where biological repair capacity can be susceptible to radiation, science is now looking for bio-indicators of health effects.

The dose paradigm is an interesting but no longer sufficient base for risk analysis. The linear dose effect relationship, a problem for many interests and experts, represents an useful operational simplification, which is however not applied uniformly. It is corrected for risk estimation purposes by concepts as dose and dose rate reduction factor (DDREF), a controversial issue especially for half of public exposure related to high dose rates such as X-rays.

The collective dose concept served as useful risk indicator for identifying risks to groups, such as for Rn exposure of categories of workers and the public, but potential misuse was given political concern. Inadequate use may not be a sufficient reason for disqualification of a useful concept. But this is argued more and more in the EU and even at UNSCEAR. The same reasoning could be applied to sustainable development concepts.

Finally at the institutional level risk assessment & management in the nuclear field is constrained by an isolated nuclear culture such as the regulatory framework of the EURATOM treaty and set up in most national regulatory approaches, where overlap of assessment and regulatory procedures with non nuclear fields are difficult to manage.

PRESENT CHALLENGING AREAS FOR RADIATION PROTECTION

In radiation protection not only reactor safety for accidental risks and nuclear waste management for long term risk are challenging areas. Digitalisation of medical imaging and Rn indoor risks are even more important for public health.

- **Medical radiation protection**

A range of new problems have emerged in the medical sector in the last years resulting in growing regulatory concern and changes in public perception.

Interventional radiology extended from cardiology to neurology and other applications and old problems such as skin burns and cataract due to ionising radiation resurfaced. Such deterministic effects should normally not occur through prevention in radiology. It illustrated potential and recurrent high skin doses for patients. But a deficiency of risk assessment was also noticed for specific standards intended to limit dose accumulation for the lens of the eye. New protection measures are now required together with adequate personal dosimetry, unable in the past to monitor such risk for medical staff. A paradox was however noticed in the controversy on low dose effects: not the stochastic risk limitation but the limit based on a threshold effect had to be reviewed, illustrating that little scientific evidence existed in the past for assuming such high threshold dose (RIHSS, 2007) (ICRP, 2011). The limit for workers for the lens of the eye needs to become stricter with a factor 8 in future basic standards with even uncertainty on the existence of a threshold.

The increasing dose of CT use, already put forward in earlier publications (Vanmarcke et al, 2004) now received concern at world level. More extensive use (health screening, dentistry) or combined use (PET-CT, therapy) of new developments of this technology are requiring elaborated risk assessment. Conceptual adaptations of risk management are needed due to contamination problems. Moreover the use of PET in nuclear medicine has illustrated that extremity dose limits are not necessarily respected for staff and that dose estimation is inadequate in a number of circumstances (Covens et al, 2010). Finally the occurrence of radiotherapy incidents, causing the overexposure of thousands of patients in France and smaller incidents elsewhere, has lead to risk policy changes in Europe, directed by ASN, the French nuclear safety regulator (Smeesters, 2011). In Belgium working groups with engagement of all relevant professional actors and round table conferences with as well as patient representatives helped to clarify issues and to improve risk assessment and management including incident reporting and feedback of experience. But an enforcement of the regulatory institution with more active surveillance in

the medical field was necessary to improve protection. A responsibility in authorisation processes of producers is now put on the agenda by ASN rearding medical devices in UE, in order to better open black boxes of technological complexity and to allow better understanding by hospital physicists.
Without increased risk awareness and safety culture of medical practitioners however, a change will remain limited and confrontations with liability claims more frequent. Patient communication too came up as a new issue for radiation protection in this sector, requiring a lot of research to manage.

- **Radon exposure and NORM industry**

Since its rediscovery Rn exposure became at the end of the seventies a paradox for safety standards. Natural exposure was illustrated to create a population exposure higher than the limits of 1 mSv/y for the public for nuclear practices. Mixed feelings grow in regulatory bodies how to handle this human enhanced natural lung cancer risk with limited public concern. ICRP hesitated and struggled with coherence of concepts regarding dose conversion. The global pooling of epidemiology however brought up a better understanding of risk, evident even at low air concentrations; the dose conversion factor doubled and coherence was found between miner data and public exposure. Indoor environmental risk standards are a general new concern for sustainable housing . Being a potential cause of about 10% of lung cancers, they have to be improved as put forward by ICRP and WHO. The very extensive use of resources containing natural radioactivity in a large number of industries, called NORM industries, has pointed out the need to better integrate radiation protection in other health and environmental policies up to waste management of numerous companies. The impact of the phosphate industry in particular was assessed but the long term environmental impact of the richest mine industries in the world such as in South-Africa has not yet been clarified in a sustainability context. RP utilitarian ethics have created instruments such as clearance and exemption to manage and tolerate radioactivity at low level in industry. The extension of risk assessment to long term radon implications of building materials and to huge waste fields of NORM industry could pose new risks for society in future. It asks for sustainability attention at least in zone planning of large areas for future generations. The half life time of the radioactivity source term, Ra-226 is 1600 y. Even accidental risks were discovered in huge waste dumps from NORM industry in Europe where serious chemical risks and heavy metals complete the risk picture of radioactivity around exemption level (Poffijn, 2010). These sites are unfortunately never again accessible for housing, but create not yet a political concern.

Natural exposure is used too much as a referential in case of man enhanced radioactivity. It calls for more ethical reflection. It is also an example of lack of equity (even trans-generational) for reasons of opportunity in the distribution of benefits and risks of practices called “existing exposure situations”.

The impact assessment of this sector could be improved a lot by a broader sustainability assessment but it is noticed that chemical risk and waste assessment at present disregard contrary to the nuclear sector long term risk considerations for nuclear waste management.

- **Nuclear accident risk assessment and management**

The Fukushima accident has demonstrated the reality of a major impact of low probability, even for reactor technologies used in Western Europe. The hazard of the huge radioactive source term of nuclear reactors and fuel management installations was made crystal clear while numerous inconsistencies were noticed worldwide. The nuclear energy sector had been globalised such like the financial sector without simultaneous globalisation of safety criteria and regulatory supervision. Transparency still seems to be a distant target for nuclear industry and equity is far from realised in the liability of risks (Eggermont et al, 2011). Virtual average scenarios as put forward by ExternE (Laes et al, 2011) had created only an image of competitiveness for the sake of economic opportunities in sustainability comparisons .

Fukushima illustrated for the third time a lack of imagination in risk assessment scenarios as well of a lack of coherence and independency in applying criteria for reactor safety. After demonstration in Harrisburg that human reliability was neglected in sophisticated MIT engineer tools for probabilistic safety assessment, Chernobyl illustrated the lack of management reliability integration and the importance of safety culture in a complex organisation. Fukushima has now remembered experts of the impact of well known rare natural phenomena, a good reference for robustness and sustainability. But also the impact of marine contamination and build up of radioactivity in coastal sludge with its environmental impact on food chain was not taken up enough compared to atmospheric pathways. Finally the increased vulnerability of society caused by technology choices for a particular socio-economic tissue was underestimated dramatically. Japan had less than 30 % nuclear electricity, half as much as some European countries. Two thirds of this electrical capacity is still unavailable constraining economic revival. Regional vulnerability tests are not yet taken up in ongoing stress tests. They limit impact assessment to a technological reassessment without considering emergencies in real situations of densely populated areas. Here sustainability could be considered by a more trans-disciplinary approach beyond health effects with a (full spectrum) of stakeholder engagement of affected regional communities and companies. It also illustrated that the valuing of life in emergency risk management is much more than monetary terms, and determined by societal network cohesion and culture.

Nuclear and radiation protection risk assessment tools however still remain strong but incomplete instruments which could inspire other sectors looking for safe environmentally sound ways of development.

- **Impact assessment of nuclear waste disposal**

A challenge for sustainability already occurred in the eighties when ocean dumping of low level nuclear waste had to be banned due to public opposition, criticising the underlying anthropocentric philosophy. Models illustrated a sufficient dilution by the ocean for health risk. The potential value of deep ocean ecosystems was of few concern for nuclear experts but unacceptable for marine ecology. Meanwhile ICRP only slightly adapted its dosimetric approach taking into account doses to some fauna and flora but not yet proposing ecosystem impact assessment. Controversy was created on ethical grounds for this practise which also is a problem of distributive equity as cheap irreversible dumping practice are selected instead of a safe engineered containment solution paid by the polluter. It contributed to the creation of instruments such as the OSPAR convention, which now also constrains authorised marine radioactivity releases by nuclear installations . The safety assessments for nuclear waste disposal projects are promising. But ethical concerns of trans-generational nature dominate and focus the problem on future site memory and how to guarantee cost coverage in due time. It became clear that health criteria such as limiting cancer risk for the long term are insufficient value references for some cultural settings. The estimation of long term potential doses had little significance regarding model, data and social uncertainties (e.g. future food habit) but was less controversial for nuclear experts than concepts such as collective dose. A search for robustness indicators is more appropriate.

Due to blocked situations in decision making on siting nuclear waste disposal projects, local participatory experiments were developed with successful results in Sweden and Belgium, and were discussed in the EC network COWAM. It was noticed during Belgian regulatory interventions that robust safety criteria can oppose local community preferences emerging from dialogue. An early involvement of radiation protection regulators in participative processes should be made possible allowing them an independent execution of their mission. Participative democracy experiments can as well be opposed by representative democracy initiatives in the decision making process as long as institutionalisation is not realised such as done in France.

Problems in waste management cannot be simply reduced to local issues, neither decoupled from nuclear energy options (Hugé et al, 2011).

It can be noticed that many of the discussed measures to correct interventions to meet radiation protection challenges call for more precise objectives and a more holistic scoping of risk assessment & management.

SUSTAINABLE DEVELOPMENT REQUIREMENTS - PRECAUTION

The concept of sustainability as it emerged in the field of technology, energy, environment and health policy making is discussed by (Hugé et al, 2011). It is based on the UN Rio Declaration and Agenda 21 (UN, 1992) which reaffirmed the early UNEP mission statement from 1980:

"*Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs*"

This means a strategy for a desired future starting from principles or criteria. Criteria for sustainable development were discussed in a PhD in PISA[2] (Laes, 2006) and were applied by the Belgian Federal planning Office (BFPO, 2007) in a strategic exercise on energy futures. Based on these experiences an interuniversity research project was set up on impact

[2] Program of integration of social science in nuclear research of SCK.CEN in Mol (Eggermont et al, 2011b)

assessment of sustainable energy policies (SEPIA) coordinated[3] by A. Verbruggen from the University of Antwerp and involved in IPCC. Within SEPIA a qualitative sustainability assessment was made of nuclear energy policies (Eggermont et al, 2011) referring to 5 major criteria or principles which also belong to the UN Agenda 21:

- Coherent **integration** and reconciliation of various aspects of development (environmental, social, economical, values,…)
  action field on the human-environment relation including trans-disciplinary science approaches
- Stakeholder **participation** in risk governance
  associating relevant actors in decision making processes for SD as also proposed by IRPA, with transparency in risk communication such as developed and modelled in RISCOM (Andersson, 2008).
- Distributive **equity** in problem solving
  element of responsibility as well intra as intergenerational; considers needs
- **Global** differentiated responsibility
  an extension of justification at each level of responsibility such as in RP but here meant particularly in a globalised world at the most relevant level of policy making which is for us the EU
- P**recaution**ary approach in risk assessment and management

Plausible risk problems characterised by complexity, uncertainty and ambiguity are forcing us to reconsider decision-making approaches . At EU level the European Environmental Agency (EEA, 2002) had argued for legal integration of this component of sustainable development, based on lessons learned from early warnings in the past or from lack of precaution (such as asbestos but also nuclear energy). This study has demonstrated that there is a need for a sufficiently broad scoping of risk. Not having taken into account in due time measures to protect the future can become very expensive as also illustrated by climate change due to anthropogenic CO2 emissions, an emission component without direct health risk. Precaution has been established meanwhile in European and national law as discussed in the reference work “Prudent Precaution” of the (Health Council of the Netherlands 2008).

[3] www.sepia.ua.ac.be

- Complexity is inherent in our RP job which already is a trans-disciplinary profession. It is by definition oriented towards problem solving and requires an interactive use of different disciplines. But we should be aware of black boxes, created to protect business, without complete clear picture.
- Uncertainties (as well data, model & science uncertainties) should be made explicit and considered systematically and should be taken up in decision-making. This is required by scientific methodology but the reality is different in complex settings sometimes undermining output statements of risk assessment as illustrated dramatically in Japan during the last 5 months. Uncertainty characterises not only technological behaviour but is also a dimension of the hazard itself as well as the exposure and risk for harmful effects.
- Ambiguity is related to divergent values (the as well normative and interpretative dimension) but can also be created by expert culture and defensive mechanisms of cognitive dissonance. Many potential conflicts of interest can hinder assessment by experts.

A broader than usual approach is needed when these three contextual factors are characterising a plausible risk; the Dutch Health Council calls precaution a strategy to better deal with uncertainties in an alert careful way but remaining reasonable, transparent and looking for a tailor made and proportional (range of) answers, allowing policy makers to decide. Stakeholder involvement is inherent to precaution throughout the whole risk assessment and management process. Precaution considers future generations and looks for the best possible protection for human health and for the quality of the environment for a range of options possible in a given context. Prudent precaution essentially is an adapted strategy, which can easily overlap with prevention already well framed in European safety policies at work. (Zaccai, 2002) remarks that each prevention problem or incident analysis in case of insufficient prevention usually allows us to learn about complexities, uncertainties and even ambiguities that had not been considered enough. Precaution is much more than a cultural controversy on the reversal of proof. It is applicable as well to financial risks in the past as in the future.

The ALARA principle can be seen as a precursor of the precaution principle and justification and optimisation as instruments to achieve this compound of sustainable development. Assessment approaches for decision support,

formalised at EU level and applicable as well in the nuclear as non nuclear field, such as environmental/strategic impact assessment (EIA & SEA) respectively, are broadening the approach. They can be seen as precursors of upcoming sustainability assessment. Such assessments allow to extend health impact assessment (HIA) as currently done in radiation protection but in a more systematic way for including the obligation to consider alternatives. This goes beyond the justification concept in radiation protection.
New cross cutting initiatives, created by international treaties such as OSPAR for reducing marine releases and the Aarhus convention guaranteeing disclosure of information are also challenging existing habits in radiation protection. These initiatives aim to improve transparency on environmental releases and to facilitate stakeholder involvement for a more sustainable decision support in the management of environmental and health effects.

- **Perspectives for Radiation Protection Dynamics**

The dose paradigm and its application for overall risk indication is questioned while evidence for synergistic effects is increasing at different levels. The exposure reality in the environment, at the workplace, for the patient and the public is always a combined exposure requiring more holistic and coherent regulatory approaches.
The new environmental concept for protecting a selection of fauna and flora species, being developed by ICRP, lacks adhesion among radiation protection professionals, nor is it adequate in the new dynamics of sustainability governance. An ecosystem approach considering different stress factors, such as being developed now for the atmosphere with regard to climate concerns, deserves more attention in nuclear regulation. Ecosystems to consider are e.g. the atmosphere, the marine coastal environment, the indoor environment etc..
The ongoing political controversies on effects at low dose from accidents as well as from medical exposure should not been used to develop a defensive strategy questioning the ALARA principle in a dose range of economic significance. On the contrary the complexities we face in RP and the uncertainties on effects and inherent ambiguities in our concepts call first of all for a precautionary strategy embodying sustainable development. Risk awareness as basis for ALARA/RP and safety culture should become

a condition sine qua non for taking responsibilities with regard to ionising radiation and should condition training in the future. Guidance should be developed to support justification at all levels of responsibility on a broader base than dose and health considerations and open attention for alternative options should be fostered as well. Moreover the other sustainability criteria allow us to create a broader scope for our impact assessments. Tools are well developed but need improvement as illustrated above for reactor safety and dose/risk monitoring .

Experience learns that stakeholder involvement can contribute a lot in improving insight in interaction. The attention for value judgements, for transparency in risk communication as well as for coherence and consistency could help RP to gain trust and confidence again. But distributive equity is strongly shaping perception and can no longer be neglected notwithstanding conflicts of interest.

Incident analysis could yield feedback of safety experience in a systematic way while emergency planning should consider real challenges and discover better public concern and valuing of life.

For the challenging areas we propose a non exhaustive summary of perspectives in the frame of sustainability:

Medical: Improved risk awareness of physicians in particular towards new effects such as cardio vascular risks; improved proactive communication with the patient; higher responsibility and involvement for producers of complex installations; systematic incident reporting and quality level registration; adequate monitoring of exposure and contamination of staff and patients ; epidemiological investigations of risks of medical exposures; enforcement of trans-disciplinary competences

NORM and Rn: Developing impact assessment including public perception and acceptability of exemption (and clearance measures; sustainable management of NORM waste and sustainability assessment of radon reduction measures in houses and industry.

Nuclear energy: see also the discussion in (Eggermont et al 2011); small inherently safe total energy concepts with more efficient fuel cycle or remote siting (case EPR); distributive equity measures are needed for liability and nuclear waste funding; Gen IV fast neutron reactors and advanced reprocessing require independent sustainability assessment before continuation, considering costs, risks and regulatory challenges. Demonstration of sustainability perspectives regarding limited nuclear

waste management improvement spread over a century. Integration of site-specific PSA level 3 and vulnerability assessment of neighbouring regions within the reactor stress tests.
Nuclear Waste; stepwise deep geological robust disposal in international sites established through consensus building. Sustainable solutions for radium bearing wastes, for depleted uranium stocks and tailing piles worldwide

Conclusions

The different present challenges for radiation protection and for the nuclear sector demonstrate that when confronted to a risk complexity, society's approach to risk can no longer be reduced to an isolated approach within a particular sector. Hazards present in most cases a combination of risks while effects can have a synergistic nature dependent of the context. Moreover risks are perceived differently dependant on the balance of advantages. Perception is co-determined by trust shaped by historical experiences and coherence. Finally the existence of trusted adequate regulatory bodies together with transparency in risk communication can considerably facilitate decision-making processes particularly when they require public support over longer periods. The concept of sustainability and precaution broadens the scope of risk assessment and can strengthen radiation protection and safety.
The EU could take up this sustainability dynamic to reconsider and integrate the EURATOM treaty while reinforcing the regulatory as well as the licensing and controlling role of EC institutions replacing multilateral networks with the aim to create European nuclear safety standards.

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ETHICAL GUIDANCE, STAKEHOLDER INVOLVEMENT AND RADIATION PROTECTION CULTURE IN THE BELGIAN SOCIETY FOR RADIATION PROTECTION

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Abstract.
The Belgian Association for Radiological Protection BVS-ABR (www.bvsabr.be), affiliated to IRPA, has set up guidance for ethical conduct and stakeholder involvement as required by IRPA. This was developed by a working group and submitted to the members for comments with final discussion and approval in the plenary meeting of the society.
Guidance is framed within the strategic objectives of the society and based on IRPA principles and on results of research and field inquiries integrating social research within the trans-disciplinary science of radiation protection. Participatory experiments at local and national level in nuclear waste decision making processes and with particular groups such as patients and workers have generated feedback of experience. Particular attention was also given to the modelling of risk communication as done in RISCOM.
The results of these exercises in generating guidance by a professional society are annexed in the paper while being illustrated by case references for present challenges in radiation protection (nuclear waste forum, round tables).
ALARA and radiation protection culture is discussed proactively with international IRPA representatives preparing IRPA13 in Glasgow, while building a bridge with safety & security culture as met in the field. Some definitions and proposals are put forward.

KEYWORDS: (IRPA, protection, ethics, stakeholder engagement, culture)

INTRODUCTION

The Belgian Association for Radiological Protection, BVS-ABR) is a professional scientific organisation for radiation protection, affiliated to IRPA. The society has about 400 members. It organises regularly seminars on actual issues such as radiation protection culture, medical protection challenges, basic safety standards, reports of and debates at the level of UNSCEAR, and a yearly training session for its members. Typical topics are ALARA in specific sectors or response to contamination incidents. A debate was directly organised on for instance Fukushima.

BVS-ABR operates in a small country with an extended nuclear industry (fuel cycle as well as reactors), nuclear research centres, numerous medical facilities including isotope production and several NORM industries. Nuclear waste management has been developed and projects for surface as well as geological disposal are in stepwise preparation.

The society has an active executive board and different working groups. The Belgian language diversity allows to organise events with societies in neighbouring countries. BVS-ABR actively supports the structuring of a European IRPA network and organises young scientist awards. The association financially supports the European ALARA networking EAN. The society has a website, an electronic quarterly newsletter and a journal, the Annals of the BVS-ABR, in which mainly contributions on its seminars are published.

Working groups operate on communication, on regulation, on education and training and criteria for expert certification. During the last years particular attention was given to the implementation of IRPA guidance on ethics and stakeholder engagement.

This work resulted in position documents of the society, approved by the general assembly and presented in this paper.

Moreover a proactive initiative was made to prepare ongoing work in IRPA international on ALARA culture for which a definition had been proposed earlier by a Belgian contribution to the EAN network conference in Prague. The brainstorming on Radiation Protection Culture should result in proposals at the IRPA-13 conference in Glasgow in 2012. Bernard LeGuen, European delegate in the IRPA executive board, introduced the subject in December 2010, followed by a discussion considering as well safety as security culture as ALARA culture. This discussion is briefly summarised at the end of this paper and is taken up currently by the working group.

THE MISSION OF BVS-ABR AS REFERENCE BASE

The mission of BVS-ABR as defined in the statutes of the organisation was used as starting framework for developing the implementation in the Belgian context of the guidance set up by IRPA and approved at the Madrid meeting in 2004 and the Buenos Aires conference of 2008 respectively for Ethical Guidance and Stakeholder Engagement IRPA 2008).

The BVS-ABR as scientific organisation aims to:
1. provide its members with objective and high level information regarding all aspects of radiological protection,
2. contribute to the knowledge of radiological protection among interested citizens and organisations,
3. promote the development of radiological protection by bringing together various scientific disciplines and through international networking,
4. put forward independent opinions on scientific, legal or organisational aspects of radiological protection when the association judges it necessary or on request.

Acording to this mission, the members of the BVS-ABR take on, as individuals, high-level responsibilities concerning public health and safety. This code will offer them appropriate and useful ethical guidance. Due to this specific context, the following guidance is not formulated in an institutional perspective, as ethical rules for the staff of an institution should be. The guidance is also different from the deontological codes that are elaborated in a professional perspective, like the deontological code for the physicians. It is conceived in a societal perspective and can be seen as an expert's deontology *ensuing from social expectations* regarding competence, neutrality and objectivity.

These principles are intended to aid members of BVS-ABR in maintaining a professional level of ethical conduct related to radiation protection. They are to be regarded as guidelines. Members may use them to determine the propriety of their conduct in all relationships in which they are exercising their professional expertise.

For the second phase on stakeholder engagement not only reference was made to the code of ethics but the second text has been considered as a later annex of the ethical code.

PROCESS OF IMPLEMENTATION

The working group was composed of 6 former presidents and of members from regulatory bodies, research centers, universities and industry, having reacted on a general call for interest. It was directed by one of the authors, Patrick Smeesters, involved since many years in ethical reflections on health and safety related to ionising radiation and chairman of RIHSS, a working party of the art 31 advisory group on radiation protection of the EC on Research Implications for Health and Safety Standards.

External expertise on ethics and philosophy was implemented. A professor in philosophy of the Université Catholique de Louvain (UCL), Bernard Feltz, was invited to join the working group. He studied the ethical dimension of scientific practice (Feltz, 2008). He also contributed in the past in reflections and discussions organised by the Belgian Nuclear Research Centre SCK•CEN within their Program on the Introduction of Societal Aspects in nuclear research, called PISA (Eggermont et al, 2006; Eggermont and Feltz, 2008).

The research experience from this “PISA program” (Eggermont et al, 2004) was actively used as two of its researchers took part in the working group (Eric Laes, ir and PhD on sustainable development in nuclear and Gaston Meskens, ir and science philosopher). In particular the results of the ethical project within this program which had helped to develop an ethical charter for the researchers working at this nuclear research centre showed valuable. The late general manager of SCK-CEN, Paul Govaerts, strongly involved in radiation protection reflections on ethics (P.Govaerts, 2008) had also used part of this research work to establish a code of ethics for the art 31 EC advisory group (EU, 2001) together with Annie Sugier of IRSN which is still of application.

Different members of the working group had been involved in the Belgian Health Council to handle conflict of interests in Health policy advisory work.

For the second phase of activity on stakeholder engagement a professional in public relations and communication from the Belgian Federal Agency for Nuclear Control (FANC) joined the group: Karina De Beule.

Lessons of local participatory experiments on nuclear waste disposal in Belgium and of the European network COWAM (www.cowam.com) were considered as well PISA results from risk perception studies and communication research, in particular applying the RISCOM model for transparency of Karita Research (www.karita.se/our_approach/riscom_model.php), were given attention in this phase.

Moreover input was given from the Belgian nuclear regulatory agency (FANC), which had set up experiments to involve patient groups in round table discussions on problems and new policy proposals in medical radiation protection.

After a number of editing meetings, the drafts were presented and discussed with the executive board of BVS-ABR, leading to some amendments. Finally the proposals were submitted for written remarks to all members

The result of the both processes was discussed in the executive board, slightly amended and then submitted to the members of the Association for comments. These were taken into account in the final approval by the general assemblies of respectively 2009 and 2010 (BVS-ABR 2009 and 2010).

CODE OF ETHICS OF BVS-ABR

The IRPA guidance was almost completely followed up by BVS-ABR, but additional elements were added emerging from the experience and reflections of the members and from the input elements discussed above.

The final BVS-ABR code of ethics specifies that:

1. Members shall give priority to the protection of public health, including for future generations, to the safety, to the protection of the environment and to the development of the best available operational radiation protection. They may express views on political, economical, financial and liability matters but the health and safety considerations must always be clearly identifiable in their opinions, proposals, guidance and statements.
2. Members shall exercise their professional skill and judgment to the best of their ability and carry out their responsibilities with integrity.

3. Members shall not allow conflict of interest, management pressures or possible self-interest to compromise their professional judgment and advice, in particular when public welfare and safety are at stake. Members are invited to declare potential conflicts of interest and could, as appropriate, notify possible management pressures or actions in favour of the interests of their company, institution or professional organization.
4. Members shall take all reasonable steps to ensure that persons carrying out work done under their supervision or direction are competent, and not under undue pressure from workload or other causes.
5. Members shall not undertake any employment, function or consultation that is contrary to the public welfare or to the law.
6. Members shall not undertake professional duties in activities beyond their competence and/or qualifications.
7. Members shall strive for the maximum possible transparency towards society. However, where necessary, they shall protect the confidentiality of information obtained during the course of their professional duties, provided that such protection is not contrary to the public welfare or to the law.
8. Members shall ensure that relations with interested parties, other professionals and the general public are based on, and reflect, the highest standards of integrity, professionalism and fairness. They will commit themselves to communicate in a form unequivocal and appropriate to the target audience with the aim of facilitating correct interpretation. In particular, they shall make clear if there are uncertainties, value judgments or ethical issues, what these are exactly and what is at stake.
9. Members should strive to improve, and regularly assess in an appropriate way, their competence (professional knowledge, skills and attitudes). With this aim in view, they shall use adequate means to take into account all the available scientific information and to avoid inappropriate selection of the sources.
10. Professional reports, statements, publications or advice produced by members should be based on sound radiation protection principles and science, be accurate to the best of their knowledge, specifying uncertainty, and be appropriately attributed.

11. Members should, whenever practicable and appropriate, correct misleading, sensational and unwarranted statements by others concerning radiation and radiation protection.
12. Members should take advantage of opportunities to increase public understanding of radiation protection and of the aims and objectives of the BVS-ABR.

GUIDING PRINCIPLES FOR RADIATION PROTECTION PROFESSIONALS ON STAKEHOLDER ENGAGEMENT

According to its mission, the members of the BVS-ABR take on, as individuals, responsibilities concerning public health and safety. The document complements the code of ethics and offers them useful guidance regarding stakeholders engagement, stakeholders meaning all relevant individual and institutional actors that could be affected by a decision or have a substantial impact on the decision making process. These Guiding Principles are intended to aid members of the BVS-ABR in promoting the participation of all relevant parties in the process of reaching decisions involving radiological protection which may impact on the well being and quality of life of workers and members of the public, and on the environment. In promoting this approach, radiological protection professionals will aid to develop trust and credibility throughout the decision making process in order to improve the sustainability of any final decisions.

As well the BVS-ABR as members of the BVS-ABR should endeavour to:

1. *Identify opportunities for engagement and ensure the level of engagement is proportionate to the nature of the radiation protection issues at stake and their context, including the associated scientific uncertainties and the implicit value judgements which could require the application of a precautionary approach.*

The primary purpose of engagement is to contribute to decision making on radiological protection measures so that:

- the measures are more widely understood and respected;
- the measures are optimal and work in practice across a broad range of foreseeable situations;
- the measures, if needed and coherent, can be tailored to the specific context (social, economic, environmental etc);

- the measures will continue to be effective and have credibility for some reasonable period of time.

Engagement will add real value to the decision-aiding process and its outcome but its extent and nature need to be proportionate to the radiation protection issues and concerns at stake. This includes being realistic about the co-operation that can be achieved and about the resources and time that might need to be expended on interacting with the more challenging stakeholders. The more complex the radiological protection problem and the more serious the risk, or even the perception of the risk, the greater is the justifiable investment in engagement.

In identifying opportunities for engagement it is important to be aware of changing societal expectations. Changes such as increasing awareness about the risks associated with some activities, concerns over environmental deterioration or loss of public confidence in some organisations are all likely to broaden or shift the range of stakeholders that need to be engaged.

2. *Initiate the process as early as possible, in principle already during the justification phase for a new practice (allowing for consideration of alternatives), and develop a sustainable implementation plan.*

Feed-back experience has shown that involving stakeholders, as early as possible, in decision-aiding processes will generally improve the mutual understanding of the situation, and therefore may avoid reaching a deadlock at a later stage. Although it may increase the duration of the process, involving stakeholders could facilitate better cooperation between all participants and lead to more acceptable and robust decisions.

At the early stage of the decision-aiding process, involving stakeholders will give the opportunity to develop together a sustainable plan in terms of scope, objectives, timetable and milestones, deliverables, knowledge production, financial support etc.

In order to improve the sustainability of the process, a reasonable approach, shared by all participants, should be adopted when defining this plan. The process has to be proportionate to the realities of the situation, and takes into account the stakeholders' time and opportunity to participate according to their particular circumstances. Finally, it has to be kept in mind that it will be necessary to revise and adapt the plan as the situation evolves.

3. *Enable an open, inclusive and transparent stakeholder engagement process.*

Openness, inclusiveness and transparency, which are interrelated, should constitute the essence of a successful stakeholder engagement process and should always be present. They are the basis for understanding, creating confidence in the process and promoting it. They may be supported by collectively agreed rules and mechanisms for their assessment.

The process should include all the relevant stakeholders, extending representation beyond the obvious candidates to all those perceived to have a share in or an impact associated with the risks of the endeavour under consideration. Different expertise and sensibilities will generally enrich the process and give more validity to the results.

All the issues entering into the decision should be considered, with openness, to identify, select and discuss any associated uncertainties.

During the process, it is important to share the information needed to build a collective understanding of the problem, starting in particular with risk communication. The flow of information should be quick, concise, clear to all and honest (in terms of accuracy, uncertainty, coherency of the argumentation, etc.). By default, information should be accessible to all, but recognising that some information truly requires protection. Rather than withholding information on grounds of personal or national security or confidentiality, it is preferable, when possible, to have it presented in a different way, rather than agree its omission.

It would be helpful to build, grow, review and maintain a common knowledge pool, identifying a responsible 'gatekeeper' or 'custodian' for the knowledge pool who is trusted and respected by all parties.

4. *Seek out and involve relevant stakeholders and experts, without exclusion, in a transdisciplinary approach, aiming at obtaining a full spectrum of views.*

A key part of decision-aiding is to be very clear over what is the issue in question, the scope of the problem and the factors that may be relevant. Inherent to this process is the need to identify those who can and should contribute; in short, ensuring that an appropriate diverse range of views are included. The radiological protection professional can help to promote this approach, as radiological protection is, by its nature, a transdisciplinary scientific approach.

There is a need to reach out to other disciplines and stakeholders, making them aware of the issues under consideration. Without this first step relevant factors may not come to light, undermining the validity and sustainability of any decisions. For example experts in one discipline may not be aware of knock on effects in other areas. Similarly if the net of consultation has been set wide enough to elicit “no comment” replies, this is useful information to support the bounding of the issue. Bringing together all the diverse views may be an iterative process, particularly for large scale decision making that may involve socio-economic factors. Thus it should be accepted that the initial set of stakeholders may not be the final set. The process can be a dynamic one with stakeholders joining, but also leaving, throughout.

There is a need to have respect for information and knowledge gained through individuals' experience as well as that from scientific and technical experts. Some issues, particularly high profile ones, bring with them stakeholders with significantly different points of views. It is important that there is engagement with, rather than avoidance of, these different groups. Inevitably there will be conflicting views and information. How these are evaluated within the decision-aiding process is a separate but important element (see principles 3 and 5), however it is clear that obtaining a full spectrum of views is important.

5. *Ensure that the roles and responsibilities of all participants, and the rules for cooperation are clearly defined.*

A clear definition, at the beginning of the process, of the roles and responsibilities of the different categories of participants (for example, experts, authorities, sponsors, lay persons, decision maker versus decision taker, ...), is important to obtain a shared understanding of what is expected from each and the extent of the influence they may have. In addition it will be helpful to set out clearly the rules under which cooperation can be achieved. A clear delineation of the consultation phase and the decision phase, as well as a clear understanding of where individuals' responsibilities and accountabilities begin and end is essential to clarify the conditions of the engagement.

Potential conflicts of interest should be declared by all involved parties. It may be helpful for radiological protection professionals to make reference to their own Code of Ethics. One of the objectives of stakeholder engagement in a decision-aiding process is to promote dialogue and mutual understanding, but not necessarily to reach a consensus on all aspects of the situation. It is thus important to preserve the autonomy of the different categories of participants concerning their points of view or their evaluation of the situation. This delineation of roles is a key element to create the conditions for the participants to contribute to the improvement of the evaluation of the situation and the radiation protection options. Beyond clarifying the roles and responsibilities, sharing the rules of cooperation between the participants will also favour the success of the process.

6. *Collectively develop objectives for the stakeholder engagement process, based on a shared understanding of issues and boundaries.*

The need for a collective approach to developing process objectives is implied by application of the other principles. Principle 2 talks of the development of a sustainable plan, Principle 4 of identifying the responsibility of contributors and of scoping problems and factors, and Principle 5 of the need to co-operate.

Lack of collectivism disenfranchises stakeholders, whereas working alongside each other allows a tight group to emerge which is then capable of explicitly defining the process objectives. The group is then in a position to validate these against its shared understanding of issues and boundaries, as well as to collectively agree on the scope or remit for the work.

Once the objectives are identified in principle then the discussions can extend to ensuring that they are refined in the light of the resources available. The realism brought about by this dialogue invariably leads to more harmonious working by avoiding feelings of frustration with the process that might be perceived as more imposed than negotiated.

7. *Develop a culture which values a shared language and understanding, and favours collective learning.*

In order for all stakeholders to fully appreciate the factors entering into the decision they must be able to understand what is being said. This understanding can be seriously compromised by the use of jargon and technical language as well as acronyms and abbreviations. The radiological protection professional, as well as experts in other disciplines, should be motivated to develop a “common language” sufficiently precise scientifically not to offend the various experts but also sufficiently rooted in common, every-day experience to be meaningful to all those involved.

Part of this approach is likely to involve formal and informal training of stakeholders leading to the creation of a shared knowledge base incorporating those technical concepts essential to a full understanding of the issues.

8. *Respect and value the expression of different expertises, perspectives, sensibilities and value judgements.*

It is important that each participant in the process recognises their own and each other's uniqueness, and, because of this, is aware that other participants have different backgrounds and sensibilities and, therefore, may view issues from different perspectives and based on different value judgements.

Participants should be aware that some may be experts in their own field, and the integration of their views is an important step in the process, whilst accepting challenges to expert opinion. Evaluation of uncertainties in the assessments where expert opinion is divided should be undertaken in an open, accessible and clear manner. Experts should recognise the limits of their mandate and of their field of knowledge.

Respect for one another's view encourages a wide range of thoughts and ideas which can be evaluated as a whole during the engagement process. This acceptance of diverse perspectives, thinking and values has the potential to enrich the process, providing that the process is controlled such that any entrenched views and ideologies, if present, are managed by agreed mechanisms. In a similar way, seemingly radical or novel opinions should not be dismissed out of hand, but evaluated with respect in the same way as other ideas. It is important that each individual can see their own contribution in the record of the meetings.

Participants should be aware that rational thought, respect and acceptance of opinions will tend to be challenged or obscured when discussing issues which are emotive, or issues which have attracted significant media or political interest. Efforts should be made if this happens to restore the desirable climate of mutual respect and cooperation.

9. *Ensure a regular feedback mechanism is in place to inform and improve current and future stakeholder engagement processes.*

When engaging with stakeholders an opportunity should be provided for both the stakeholders and those responsible for the process to give feedback on the approaches and tools used and on the outcomes. This serves to inform and improve ongoing processes as well as influencing how future processes should be conducted. The following types of criteria might be included in the evaluation: appropriateness of the terms and timing of engagement, the quality and appropriateness of the information provided; comprehensiveness of the issues that were addressed; inclusivity in terms of the number and diversity of stakeholders involved and the nature of that engagement; practicability and feasibility of the eventual outcomes.

Stakeholder engagement commonly involves a series of meetings, discussions and other types of face-to-face encounters. These provide continuous learning opportunities to be discussed by the group at the end of each meeting, whereby agreements on improvements in the management of subsequent meetings are agreed. It should be recognised that implementation of changes may require additional resources and so any improvements agreed upon must be realistic and achievable.

When a stakeholder engagement process comes to an end, it is important that those responsible for the process make the results known to all those who participated. If these results do not reflect the recommendations or findings from the stakeholders, those responsible must offer an explanation to the stakeholders for any deviation from what was agreed. In this way, the feedback of results and decisions will help to maintain confidence in the process.

Tangible improvements in stakeholder engagement resulting from the establishment of a constructive feedback mechanism will contribute to a more sustainable process, which could serve as a role model for future engagement. Dissemination of the lessons learned, achievements and how challenges can be met should be carried out as widely as possible among the radiological protection community.

10. *Apply the BVS-ABR Code of Ethics in their actions within these processes to the best of their knowledge*

ALARA-SECURITY-SAFETY CULTURE

A major issue of optimisation of radiation protection in daily practice at the level of the working people is that radiation protection is only one aspect to consider. Within the nuclear industry, nuclear safety (reactor safety, criticality management) are vital as well. The growing concern for potential terrorist acts after 9/11 has lead to an enhancement of security measures and attitudes expected. This has created 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 routine circumstances, but especially poses 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 or within a nuclear facility in general sometimes looks like implementing the quadrature of the circle. International guidance exists, but is not always easily converted into an adequate policy comprehensible to all levels in a plant, from management to the work floor.

The BVS-ABR has been paying interest to the cultural dimension of safety management, and as such also spent some debate and a scientific meeting on the issues of the implementation of a safety culture, an ALARA culture and an adequate security culture within a single organisation.

Some examples to illustrate practical difficulties:

1. infrastructure related problems: from a security point of view, fuels are better stored in the heart of a protected zone, while in case of criticality, fire… a more peripheral location is appropriate.
2. Safety related problems: Protection infrastructure may lead to difficulties of evacuation in case of emergencies; access limitations may be a burden in the management of safety interventions, maintenance…
3. Administrative contradictions: inventories of fuel storages and high active sealed sources are a cornerstone of inspections and verifications; yet, this information is a treasure for terrorists aiming at actions to obtain special materials.
4. Dose management: measures taken to secure sources may lead to a dose increase (e.g. labelling of old sources).

However, the main difficulty is related to the *'cultural'* aspect. There are synergies between safety culture, "ALARA" culture and security culture. An individual aspect of desirable behaviour (e.g. questioning attitude), complemented with an organisational dimension (e.g. training, raising awareness) are obviously common. The objective is also in line: to avoid reduction of well-being of people, to protect the environment, to prevent damage to facilities.

The main difficulties arise however because of the fundamental differences being present. There are aspects of trust and distrust, supervision and

coaching versus control and verification; acceptability of measures implemented; having control or being victim of global evolutions.
As a conclusion of the debate, it has been concluded that 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 understandable to the workforce and taking into account all aspects: safety, security and dose optimisation.

CONCLUSION

The Belgian Association for Radiological Protection has now set up guidance for ethical conduct and stakeholder involvement in full accordance with IRPA requirements.
We have the strong feeling that we have actually realized an exemplary process, in line with the most recent ideas on this field. Both documents of the BVS/ABR rely on a large experience feedback and can be used as a reference by the members of our organization. Both documents, specially the guiding principles on stakeholder engagement, can achieve a broader scope than only the radiological aspects and help to solve a lot of societal topics.
In accordance with to-day concern of radiological protection and nuclear safety community, we are now trying to take into account the nuclear security challenge. The state of our reflection shows that some work has already been done but some contradictions remain unsolved (close to the quadrature of the circle). We are confident that a good compromise can be found.
It is obvious for us that synergy between safety- ALARA- and security culture will play a major role in the coming year in day to day life of the organizations (nuclear power stations, research centers, hospitals and so on) using ionizing radiation.

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LA CATASTROPHE DE FUKUSHIMA

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Le 11 mars 2011, à 14h46, 25 ans après Tchernobyl qui était la plus grande catastrophe du nucléaire civil, dont les rejets avaient largement dépassé les frontières de l'Ukraine et de la proche Biélorussie, un nouveau cataclysme nucléaire a frappé cette fois le Japon.

Ce n'est plus **un** seul réacteur qui explose (N° 4 à Tchernobyl), mais **trois** réacteurs qui sont détruits à Fukushima : les réacteurs N° 1, 2 et 3 tandis qu'un quatrième, le N° 4, qui était à l'arrêt (le cœur, retiré de la cuve était placé dans la piscine de stockage), a été très endommagé[1]. Lors du séisme, les réacteurs N° 5 et 6 étaient à l'arrêt. Ils sont en outre situés sur une plateforme plus haute que celle des réacteurs N° 1 à 4.

Un tremblement de terre, de magnitude 8,9 à 9 sur l'échelle de Richter, frappe la côte nord-est de l'île d'Honshu, l'île la plus grande et la plus peuplée du Japon. C'est le tremblement de terre le plus fort enregistré par des sismographes au Japon. Il dure deux minutes et demi.

Le déplacement brutal du fond marin[2], à 120km de la côte, provoque notamment une énorme vague qui se propage à très grande vitesse, sur un front d'environ 500 km. Arrivée à la côte en 55 minutes, cette vague atteint

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[1] N'étant plus alimentée, après ébullition et évaporation de l'eau, la piscine découvrait la "tête" des assemblages combustibles qui ont dû s'endommager et produire de l'hydrogène qui occasionne feu et explosion. Un incendie s'est déclaré au niveau de la piscine d'entreposage du combustible usé le mardi 15 mars 2011. L'état du combustible stocké dans cette piscine, potentiellement affecté par l'incendie, n'est pas déterminé. Un deuxième incendie s'est déclaré le 16 mars 2011. L'ossature du bâtiment a été fortement endommagée.

[2] Un déplacement vertical du fond marin de 17 à 25 m, dans la zone maritime la plus affectée.

environ 14 mètres en arrivant au niveau du groupe de 4 réacteurs[3] de la 1ère centrale de Fukushima (6 réacteurs), protégée par une digue de … 5,7 m.
Le corps de deux jeunes travailleurs (21 et 24 ans), portés disparus sont retrouvés dans la dernière semaine de mars. Il y avait 3 639 personnes présentes sur le site le 11 mars 2011.
Si les trois réacteurs nucléaires N° 1, 2 et 3, en fonctionnement dans la 1ère centrale de Fukushima, se sont arrêtés automatiquement, cinq secondes après la mesure de l'onde sismique, les dégâts dus au *seul* tremblement de terre sont mal connus, notamment ceux relatifs aux diverses tuyauteries qui jouent le rôle important de l'apport d'eau dans les circuits de refroidissement. La vague, en pénétrant dans les annexes techniques des réacteurs, a détruit et noyé les équipements électriques nécessaires à leur sécurité, comme ceux de la station de pompage[4]. Le système d'alimentation électrique de toute la région est interrompu et 11 diesels de secours sur 12 (installés en sous-sol), comme les pompes qui assurent le refroidissement du cœur des réacteurs, sont noyés et hors d'usage. Le 12ème diesel, refroidi par l'air et non par l'eau comme les autres, permettra aux réacteurs N° 5 et N° 6, qui étaient en arrêt pour maintenance, de conserver un système de refroidissement au niveau des piscines d'entreposage.
Les quatre réacteurs de la centrale N° 2 de Fukushima (Daini), ont été mis à l'arrêt et toutes les grappes de commande ont été insérées. Les alimentations électriques externes étaient disponibles.
L'Agence japonaise de sûreté nucléaire[5] (NISA) qui avait classé la catastrophe au niveau 5 de l'Echelle internationale des évènements nucléaires et radiologiques (INES), a élevé le 12 avril 2011 l'accident de Fukushima au niveau 7, celui de Tchernobyl, classé au niveau le plus haut de l'échelle.
Il y avait, dans l'histoire des catastrophes nucléaires, un "avant" et un "après" Tchernobyl. Aujourd'hui un nouveau jalon s'impose avec Fukushima.

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[3] Le Japon a déjà connu des tsunamis produisant des vagues supérieures à celle de mars 2011. Sur la petite île d'Okushiri (3700 habitants) située à l'est d'Hokkaido dans la Mer du Japon, le 12 juillet 1993, une vague d'un maximum de **31 m** de haut, n'a fait que 239 victimes grâce au système d'alerte.

[4] *Note technique de l'ASN du 12 mars 2011 à 20h30.*

[5] "NISA", est l'acronyme anglais de l'Agence nucléaire japonaise (Nuclear and Industrial Safety Agency)

Un scénario catastrophe

Une situation imprévue dans tous les scénarios déterministes imaginés dans le monde entier : la perte *simultanée* de l'alimentation électrique et de la "source froide" qui permettent d'assurer le refroidissement du combustible nucléaire, dans la cuve du réacteur et dans les piscines d'entreposage. "*Fukushima a montré que l'improbable est possible*" a déclaré, Mr Philippe Jamet, un responsable de la sûreté nucléaire en France.[6] Un propos courageux mais aussi un aveu inquiétant.
Le pire des scénarios catastrophe se développe alors avec la production d'hydrogène puis la fusion du combustible. Cette fusion serait survenue seulement 16h après l'arrivée de la vague, devait admettre deux mois plus tard (15 mai), TEPCO, l'exploitant de la centrale[7].
Selon le scénario de TEPCO (30 novembre 2011), la totalité du combustible serait en fusion[8] et aurait percé la cuve du réacteur N° 1, de 15 à 16 cm d'épaisseur et la dalle de béton du bâtiment réacteur (7,6 mètres d'épaisseur) serait attaquée jusqu'à une profondeur de 37 cm. C'est le début du scénario d'un film imaginé dans les studios d'Hollywood en 1979 : "Le Syndrome chinois".
Au contact de l'eau, les gaines en zirconium portées à plus de 700° C s'oxydent. En captant l'oxygène de la vapeur d'eau, le zirconium libère de l'hydrogène et de la chaleur. L'hydrogène libéré, peut s'enflammer ou exploser spontanément suivant la concentration obtenue dans l'air. Il provoque le samedi 12 mars à 15h36, soit 24h après l'arrivée de la vague sur la centrale, feu et explosion dans le réacteur N° 1 et le 14 mars à 11h01 dans le réacteur N° 3 où 7 travailleurs sont blessés. Les toits des bâtiments réacteurs

[6] Revue "La Recherche", N° 453, pp (50-53), juin 2011,

[7] Une simulation faite aux USA, dans le centre nucléaire d'Idaho, a montré que la fusion du combustible a pu débuter 3,5 heures après le passage du tsunami. Le 15 mai 2011, un important rapport de Tepco (Tokyo Electric Power Co) précisait qu'au bout de 3h l'eau dans le cœur était à hauteur de la "tête" des combustibles, et 16h après le tremblement de terre, tout le combustible avait fusionné et percé la cuve.

[8] Le combustible des réacteurs BWR est constitué d'un faisceau de tubes en " Zircaloy 2" (alliage de zirconium 98,4 %, de 1,3 % d'étain, 0,1 % de fer, 0,1 % de chrome et 0,05 % de nickel) de 4m de long, qui renferment des pastilles d'oxyde d'uranium dans lesquelles se sont formés *une centaine* d'isotopes stables ou radioactifs. La fusion du zircaloy est atteinte vers 1200° C, celle de l'ensemble des constituants, le "corium", commence à environ 2100° C. Elle est totale à 2300° C, d'après les expériences faites en France.

sont soufflés. Le 15 mars à 6h10, une explosion se produit dans le réacteur N° 2. A 6h14, le réacteur N° 4 connait deux grosses explosions qui causent deux brèches d'environ 8 mètres de large sur l'enceinte extérieure du bâtiment abritant le réacteur. A 9 h 38, il y a une nouvelle explosion, suivie d'un incendie de la piscine de stockage du combustible, qui s'éteint vers midi.

A l'extérieur des bâtiments réacteurs, l'intensité des rayonnements émis par le cœur sans leur écran d'eau, va atteindre des niveaux très élevés qui rendent impossible toute intervention humaine. Le 13 mars, les autorités japonaises annoncent que de l'eau de mer, enrichie en bore a été injectée dans la cuve du réacteur[9] (dès le 12 mars à 20h30). Pour Tepco, cela signifie que les réacteurs sont donc irrémédiablement détruits. Ce n'est que le 20 avril, afin de refroidir les cœurs des réacteurs, que le refroidissement à l'eau douce a repris avec des débits importants (15m^3/h) afin d'éviter les dépôts de sel cristallisés sur les structures chaudes.

Selon le rapport de TEPCO, le combustible du réacteur N° 3 fusionnera à son tour au bout de 60h (14 mars à 20h) et celui du réacteur N° 2, quatre jours après le tremblement de terre.

En décembre 2011, il était acquis que le combustible du réacteur N° 1 (400 éléments combustibles) était en très grande partie fondue tandis que ceux des réacteurs N° 2 et 3 (548 éléments combustibles) étaient fortement endommagés, mais dans des proportions inconnues.

La catastrophe était elle imprévisible ?

Au cours des 5 derniers siècles, il a été recensé, au Japon et dans les iles avoisinantes, 16 tsunamis avec des hauteurs de vagues supérieures à 10 mètres. Depuis 1918, six tsunamis sur seize ont occasionné des vagues de 25 à 30 mètres. La survenue d'un tsunami provoquant une vague de 14 m n'était donc pas invraisemblable.

En 2008, puis en février 2011, Tepco avait réévalué le risque présenté par un tsunami. La hauteur de la vague qui atteindrait la 1ère centrale de Fukushima[10] avait été estimée à *plus de 15 mètres de haut* mais Tepco n'avait pris aucune initiative, jugeant la probabilité de sa survenue quasi nulle. La Com-

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[9] Communiqué de presse de l'ASN du 13 mars 2011.

[10] Rapport intérimaire de la Commission d'enquête sur les accidents survenus à la centrale nucléaire de Fukushima, 26 décembre 2011

mission indépendante de dix experts, nommés le 24 mai par le Premier ministre japonais Naoto Kan[11] pour enquêter sur la catastrophe de Fukushima, a publié le 25 décembre 2011 un rapport intérimaire. Elle a noté un point plus grave encore que la faute de l'exploitant, celle des responsables de la sûreté nucléaire japonaise: "*L'organisme de régulation nucléaire du gouvernement (NISA) n'a pas demandé à Tepco de prendre des mesures précises, comme par exemple d'effectuer des travaux supplémentaires après avoir reçu les études par simulation de Tepco en 2008 et début 2011 concernant l'impact des tsunamis sur ses installations*".
La Commission indépendante souligne aussi que la Commission de sûreté nucléaire (Nuclear Safety Commission, NSC) du Japon a publié en septembre 2006, après 5 années de travaux, un guide règlementaire sur le risque sismique, sans avoir inclus de sismologue parmi les rédacteurs et sans préciser les mesures concrètes à prendre contre les tsunamis. La Commission relève aussi que la centrale de Fukushima Dai-ichi a été conçue sur *la plus haute* vague observée au port d'Onahoma (à 40 km au sud de Fukushima), à savoir 3,1 mètres au-dessus du niveau de la mer.

Les rejets dans l'environnement

Les dégradations des trois réacteurs et de la piscine du réacteur N° 4 ont entraîné des rejets atmosphérique*s* et marins. Les premiers rejets atmosphériques résultent des explosions et des décompressions volontaires des enceintes de confinement des réacteurs (afin d'éviter leurs ruptures) et les rejets en mer, de fuites d'eaux fortement contaminées (utilisées pour refroidir les combustibles endommagés) qui produisent des déversements direct en mer, depuis la centrale.

Rejets atmosphériques

La production d'hydrogène, qui a provoqué les explosions[12] dans les réacteurs N° 1, 2 et 3, s'est prolongée par des rejets radioactifs atmosphériques.

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[11] Nommé ministre de la santé en janvier 1996, Naoto Kan découvre en février une affaire de sang contaminé. Refusant de couvrir les fonctionnaires responsables, il présente publiquement ses excuses à la télévision en présence de représentants des victimes. C'est lui qui a empêché Tepco de retirer son personnel de la centrale accidentée comme l'exploitant en avait un temps l'intention.

[12] En décembre 2011, des publications scientifiques soutenaient l'hypothèse selon laquelle le réacteur N° 3 a été le siège d'une "excursion critique nucléaire" et pas seulement d'une explosion d'hydrogène.

Les rejets les plus importants se sont produits entre le 12 et le 22 mars. Le 15 mars, en lessivant le panache de poussières radioactives, la pluie et la neige ont été à l'origine d'importants dépôts radioactifs observés dans les territoires touchés (une bande de plus de 40 km de long suivant un axe nord-nord-ouest). Dans les 20 premiers km, ainsi que dans les trois entités administratives ayant reçu les dépôts radioactifs les plus importants (Iitate village, Katsurao et Namie), la contamination en césium 134 et 137 dépassait, jusqu'au 23 mars, le million de becquerels par m². Jusqu'au 18 mars, les légumes à feuilles accusaient plus de 10 000Bq/kg en iode 131.
Dans une synthèse des données disponibles[13] en juillet 2011, l'IRSN fournit, pour un prélèvement de sol à 80km de la centrale, une contamination *massique* de 10kBq. Dans sa synthèse[14] de septembre 2011, l'Institut reproduit une carte de la contamination surfacique en césium 137 (plus de 2000 points) qui montre que l'essentiel de la contamination se situe dans un rayon de 80km, centré sur la centrale. Cependant, suivant un axe ouest-sud des contaminations comprises entre 60 et 100kBq/m² sont mesurées, et à l'ouest de 10 à 30kBq/m² à plus de 100km. Un quotidien japonais[15] cite des contaminations de 30 à 60kBq mesurées (du 8 au 12/09/2011) dans les zones des préfectures de Chiba et de Saitama qui touchent la municipalité de Tokyo et s'étendent entre 200 et 250 kilomètres de la centrale de Fukushima, des contaminations en taches provoquées vraisemblablement par le lessivage du panache des rejets.
Les dépôts ont contaminé gravement les habitations, les terres (qui assurent 20 % de la production nationale de riz) et forêts *à plus de 100 km* de rayon autour de la centrale. Le ministère de l'environnement japonais envisage de procéder à des décontaminations de zones, partout où le débit de dose annuel sera égal ou supérieur à 5mSv/an (la norme internationale pour le public est de 1mSv/an, hors situation accidentelle). Cela concernera plus de 110 000 habitations individuelles, écoles, lieux publics, etc. situés sur 1800 km² dont 70 % sont couverts par une forêt. 29 millions de m³ de terres

[13] Synthèse des informations disponibles sur la contamination radioactive de l'environnement terrestre japonais provoquée par l'accident de Fukushima Dai-ichi, 13 juillet 2011
[14] Synthèse des informations disponibles sur la contamination radioactive de l'environnement terrestre japonais provoquée par l'accident de Fukushima Dai-ichi, 27 septembre 2011
[15] Asahi Shimbun (http://asahi.com/english/TKY201109300393.html)

et débris contaminés seront produits.
Après de successives interdictions de vente de riz contaminé, touchant plus de 4000 exploitants, le Ministère de l'Agriculture a été contraint d'acheter, en décembre 2011, les récoltes des circonscriptions de la préfecture de Fukushima (4000 tonnes de riz contaminées[16] à plus de 100 becquerels par kg).

Rejets en mer

Les rejets importants ont duré jusqu'au 8 avril 2011. Les retombées dans l'océan, d'une partie des radionucléides rejetés dans l'atmosphère lorsque les vents soufflaient en direction du Pacifique n'ont pas contribué significativement à la très forte contamination marine (0,3 % selon l'IRSN).
Les rejets de radionucléides artificiels dans le milieu marin, réalisés en quatre semaines environ, représentent sur une aussi courte période, l'apport le plus important apport jamais observé dans le monde. La contamination provoquée est dominée par l'iode 131 et par les césium 134 et 137, à part égale. A proximité immédiate de la centrale (environ 500m), les concentrations dans l'eau de mer ont atteint fin mars et début avril jusqu'à plusieurs dizaines de milliers de becquerels par litre (kBq/l) pour les césiums 134 et 137 et même dépassé les cent mille Bq/l pour l'iode 131.
En plus de ces trois radionucléides principaux, du césium 136 (T=3,1j) et du tellure 132 (T=3,26j) ont été mesurés. L'estimation des rejets[17] faite par l'IRSN est environ 30 fois supérieure à celle de l'exploitant Tepco.
Compte tenu d'importants mouvements marins dans le Pacifique, qui apportent de l'eau non contaminée, l'activité des césiums mesurée dans l'eau

[16] Dans l'hypothèse d'une incorporation journalière de 1,5kg de nourriture contaminée par du césium 137, les 1mSv/an de la réglementation sont atteints avec une contamination moyenne de 140 becquerels par kg. A cette exposition *interne* va s'ajouter l'inhalation de poussières contaminées et l'exposition *externe* due aux dépôts au sol des césiums 134 et 137. Cette exposition est durable car le césium diffuse peu dans les sols.

[17] L'IRSN a estimé la quantité totale de césium 137 (pratiquement égale à celle du césium 134) rejetée directement en mer du 21 mars jusqu'à mi-juillet. La valeur ainsi obtenue est de 27.10^{15} Bq, la majorité (82 %) ayant été rejetée avant le 8 avril (*Synthèse actualisée des connaissances relatives à l'impact sur le milieu marin des rejets radioactifs du site nucléaire accidenté de Fukushima Dai-ichi* du 11 juillet et du *26 octobre 2011)*

de mer diminue exponentiellement avec une période de 6,9 jours, une donnée importante pour la région qui représentait 20 % de la production nationale des produits de la mer.

Tableau 1 : Comparaison partielle des rejets à Tchernobyl et à Fukushima

Radionucléide	Période	Rejets atmosphériques Tchernobyl (10^{15}Bq)	Rejets atmosphériques Fukushima (10^{15}Bq)	Rejets en mer Fukushima (10^{15}Bq)
Xénon 133	5.3 d	6500	2000*	-
Iode 131	8.0 d	~1760	200	?
Césium 134	2.0 y	~54	30	27
Césium 137	30.0 y	~85	30	27
Tellure 132	78.0 h	~1150	90	?

Sources : Synthèses IRSN et Mise à jour 2002 de *Tchernobyl : Dix ans déjà, (OCDE, 1996)*
* *Estimation de l'activité de l'ensemble des gaz rares*

L'exposition des travailleurs

Dès le 14 mars 2011, le ministre de la santé japonais a porté à 250 millisieverts (mSv) la dose limite pour les intervenants dans la centrale nucléaire sinistrée. Les débits de dose autour des réacteurs accidentés ont vite atteint 500 à 1000 mSv/h, ce qui rendait impossible toute intervention de proximité.

Selon les chiffres publiés par TEPCO, entre le 12 mars et le 30 avril, 565 salariés de la société d'électricité et 3760 employés « d'entreprises partenaires » (sous-traitants ou intérimaires), soit un total de 4325 travailleurs, auraient pris part aux travaux sous rayonnements. Nous ne les retrouvons cependant pas dans les données publiées le 18 juin 2011 qui ne concernent que 3700 intervenants, dont 3514 ont eu un bilan dosimétrique d'exposition interne (cf. tableaux 2 et 3).

Tableau 2 : Doses ***externes*** *reçues par les intervenants sur la centrale de Fukushima*

Dose (millisieverts)	Salariés de Tepco	Entreprises extérieures	Total
Plus de 250	9	0	9
200 à 250	4	4	8
150 à 199	20	6	26
100 à 149	59	22	81
50 à 99	179	109	288
20 à 49	271	352	623
10 à 19	232	523	755
Inférieur à 10	650	1074	1724
Total	1424	2090	3514

Source : TEPCO, Bilan au 20 juin 2011.

Tableau 3 : Doses ***internes*** *reçues par les intervenants sur la centrale de Fukushima*

Dose (millisieverts)	Salariés de Tepco	Entreprises extérieures	Total
Plus de 250	7	0	7*
200 à 250	3	2	5
150 à 199	8	3	11
100 à 149	10	9	19
50 à 99	97	50	147
20 à 49	252	108	360
10 à 19	255	173	428
Inférieur à 10	792	1745	2537
Total	1424	2090	3514

*Dont 2 ont une dose de 643 et 678 mSv due à une contamination interne à l'iode 131
Source : TEPCO, Bilan au 20 juin 2011.

Ces données des tableaux de juin 2011 ne peuvent être sommées (la sommation des doses internes et externes ne peut se faire qu'individu par individu) pour obtenir la distribution des doses totales. Cependant, Tepco précise, pour le 20 juin et le 8 décembre 2011, la distribution relative aux travailleurs qui ont reçu des doses totales (interne + externes) supérieures à 100 mSv (cf. tableau 4).
Nous observons des incohérences probables dans les données de TEPCO relatives à la tranche de doses égales ou supérieures à 200 mSv (les expositions internes plus externes devraient concerner plus de 17 personnes au dessus de 200mSv). On constate que le nombre d'intervenants dans la centrale accidentée a été multiplié par 5 entre le 20 juin et le 8 décembre 2011.

*Tableau 4 : Doses **totales** reçues par les intervenants sur la centrale de Fukushima*

Dose (millisieverts)	Bilan au 8 décembre 2011
Plus de 250	6*
200 à 250	3
100 à 199	160
Nombre total de doses supérieures à 100mSv	169 sur 17671 intervenants

* doses étalées entre 309 mSv et 678 mSv

Sources : TEPCO, Bilans au 20 juin et au 8 décembre 2011.

Les doses les plus élevées[18] concernent un intervenant âgé d'une trentaine d'années (678 mSv), un autre a la quarantaine (643m Sv).

Conclusions provisoires

Dans l'état actuel de nos connaissances, la situation des intervenants japonais ne ressemble pas à celle des 830 000 « liquidators » soviétiques qui ont procédé aux diverses interventions qui suivirent la destruction du réacteur N° 4 de Tchernobyl, avec également une limite de dose théorique de 250

[18] *Fukushima workers' exposure tops 650mSv*, Japan Sunday Times, Friday, June 10, 2011

millisieverts par intervenant. Cependant, des articles soulèvent l'importance du nombre d'intervenants extérieurs sans formation[19] qui interviennent sur le parc japonais et sur le poids de la mafia japonaise (les *yakusas*) dans les recrutements[20] de la main-d'œuvre temporaire.
A Tchernobyl, l'absence de dosimétrie individuelle ou le truquage de ces données, étaient notoires. La décontamination rustique du toit du réacteur N° 3, afin de permettre uniquement l'inavouée poursuite de la production électrique, s'est traduite par des doses individuelles 20 fois supérieures aux limites officielles[21]. Le contrôle des données dosimétriques japonaises semble moins préoccupant.
Cependant les pratiques douteuses de Tepco et de l'agence de sûreté nucléaire japonaise NISA, révélées par la presse japonaise, invitent à rester prudent.
L'évacuation des populations japonaises a été plus rapide que celles conduites autour de la centrale ukrainienne. Cependant, l'absence de mesures prophylactiques vis-à-vis de la contamination thyroïdienne par de l'iode radioactif, devrait conduire dans quelques années au Japon, à une augmentation significative des cancers de la thyroïde, plus particulièrement chez les enfants de moins de 15 ans (forte chez les moins de 4 ans).
Les contrôles de la contamination sont faits au Japon par l'exploitant et les organismes officiels mais aussi les universitaires ont dressé une importante carte de la contamination[22] et des associations japonaises[23] et françaises

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19 GAULENE Mathieu, *Japon: les clochards du nucléaire,* Reuters, 2 avril 2011.

20 Publications du journaliste japonais indépendant, Tomohiko Suzuki, qui s'est fait embaucher à Fukushima. Il signale les disparitions du suivi d'un nombre croissant d'intervenants (69 des intervenants sur le réacteur N° 1 le 20 juin, 198 le 21 juillet, 840 le 15 décembre). Tepco reconnaît cette incapacité à identifier ces manques. Tomohiko Suzuki vient d'éditer un livre intitulé «La pègre et les centrales nucléaires, Journal d'une incursion à Fukushima Daichi». Il a été publié (en japonais) par Bungei Shunju le 15 décembre 2011

21 MOLITOR Marc, TCHERNOBYL, Déni passé, Menace future ?, Editions Racine, avril 2011. Un ouvrage à lire absolument pour comprendre l'importance et la complexité des conséquences humaines, sociales et politiques de cette catastrophe nucléaire.

22 Sur un demi-cercle de rayon 80km, centré sur la centrale de Fukushima, 600 universitaires japonais se sont partagé les analyses de prélèvement de sol effectués dans 2000 secteurs où 5 prélèvements ont été effectués, soit une valeur de contamination du sol par Km².

23 Notamment, le *Citizens' Nuclear Information Center*

comme l'ACRO et la CRII-RAD font et publient librement les résultats de mesure des prélèvements (sols, aliments d'origine terrestre et maritime, produits laitiers, urines d'enfants, poussières d'aspirateurs, etc.).
Sur les 54 réacteurs dont disposaient les 10 exploitants nucléaires japonais (30 BWR et 24 PWR) fin 2010, seuls 2 d'entre eux fonctionnent aujourd'hui. Tepco, avec ses 17 réacteurs, le tiers du parc électronucléaire japonais, est en très mauvaise posture, suite aux indemnités qu'il devra payer aux populations sinistrées et au quart de son parc détruit qu'il faudra démanteler. La population vivant dans l'environnement des centrales s'oppose au redémarrage des réacteurs arrêtés. Deux réacteurs sont en construction, dont un ABWR (OHMA) de 1325 MWe, qui devait être le premier réacteur pouvant utiliser 100 % de MOX. La construction sera-t-elle poursuivie ? Si oui, seront-ils autorisés à diverger ?

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