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Working Party on Decommissioning and Dismantling (WPDD)

Topical Session on the Decommissioning and Dismantling Safety Case

Paris, 5th December 2001

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INTRODUCTION

Set up by the Radioactive Waste Management Committee (RWMC), the WPDD brings together senior representatives of national organisations who have a broad overview of Decommissioning and Dismantling (D&D) issues through their work as regulators, implementers, R&D experts or policy makers. These include representatives from regulatory authorities, industrial decommissioners from the NEA Co-operative Programme on Exchange of Scientific and Technical Information on Nuclear Installation Decommissioning Projects (CPD), and cross-representation from the NEA Committee on Nuclear Regulatory Activities, the Committee on Radiation Protection and Public Health, and the RWMC. The EC is a member of the WPDD and the IAEA also participates. This ensures co-ordination amongst activities in these international programmes. Participation from civil society organisations is considered on a case by case basis, and has already taken place through the active involvement of the Group of Municipalities with Nuclear Installations at the first meeting of the WPDD

At its second meeting, in Paris, 5-7 December 2001, the WPDD held two topical sessions on the D&D Safety Case and on the Management of Materials from D&D, respectively. This report documents the topical session on the safety case.

The topical session was meant to provide an exchange of information and experience on the following issues:

- What topics should be included in a safety case? Of what should it consist?
- Is there sufficient and complete guidance nationally and internationally?
- How do practices differ internationally?

Main boundary condition to this session was that it would deal with plants where spent fuel has been removed. Also the topical sessions was kept at a level that makes the most of the varied constituency of the WPDD. Namely, interface issues are important, and issue-identification and discussion was the immediate goal. There was less interest in examining areas where variability amongst national practices is low, the idea being that it is important to understand differences in approaches.

Frances Taylor, Head of Radioactive Waste Management and Decommissioning Strategy Unit, HM Nuclear Installations Inspectorate, Health and Safety Executive, served as Session Chair. Scott Moore, Section Chief of the Special Projects section, U.S. Nuclear Regulatory Commission, served as the rapporteur for the Topical Session.

Presentations during the topical session covered key aspects of the safety case, including:

- international requirements and guidance,
- environmental impact assessment,
- plant configuration and decommissioning and dismantling (D&D) licensing,
- accident assessment,
- balancing radiological and industrial risk, and
- the safety case for safestore and dormancy periods.

At the end of each presentation time was allotted for discussion of the paper. Integral to the Topical Session was a facilitated plenary discussion on the topical issues identified above. The rapporteur briefly reviewed the main points at the end of the topical session.

The Topical Session is documented as follows. First a summary of the presentations is given along with the questions that were asked of each speaker; then follow a summary of the plenary discussions and the main points made. The extended abstracts or full papers supporting each presentation are given in Appendix 1.

As a follow-on to the Topical Session a Task Group has been constituted in order to propose to the WPDD a more detailed work programme in this area.

Acknowledgements

Special thanks are due to Scott Moore for serving as rapporteur of this Topical Session, for liaising with the other WPDD members, and for providing the Secretariat with the relevant materials of this document.

SUMMARY OF THE PRESENTATIONS

1. IAEA requirements/guidance for the decommissioning safety case
Mike BELL, IAEA

- What are the requirements laid down in international conventions?
- Safety requirement and safety guide documents by the IAEA. What is in them?
- What is the rationale and basis of both requirements and guidance?
- Any feedback of experience?

In the initial topical session presentation, Michael Bell, Head of IAEA’s Waste Technology Section, described IAEA’s safety regime for decommissioning. He discussed the international regulatory framework for decommissioning, including Article 26 in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, IAEA’s Safety Requirements related to decommissioning, IAEA’s Safety Guides on decommissioning of nuclear power plants and research reactors and on decommissioning of nuclear fuel cycle facilities. Michael Bell’s presentation provided WPDD members with information to address the second main question for the topical session: namely, whether there is sufficient and complete international guidance on the D&D safety case. While additional international guidance by the WPDD and other organizations may be needed, the presentation demonstrated that IAEA already has a general framework of decommissioning requirements and guidance

2. Safety case in an EIA context
Patrick O’SULLIVAN, The Netherlands

- What international guidance exists on EIA?
- What topics should be included in an EIA for D&D?
- Of what should the safety case consist?
- Any feedback of experience?

Patrick O’Sullivan, Co-ordinator of the Radioactive Waste and Decommissioning Team at the Nuclear Research and Consultancy Group (NRG) in the Netherlands, gave the second presentation during the topical session, on Environmental Impact Assessment (EIA) in Geological Disposal and Decommissioning. He discussed the European Commission’s (EC’s) EIA study on geologic repositories for radioactive waste, followed by a study on EIA for decommissioning; an EC directive on EIA; the model EIA process and public involvement; an EC directive on strategic environmental assessment; and potential EIA issues for further consideration. Patrick O’Sullivan’s presentation expanded on the information in the preceding IAEA presentation, by addressing international directives and guidance on EIA within the European Commission countries. He provided a conceptual flow diagram that outlined the EIA process specified in the EIA Directive, and he also provided a slide on the steps of the EIA process and the corresponding timeline. Patrick O’Sullivan’s material demonstrated that, at least with respect to EIA within EC States, international guidance and directives exist that already address the environmental safety case. He ended the presentation with potential issues for further consideration, including whether more guidance is needed to decrease diversity on how EIA is performed, and whether a gap exists in the EIA legislation regarding monitoring of environmental impacts.

3. Plant configuration and the D&D licensing process

Eugenio GIL LOPEZ, Spain
Pedro CARBONERAS, Spain

- The plant configuration evolves during D&D. What issues does this lead to? How should this be dealt with in the licensing process? On what basis should judgement be reached?

Eugenio Gil Lopez, Deputy Director for Environmental Radiation Protection at Spain's Consejo de Seguridad Nuclear (CSN), gave a presentation that he and Pedro Carboneras of ENRESA developed, describing plant configuration and the D&D licensing process. Eugenio Gil layed the framework for the presentation by describing the Spanish regulatory framework between the decision-makers (MINECO), the regulator (CSN), and the D&D Operator (ENRESA). He discussed the main licensing milestones in D&D, the licensing basis, and the activities of each organization in the regulatory triangle. Then he tied the licensing activities to the Vandellos I D&D project, by describing the schedule, licensing process, regulatory control, and lessons learnt on the Vandellos I D&D. Finally, Eugenio Gil discussed special topics regarding Vandellos I and Spain's D&D program, including the need for new safety systems during D&D, evolution of technical specifications, how project modifications are solved, safety provisions for dormancy, ALARA policy and programme, and clearance issues. He concluded with a slide on regulation updating, and noted that short term regulatory changes for D&D were introduced in Spain, and long term regulatory changes needed to be considered for a general updating of the D&D regulations, including changes that would address the legal status of land that had been affected by past practices and accidents. Eugenio Gil's presentation addressed the second main question of the Safety Case Topical Session from a national perspective. His conclusion, with respect to Spain, demonstrates that sufficient national standards and guidance exist to address the D&D safety case, but those regulations and guidance could be improved through experience such as that gained at Vandellos I.

4. Accident assessment

Ivo TRIPPUTI, Italy
Ingmar LUND, Sweden

- What accidents should be considered? How wide does one have to go?
- What role is there for probabilistic assessment?
- What assessment tools are available for accident analysis?
- Are there any severe accidents to be reckoned?
- Relationship between safety analysis and emergency plan: when does one need an emergency plan, and when and why can one stop having one?

Ivo Tripputi, Spent Fuel Storage Director at SOGIN in Italy, and Ingemar Lund, Radiation Protection Officer of the Swedish Radiation Protection Institute, gave the fourth presentation of the topical session, on accident assessment in the safety case. Ivo Tripputi began the presentation with a thought-provoking discussion on why and why not the D&D Safety Case should be discussed. That led into a description of the general issues regarding accident analysis in the safety case for nuclear power plants, including: classification and grouping of events, relation between operating plant safety case and D&D, which plant configuration has to be analyzed in the D&D safety case, the role of quality assurance and sustaining the safety culture, emergency planning, and whether to consider very unlikely events. Ingemar Lund continued the presentation by providing an example of the number of falls at the Ringhals NPP, as they related to total number of work accidents, and in doing so, he introduced a topic of considerable discussion later in the day regarding how to balance radiological and non-radiological risks. He provided examples of technical issues regarding accident analysis, such as the technical bases for accident analysis assumptions and the need for computer codes for release and consequence calculations, noting that release characteristics and fire protection risks may be different in D&D from operating plants. Ingemar Lund provided an example of event grouping that included: decommissioning activities, loss of plant support systems, internal events such as criticality or fires, natural external events such as earthquakes and lightning, man-made external events such as explosions and aircraft crashes, and human errors. The presentation by Ivo Tripputi and Ingemar Lund concluded that an effort for a comprehensive D&D safety assessment is justified, and that the experience from other decommissioning projects and large-scale industrial activities is essential. They also observed that an effort for better international harmonization of the approaches is useful. Their presentation laid a strong foundation for accident analysis as part of the safety case, and addressed the first main question of the topical session (i.e., what topics should be included in a safety case). Their description of how a D&D plant's safety case differs from an operating plant's, with respect to accident analysis, raised key points for this topical session, and they set the stage for the following presentation on balancing radiological and non-radiological risk.

5. Balancing radiological and industrial risk in the safety case

Pascal DEBOODT, Belgium

- Criteria and approaches to managing this balance
- [One of the principles which have to be carried out in the field of radiological protection is the ALARA principle. Based on more than 10 years of practice and taking into account the recent trends in the regulations as far as the Safety on the Workplaces is concerned, this presentation stresses the need for a global approach to the Safety of workers. Some examples, dealing with the decommissioning project of the BR3 reactor will be given.]

Pascal Deboodt, Health Physics and Safety Department at Belgium's Nuclear Research Centre (CEN/SCK), gave the fifth presentation of the Safety Case Topical Session, on management of radiological and non-radiological risks in a decommissioning project. He provided the background for the presentation by introducing the Belgian Nuclear Research Centre and its programmes, describing the history of the Belgian Reactor 3 (BR3), and explaining the dual safety and health roles of CEN/SCK's Health Physics and Safety Department. His presentation centered around a non-radiological technical problem encountered in the BR3 D&D, involving removal of asbestos. Pascal Deboodt explained how SCK/CEN approached the BR3 asbestos problem, including performing a risk analysis, and he gave measures of the main technical and safety related results of the asbestos removal action. He described the lessons learned on the asbestos removal, such as that communications was of major importance, commitment was needed at each level among the stakeholders, and that support was important between the radiological and non-radiological partners on the project. He raised several questions for the WPDD to consider about this example, such has how we optimise non-radiological situations, how far we optimise them, and what optimisation means in such situations, and he described the recommendations of the 4th Workshop of the European ALARA Network. Pascal Deboodt concluded by noting that in his own job, he must deal with both radiological and non-radiological risks; that optimisation is a first and necessary step to be extended to both types of risks; and that we should consider giving more attention to the justification principle. His presentation prompted comments among the WPDD participants about the importance of balancing radiological and non-radiological risks, and how non-radiological risks often go unaddressed while significant resources and effort are put into mitigating lower radiological risks.

6. The safety case for safestore and dormancy periods
Paul WOOLLAM, UK

- Elements
- Criteria for judgements
- Monitoring requirements
- Role of stakeholders
- Security / intrusion

Paul Woollam, Head of Decommissioning and Liabilities at BNFL Magnox Electric in the United Kingdom (UK), gave the final presentation of the topical session, on the Safety Case for Safestore. He started with an overview on magnox reactors in the UK, and described BNFL's decommissioning policy and strategy. This led to a thorough discussion of the safety case for safestore, including comments on the scope of the safestore safety case, basic principles, radioactive inventory, facility design for safestore, hazard identification, and human intrusion. Once he had described the basic principles, he addressed the short-term safety case during a decommissioning deferral period, and changes with respect to a long-term safety case. He gave information on inspection and monitoring regimes for the short-term case, monitoring conditions, radioactive environmental monitoring, and civil structure inspections. He noted that in the long-term safety case, radioactive decay reduces the source term, but that increased physical and chemical degradation and increased risk of human intrusion must be addressed. He also raised questions about the robustness of safety management systems during safestore if companies, organizations, or governments fail in their responsibilities under a long-term safety case, but concluded from dose and risk results that the risks to the public are negligible even if the safety management system fails. He concluded that a rolling, 25-year basic safety case for safestore can be developed, with a defined inspection and monitoring regime and ongoing safety management, but that potential changes should be identified to make a 100-year safety case. In summary, Paul Woollam's presentation provided a detailed overview of the safety case for short-term safestore, and addressed changes in the safety case regarding long-term safestore.

SUMMARY OF DISCUSSIONS

Following the six presentations, the WPDD members discussed the safety case in an open discussion led by the Topical Session Chair, Frances Taylor. The discussion was wide-ranging, and topics varied from the standards that apply to releases to the environment during safestore, to decommissioning parallels with other major processing industries and facilities (such as oil rigs). Frances Taylor steered the discussion toward addressing the questions that the WPDD Core Group had proposed for the topical session.

The Chair, the Rapporteur, and some members of the group sensed that the presentations had covered such an wide variety of issues, and that the content of the presentations themselves differed so greatly, that it would be difficult to distill a position paper from the information gathered, as had been the mandate from the Core Group. In addition, the meaning of the term "Safety Case" differed greatly among participants in the topical session. Some took the term to mean the analysis and document that the implementor provides to the regulator, describing how operations will be performed safely. Others considered the term to mean the overall safety and risk conditions inherent in a nuclear facility during operations or decommissioning. With the differences in presentations and with the meaning of the terminology remaining unclear, the WPDD participants did not reach consensus conclusions on December 5, 2001, during the Safety Case Topical Session. However, in examining the presentations, several common themes appear to have emerged from the Topical Session:

1. **What topics should be included in a safety case? Of what should the safety case consist?**

   - A dominant theme emerging from the presentations was that the safety case (or the safety assessment) for D&D is different from the safety case for plant operations, and so the D&D safety case (or safety assessment) should be established separately. Stated more succinctly, the safety case for plant operations at a NPP may not be appropriate for D&D, and a separate safety case for D&D is justified. For example, from Ivo Tripputi's and Ingemar Lund's presentations, facilities in D&D may need their own accident analysis, so that should be taken into account in the D&D safety case.

   - Nobody in the presentations or discussions argued for omission of specific topics from the D&D safety case. Instead, presenters seemed to encourage inclusion (vs. exclusion) of topics. It was apparent that the topics addressed in the presentations should be included in the D&D safety case (e.g., EIA, plant systems and configuration, accident assessment, radiological and non-radiological risks, ALARA), but safety cases should not be constrained to cover just these topics. Other topics may also be appropriate.

   - Further discussion by WPDD or a task group on the Safety Case Topical Session may be needed to address the topics that should be included in the D&D Safety Case.

   - From Pascal Deboodt's conclusions, it appears that significant non-radiological risks should be addressed in the D&D safety case, especially if/when they outweigh some radiological risks.

- From Patrick O'Sullivan's presentation, environmental assessment must be addressed as part of the D&D process, and it is required in some countries. The D&D safety case is one possible mechanism for addressing and assessing environmental impacts.

- Based on Eugenio Gil's and Paul Woollam's presentations about NPPs conducting different approaches to decommissioning, the D&D safety case appears to be situationally-dependent and time-dependent. The safety case for a plant undergoing traditional D&D may differ from the safety case for a plant going into safestore. Safety cases for different sites and different decommissioning processes (e.g., dismantling, safestore) may be similar, and some topics within the safety cases may be applicable to multiple facilities at different times, but D&D safety cases should be developed on case-by-case, site-specific bases.

- With regard to the terminology, it may be helpful to distinguish between the safety case and safety (and environmental) assessments. The safety case could apply to a nuclear facility throughout its lifecycle, and could be updated as the relevant hazards, and how they are managed, change. In this context, the safety and environmental assessments are key inputs to the safety case. Safety and environmental assessments related to decommissioning should be undertaken at an appropriate level of detail depending on the stage in the facility's lifecycle.

- The Safety Case Task Group should consider and address the meaning of the term "safety case". The Safety Case Task Group should also consider addressing how the safety case is communicated to different audiences and to what extent the safety case should incorporate the environmental assessment.

2. **Is there sufficient and complete guidance nationally and internationally?**

- Michael Bell's and Patrick O'Sullivan's presentations indicated that, internationally, a general framework of decommissioning requirements and guidance exists and that specific international guidance covering the decommissioning safety case is being developed. In addition, most of the presentations and resulting discussion mentioned national regulatory oversight (in Belgium, Spain, UK, Italy, Sweden, and the Netherlands), implying that national requirements may already exist for the decommissioning safety case in some countries. However, since some countries may rely on guidance related to facility operation, rather than decommissioning, the Safety Case Task Group should consider addressing the need for national guidance on the decommissioning safety case.

- While national and international guidance and requirements exist, they may be insufficient or incomplete. For example, Patrick O'Sullivan indicated that a gap may exist in EIA legislation regarding environmental impact monitoring. Eugenio Gil noted that D&D regulations and guidance could be improved based on lessons learned at Vandellos I. Ingemar Lund's discussion of falls at Ringhals NPP, and Pascal Deboodt's discussion of non-radiological risks may imply the need for guidance on risk balancing and optimisation among radiological and non-radiological risks.

- While it appears that existing national and international guidance exists for the decommissioning safety case, as more D&D experience is gained and lessons are learned over time, that guidance may need improvements. (For example, see Eugenio Gil's comments on regulation updating.)

– Guidance on building the safety case for operating plants is not likely to address the specific needs for a decommissioning safety case. Because decommissioning safety cases are different, they probably need their own guidance rather than relying on the guidance for operating plants.

3. How do practices differ internationally?

– The presenters described the decommissioning practices in their own countries, and generally did not compare and contrast those practices with other countries. However, it appeared that some of the specific decommissioning practices differed based on what is allowed in the country's regulations. For instance, rubblization of concrete and clearance-related issues appear to have been resolved in some EC countries, while they remain open regulatory issues in other countries. D&D practices and approaches differ on a site-by-site basis, as well, based on the presentations (e.g., safestore at the magnox reactors versus dismantling at Vandellos I).

– While international practices toward decommissioning and the D&D safety case appear to differ, there appears to be a healthy exchange of knowledge between countries and organizations, through venues such as the WPDD, IAEA, and the European ALARA Network.

APPENDIX I: PAPERS AND EXTENDED ABSTRACTS

The IAEA Safety Regime for Decommissioning

M. J. Bell
International Atomic Energy Agency, Vienna, Austria

Abstract

The International Atomic Energy Agency is developing an international framework for decommissioning of nuclear facilities that consists of the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, and a hierarchy of Safety Standards applicable to decommissioning. The Joint Convention entered into force on 18 June 2001 and as of December 2001 had been ratified by 27 IAEA Member States. The Joint Convention contains a number of articles dealing with planning for, financing, staffing and record keeping for decommissioning. The Joint Convention requires Contracting Parties to apply the same operational radiation protection criteria, discharge limits and criteria for controlling unplanned releases during decommissioning that are applied during operations.

The IAEA has issued Safety Requirements document and three Safety Guides applicable to decommissioning of facilities. The Safety Requirements document, WS-R-2, Predisposal Management of Radioactive Waste, including Decommissioning, contains requirements applicable to regulatory control, planning and funding, management of radioactive waste, quality assurance, and environmental and safety assessment of the decommissioning process.

The three Safety Guides are WS-G-2.1, Decommissioning of Nuclear Power Plants and Research Reactors, WS-G-2.2, Decommissioning of Medical, Industrial and Research Facilities, an WS-G-2.4, Decommissioning of Nuclear Fuel Cycle Facilities. They contain guidance on how to meet the requirements of WS-R-2 applicable to decommissioning of specific types of facilities. These Standards contain only general requirements and guidance relative to safety assessment and do not contain details regarding the content of the safety case. More detailed guidance will be published in future Safety Reports currently in preparation within the Waste Safety Section of the IAEA.

Because much material arising during the decommissioning of nuclear facilities may be only slightly contaminated with radioactivity, an important matter for decommissioning of facilities is the level of contamination, which may be released from regulatory control. This issue is being addressed in a Safety Guide being prepared by the IAEA dealing with the Scope of Regulatory Control. This Safety Guide will attempt to rationalise levels of radioactivity subject to exclusion, exemption, discharge, recycle, contained in commodities, and released from regulatory control, taking into consideration levels of radioactivity in naturally occurring radioactive materials. This Safety Guide is scheduled to be completed late in 2002 or in 2003.

The IAEA is organizing, in co-operation with the Bundesamt für Strahlenschutz, an International Conference on Safe Decommissioning for Nuclear Activities. The Conference will take place 14 to 18 October 2002 in Berlin, Germany.

Environmental Impact Assessment in Geological Disposal and in Decommissioning

P.J. O'sullivan
Nuclear Research And Consultancy Group (Nrg), The Netherlands

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This note is based upon a report prepared under contract with the European Commission, DG-Energy and Transport, that formed the basis for discussions at the "Club of Agencies" meeting at Oskarshamn, Sweden, on 22-24 October 2001. The author is grateful to the Commission's services for the permission to present the information also to the NEA WPDD meeting in Paris on 5 December 2001.

The note discusses the results of two major studies undertaken for the European Commission (DG-Environment) on the application of environmental impact assessment to the development consent process for the following projects in the nuclear field: (1) geological repositories and long-term storage facilities; (2) (and of especial relevance in the context of this meeting) the decommissioning of nuclear power plants.

The first study[1] was undertaken during 1998 and the first half of 1999 by the following consortium of companies: Nirex (UK), University of Wales Aberystwyth (UK), ENRESA (Spain), SKB (Sweden) and ONDRAF/NIRAS (Belgium). The second study[2] was undertaken during 2000 and the first quarter of 2001, by the European Economic Interest Grouping Cassiopee, together with the University of Wales Aberystwyth, ECA Global (Spain). Both studies were managed by Nirex.

1. INTRODUCTION

The European Council Directive 97/11/EC[3] of 3 March 1997 reinforced existing requirements[4] on Member States to undertake an EIA for a wide range of projects with the potential to impact the environment, including:

- nuclear power stations (both for initial construction and for their eventual decommissioning)
- repositories designed for permanent disposal of radioactive waste; and
- off-site facilities for the long-term storage of radioactive waste.

Other installations designed for the processing or storage of waste may also be subject to EIA, at the discretion of individual Member States. An unofficial consolidation of the two Directives is given in the

1 *Environmental Impact Assessment and Geological Repositories,* Report EUR 19152, October 1999. (see also 'http://europa.eu.int/comm/energy/en/nuclearsafety/reports.htm'.

2 *Environmental Impact Assessment for Decommissioning Nuclear Power Plants*, (to be published shortly in the EUR Report series, including in pdf format at 'http://europa.eu.int/comm/energy/en/nuclearsafety/reports.htm'.

3 Official Journal No. L 174/40 of 5/7/85

4 In Council Directive 85/337/EEC of 27 June 1985

appendix to this report (see also 'http://europa.eu.int/comm/environment/eia/full-legal-text/9711_consolidated.pdf'). The EIA process as set out in the amended Directive is shown on Figure 1 below.

Member States were required to incorporate the Directive requirements into domestic legislation by March 1999. In addition, those countries applying to become members of the European Union (EU), must ensure that the requirements are reflected in domestic legislation as part of the accession process.

The Council Directives set out the broad principles of the environmental assessment system, leaving the procedural details to the Member States. Aspects over which there is discretion include:

(1) although an EIA must be undertaken before development consent is granted and the results taken into account in the consent procedure, the precise role of the EIA in the decision process is not defined

(2) the Directive is not specific about which impacts to the environment and to human beings should be taken into account (e.g. socio-economic impacts need not be included), though in practice most Member States include a very wide range of impacts.

(3) requirements for the involvement of the public in the assessment process are not specified, beyond a requirement that the public concerned are given reasonable opportunity to provide views before consent is granted.

(4) the Directive is concerned with the assessment of impacts, taking account of measures envisaged to avoid or mitigate adverse effects. It does not include requirements as to the arrangements for enforcing these measures; and

(5) the role of the competent authority in reviewing the adequacy of the EIS (Environmental Impact Statement) is not addressed.

Against the above background the Commission[5] was concerned about the possibility of there being significant variations in how the Directives were implemented in different Member States, particularly as regards how much information on the environment should be collected, analysed and presented to the authorities and the public. There was therefore the possibility of different financial burdens being placed on those responsible for undertaking an EIA in different Member States and the risk that the completeness and hence validity of assessments could be called into question.

To address the above concern both studies were required to include a comprehensive review of the legal framework in the Member States and in the applicant countries, particularly in the context of the role, scope and definition of EIA requirements for the relevant facilities. As a corollary to this the studies were also required to consider how the requirements were being implemented in practice. In order to illustrate the potential benefits of greater harmonisation of approaches it was suggested that that the studies include a 'model' EIA based on best practice considerations.

The Commission also noted that the EIA process could be a useful tool for communication with the public. The studies were required to consider how the role of the public, non-governmental organisations and consumer groups in the process could be enhanced.

[5] At that time radioactive waste and decommissioning was the responsibility of Directorate General Environment. This responsibility has since been transferred to Directorate General Energy and Transport (DG TREN).

2. APPLICATION AND SCOPE OF EIA

In terms of the legal frameworks in the Member States and in candidate countries the studies found that, with few exceptions, the legal frameworks already reflected the key requirements of the amended Directive. By autumn 1998 most Member States had begun the process of fully transposing the amended Directive into national legislation. But, as mentioned earlier, the Directive allows significant discretion to Member States on aspects of implementing the general requirements and it is clear that a variety of approaches are being taken as regards these aspects, as discussed below.

2.1 Role of EIA in the consent process

The Directive requirement is that, in effect, the Environmental Impact Statement (EIS) should be made available to the public and that the public is given an opportunity to express an opinion before a development is initiated. In some States this is interpreted to mean that the EIS addresses the short-term implications for the physical environment of the 'development phase' of the project and is therefore one of a package of documents provided by a developer to the authority responsible for deciding the consent application. Other considerations, such as the long-term implications of the project for human health and safety are addressed in other documents that may have a higher profile in the decision process.

In other States the EIS is used to draw together all the main arguments supporting the consent application, with (for example) safety reports being subsidiary documents. This approach normally also involves greater involvement of the public in the EIA process, as it enables a unified approach to be taken to the full range of public concerns – environmental, safety and socio-economic. This latter approach was favoured in the two studies and it was suggested that the EIS could be presented as a hierarchical document with progressively more detailed information at lower levels of the hierarchy. The implications for the process of public involvement is discussed further below.

2.2 Which impacts should be assessed?

The amended Directive (Article 3) requires that the environmental impact assessment shall

'identify, describe and assess in an appropriate manner … the direct and indirect effects of a project on the following factors:

- *human beings, fauna and flora;*
- *soil, water, air, climate and the landscape;*
- *material assets and the cultural heritage;*
- *the interaction between the factors mentioned in the first, second and third indents.'*

An environmental impact assessment for any nuclear installation will differ substantially from an assessment for a non-nuclear facility due to the nature of the hazard presented by the presence of radioactivity. Where the installation includes facilities for long-term storage or disposal of radioactive waste the potential impact will last significantly beyond the operational period of the plant. In all the countries surveyed it was intended that an environmental impact assessment for the development (and decommissioning) of a nuclear installation should address the potential short-term and long-term effects of radioactivity on the environment and on human beings.

In most (though not all) countries it was also intended that the assessment would not be restricted to physical impacts on the natural and built environment and on human beings: that is, social, economic and health effects would also be considered. Potential social impacts will include effects on population demographics, social structure, and community image and cohesion. Potential economic impacts include effects on community services, employment, housing and business development. Potential impacts on community health may include psycho-social effects. This latter approach is compatible with the methodology for environmental impact assessment adopted in the United States, Canada and Australia.

2.3 Requirements for involvement of the public

The greatest diversity of approaches to environmental assessment concerned the issue of public involvement. The Directive requires (Article 6(2)) that:

> *'Member States shall ensure that any request for development consent and any information gathered pursuant to Article 5 are made available to the public within a reasonable time, in order to give the public concerned the opportunity to express an opinion before the development consent is granted.'*

In many countries this is interpreted to mean that there should be a public notice announcing the existence of an Environmental Impact Statement and inviting comments to be sent to the competent authority for its consideration. In some other countries, notably the Nordic States, the public is generally given the opportunity at an earlier stage of the assessment. For example, the environmental impact assessment process for a geological repository in Finland included publication of an 'EIA programme' report which outlined the impacts that were planned to be assessed and invited comments on these.

In January 2001 the Commission adopted a proposal[6] to seek modifications to the EIA Directive in order to bring the requirements into line with the Aarhus Convention[7], which has already been signed by most Member States and accession countries. The intention is to modify the existing text such that Member States are required to:

> *'take the necessary measures to ensure that the public concerned are given early and effective opportunities to participate in the development consent procedure'.*

The revised Directive will indicate the minimum requirements such as providing copies of the main reports and advice issued to the competent authority during the development consent procedure. The 'public concerned' is taken to include anyone affected by or having an interest in the development consent procedure, including NGOs promoting environmental protection.

It may be expected that, following the adoption of the revised Directive, there will be a general move towards developing mechanisms for earlier public involvement in the assessment process including a more structured approach to the scoping phase of the assessment. For example, this could involve the publication of a scoping report setting out the impacts intended to be assessed, such that the main assessment could take account of responses to the scoping report. This aspect is discussed later in this report.

2.4 Mitigation of impacts and choice of alternatives

The Directive includes a requirement (in Article 5(3)) that:

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6 Proposal for a Directive … providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending Council Directive 85/337/EEC and 96/61/EC, COM (2000) 839 ('http://www.europa.eu.int/comm/environment/eia/eia-legalcontext.htm'). .

7 *Convention on Access to Information, Public Participation in Decision-making and Access to Justice on Environmental Matters*; United Nations Economic Commission for Europe (UNECE); (See 'http://www.unece.org/env/pp/'.)

'The information to be provided by the developer … shall include at least:

- …
- a description of the measures envisaged to avoid, reduce and, if possible, remedy significant adverse effects
- *an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects*
- *a non technical summary …'.*

As regards mitigation measures, the Directive does not include requirements relating to how these are implemented in the event of development consent being granted, i.e. the Directive is concerned with the development consent phase of a project. The studies suggest that a monitoring plan should be developed as part of the EIS, to show how the residual impacts identified will be tracked and to ensure that the proposed mitigation measures are working adequately. If unexpected impacts do arise, this would give an opportunity to take remedial action. The mechanisms for ensuring that remedial action is taken are outside the scope of the Directive.

Prior to 1997 the EIS was only required to include information about alternatives to the proposal for which consent is being sought *'where appropriate'*. This caveat was removed by the amending directive in 1997, the practical implication being to make it obligatory for a developer to study alternative options to that being proposed in the application for development consent, unless there clearly are no real alternatives. The EIA process must therefore be integrated closely into the process of selection of a preferred decommissioning strategy (in the case of applications for consent to proceed with decommissioning of nuclear power stations). Some countries may choose to address the latter issue by means of a process of strategic environmental assessment prior to station shutdown. The EC Directive[8] on environmental assessment of plans and programmes is discussed later in this paper.

The studies found that a difference of approach between Member States and applicant countries in the context of alternatives, with the requirement to integrate the EIA process with the selection of alternatives being more generally accepted in Member States.

2.5 Role of the competent authority

In terms of the EIA Directive the competent authority or authorities are those designated by Member States as being responsible for determining applications for development consent for projects within the scope of the Directive. There is no strict requirement that the authority should review the completeness of the EIS or the technical adequacy of the EIA process, though it is implicit that, were insufficient information presented on the impacts from the project, more detail should be sought from the developer.

Following the grant of consent to proceed with decommissioning of nuclear installations the ongoing supervision by the project, in all countries surveyed, is thenceforth undertaken by the nuclear safety and/or environmental authorities.

8 Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment, Official Journal L197, 21 July 2001.

3. A MODEL EIA PROCESS

An important part of the second study (on EIA for decommissioning of nuclear power plants) was the development of a suggested methodology for the overall EIA process. This is reproduced in Figure 2 below. Although developed in the context of decommissioning projects the methodology is generally applicable to projects in the nuclear field.

The process can be broken down into four main phases. The initial phase involves the identification of stakeholders, and then (through consultation with key stakeholders) the development of decision-making procedures and the identification of technically feasible alternatives. The second phase involves a preliminary assessment (scoping) of the feasible alternatives with the aim of arriving at a preferred alternative or alternatives for detailed assessment. At the end of this phase it is suggested that a ‘scoping report’ be prepared for public discussion.

The third phase involves the environmental impact evaluation for the preferred alternatives. This involves the determination of baseline information, prediction of impacts and assessment of their significance, the identification of mitigation measures and the development of a monitoring plan to enable actual impacts to be measured and controlled in due course.

The fourth phase involves the preparation of the EIS and the review process overseen by the competent authority. This could involve the preparation of a draft EIS (as in the United States) which is then subsequently revised to take account of public comments. Where a consultation phase (about the terms of reference for the impact assessment) is included this latter step will not normally be necessary.

The model process proposed in the study addresses directly the requirement in the Aarhus Convention that the public is given early and effective opportunities to participate in the development consent procedure. The incorporation of a structured approach to scoping the impacts to be assessed is particularly important in this respect. The proposal involves continuous interaction with an identified group of stakeholders with wider opportunities for public involvement prior to the detailed assessment and during the review of the EIS.

4. THE ‘STRATEGIC ENVIRONMENTAL ASSESSMENT’ DIRECTIVE

Directive 2001/42/EC[9] on the assessment of the effects of certain plans and programmes on the environment has been in force since June 2001. The Directive should be transposed into domestic legislation in the Member States before 21 July 2004. It establishes similar requirements for plans and programmes to those established by the EIA Directive for ‘projects’ and is concerned particularly with plans and programmes which set a framework for future development consent of projects listed in Annex I and II of the EIA Directive.

For the purposes of the Directive ‘plans and programmes’ are those:

‘- which are subject to preparation and/or adoption by an authority at national, regional or local level or which are prepared by an authority for adoption, through a legislative procedure by Parliament or Government, and

which are required by legislative, regulatory or administrative provisions.’ (Article 2)

[9] Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment, Official Journal L197, 21 July 2001.

The above definition appears to limit the strict requirement to apply the Directive in the context of radioactive waste management to waste management plans developed by national or regional government, providing these plans establish a framework within which specific waste management projects are proposed. The development of government policy on waste management (as opposed to more detailed plans or programmes) is outside the scope of the Directive. That is, a plan produced by government identifying areas where certain types of waste management facilities will be based may come within the scope of the Directive, if the need for such a plan is required by law. On the same basis, a policy statement that certain strategies will be followed for the management of certain waste types would appear to be outside the scope of the Directive.

Regardless of the precise legal requirement (which will differ according to the legal framework in individual countries) the Directive offers a mechanism for consultation with stakeholders on issues that may be better addressed before a site selection process is commenced. In principle, the approach is similar to that required by the EIA Directive, in so far as an environmental report is prepared in which the likely significant effects on the environment, and of reasonable alternatives to the proposed plan or programme, are identified, described and evaluated. The public is given an early opportunity to comment on the draft plan/programme before it is adopted. The Directive also envisages consultations with neighbouring States when there are potential transboundary issues, as does the EIA Directive. In this respect the Directive takes account of the requirements of the Espoo Convention[10].

When the relevant authority makes a decision a statement summarising the results of consultations, together with the reasons for choosing the plan or programme as adopted in the light of the other alternatives is circulated. It is also a requirement that measures for monitoring significant environmental effects are described and, subsequently, that these effects are monitored by Member States.

5. POTENTIAL ISSUES FOR FURTHER CONSIDERATION BY THE COMMISSION

The issues that may be appropriate for further consideration by DG TREN in the light of the two studies are discussed below in the context of policy considerations and technical considerations.

5.1 Policy considerations

Role of EIA in site selection/decommissioning including selection of alternatives

An impact of the Aarhus Convention will be to strengthen the requirements of the EIA Directive in terms of a need for the public to be given early and effective opportunities to participate in the development consent procedure (as discussed above). A key aspect of this is the role of the EIA/SEA process in the selection of alternatives, whether that is the selection of repository sites, or for strategies for decommissioning or for management of waste. This suggests the need for a formalised approach to the scoping phase of the assessment. Guidance from the Commission on these aspects, taking account of the implications and different legal and cultural frameworks in Member States and applicant countries, should be considered.

Responsibilities of participants in the EIA process

There is currently a lack of clarity on the role of different participants in the EIA process as described in the Directive, particularly at review stages. Indeed the competent authority for the decision on

[10] United Nations Economic Commission for Europe, Convention on Environmental Impact Assessment in a Transboundary Context (see 'http://www.unece..org/env/eia').

development consent is not explicitly responsible for reviewing the EIS either as regards technical content or procedural approaches, nor are there any specific requirements for review by others. Although, in practice, shortcomings may come to light during the general review process, it would be helpful to have more specific guidance on this issue, particularly to encourage the development of common approaches to procedural aspects of EIS preparation and review in all Member States.

Requirements for monitoring environmental impacts

In contrast to the SEA Directive, there are no requirements in the EIA Directive for monitoring actual impacts on the environment. The former does explicitly require Member States to monitor the environmental effects of the implementation of plans and programmes, in order that remedial action can be taken at an early stage in the event of adverse effects. It may be appropriate for further consideration to be given to this aspect by the Commission, including relevant responsibilities.

Extent of information in Environmental Impact Statements

Although it may be counter-productive to attempt to specify in detail the information requirements in an EIS (given that this is an objective of the scoping process) it would be beneficial to establish some basic ground rules. The study reports noted that there is currently a significant amount of duplication of information requirements in the context of the EIA Directive, the information required to be sent to the Commission under Article 37 of the Euratom Treaty, and the requirements national safety and environmental legislation. It was suggested that a hierarchical approach to presenting an EIS might be helpful in this respect. Advice on the possibilities for rationalisation of these information requirements would be helpful.

Public involvement

As with the level of information in an EIS it is not likely to be helpful to offer prescriptive advice on approaches to involving the public in the EIA process. Nonetheless, guidance on basic aspects such as how documentation can be made available to public would be helpful, especially for those countries where the public has not previously been involved in development consent procedures to any significant extent.

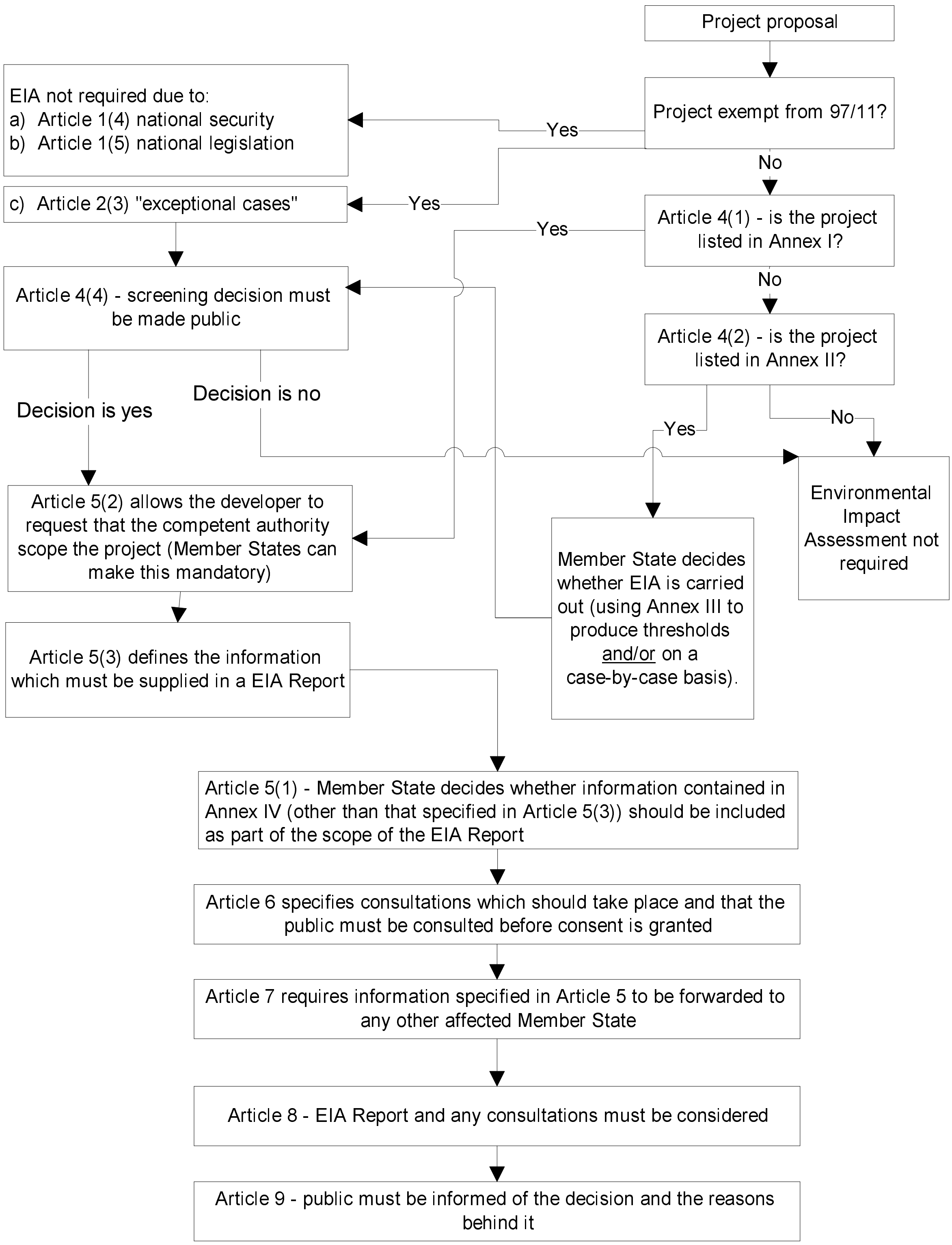


Figure 1. The EIA process specified in the EIA Directive

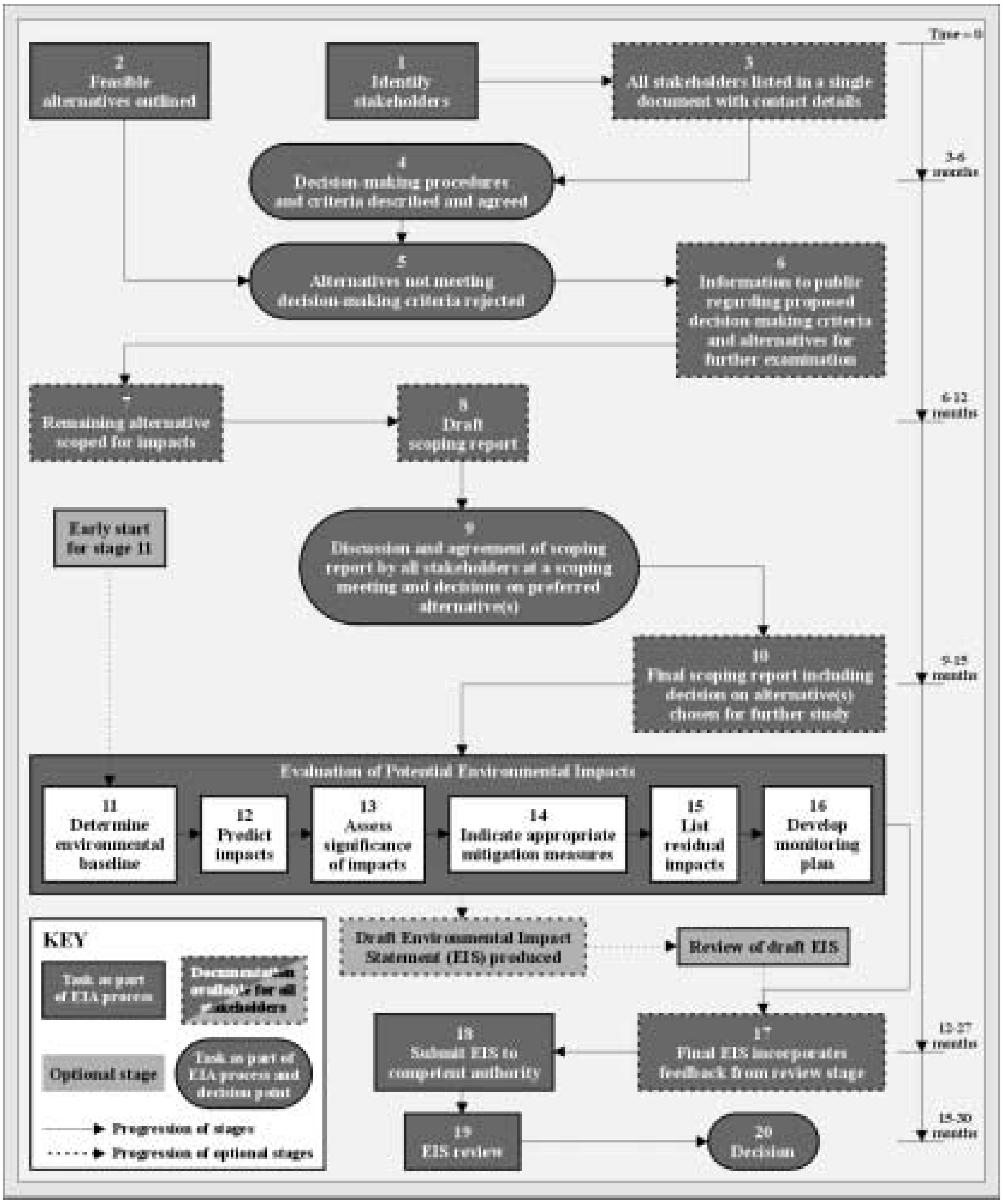


Figure 2. The steps of the EIA process

Plant configuration and the D&D licensing process

Eugenio Gil, Consejo de Seguridad Nuclear, Spain
Pedro Carboneras, ENRESA, Spain

Objective

This paper deals primarily with the decommissioning after termination of normal operations and planned final shutdown. However, most provisions also apply to decommissioning after an abnormal event that has resulted in serious damage or contamination at a facility.

Scope

Decommissioning refers to administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a nuclear facility. These actions involve decontamination, dismantling and removal or radioactive materials, waste, components and structures. They are carried out to achieve a progressive and systematic reduction in radiological hazards and are undertaken on the basis of preplanning and assessment, in order to ensure safety during decommissioning operation.

A facility may be considered decommissioned when an approved end state has been reached. Subject to national legal and regulatory requirements, this may encompass situations such as:

- Incorporation into a new or existing facility; and
- Partial or full dismantlement with or without restrictions on further use.

Commissioning vs D&D

There are many factors that have to be addressed to ensure the safety of nuclear installations (reactors) during the operational phase. Some of those factors will continue to apply during decommissioning, but decommissioning gives rise to issues that are in some respects different from those prevailing during the operation of the installation. These issues need to be considered in an appropriate way to assure overall safety during decommissioning.
There are three important considerations to define the basic criteria and conditions to achieve safe decommissioning.

- Whether the spent fuel has been fully removed from the site.
- The inherent need to progressively remove from service safety systems and destroy confinement barriers.
- The progressive reduction of the existing radioactive inventory and its characteristics and the associated changes on the remaining radiological risk.

As far as spent fuel is retained at the site, specific safety concerns remain. Consequently, many of the nuclear safety principles, objectives and criteria applicable during operation shall remain in force.

When spent fuel has been fully removed from the site, the safety concerns change qualitatively into a situation of almost purely radiation protection. Along the decommissioning process, the radioactive inventory will not only decrease, but also will consist of a progressively greater fraction of non-dispersible materials. At the same time, the remaining operative safety systems will have to be progressively taken out of service and the confinement barriers be destroyed, all this causing a continuous variation in the residual radiological risk to workers, public and the environment.

Non-radiological hazards can also arise during decommissioning activities. It is important that they be given due consideration during the planning process, in the risk analysis and along the execution period.

Safety Principles

The safety and radiological principles, objectives and criteria applicable to decommissioning, although defined as one single set, will have to be applied accordingly with the level of hazard and risk remaining at each moment. Potentially a limited and well-defined set of steps having successively lower requirement could be defined, to better help define the practical application of the safety principles, objectives and criteria. This situation shall be duly considered in the safety and environmental impact analysis as well as properly incorporated in the licensing documents.

- Decommissioning shall be performed in a manner that protects human health and the environment, now and in the future, without imposing undue burdens on future generations.
- Consideration shall be given to the protection of workers and the public and to the protection of the environment. Protection shall also be provided, when applicable, beyond national borders.
- These considerations shall include radiological and non-radiological hazards, including conventional health and safety aspects, and the potential impact and burdens on future generations from delayed decommissioning.
- National radiation protection requirements shall be established with due regard to the international recommendations and practices. In addition to provision for protection against the normal exposures, provisions shall also be made for protection against potential exposures, including the managerial and technical measures to prevent the occurrence of incidents or accidents and the provisions for mitigating their consequences.
- Requirements for environmental protection shall be established by the regulatory body, taking into consideration the potential environmental impacts that can reasonably be expected.
- A "safety culture" shall be fostered and maintained in both, the operating organization and the regulatory body, in order to encourage a questioning and learning attitude to protection and safety and to discourage complacency. Such a culture is particularly important for decommissioning activities, in which new radiological and non-radiological hazards may arise, for example, owing to the removal of safety systems and barriers. This includes the regular audit and review of performance.
- Responsibilities for safety shall be clearly allocated at all times, during the decommissioning process of a nuclear facility. The established legal framework shall contain provisions to ensure that there is clear and unequivocal allocation of responsibility for safety. The continuity of responsibility for safety shall be ensured by regulatory control, e.g. by a license or a sequence of licenses, according to the national legal framework.
- The management of radioactive residual materials is a key component in the decommissioning of nuclear facilities.

Implementation

The implementation of a national policy of dismantling, decommissioning and post-closure institutional closure should be enfaced from three perspectives:

- Allocations of responsibilities of policy makers, regulators, operators and stakeholders
- Definition and execution of strategies, plans and specific projects
- Control of safety taking into account actual risk associate with different phases of a D&D project

A. In allocating responsibilities following considerations should be taken into account:

The Policy Makers responsibilities are basically the same as usually they have assigned in relation to radioactive waste management. These responsibilities include establishing a legal framework defining responsibilities, financial resources, etc., to define national strategies, to assure that a appropriate Radioactive Waste System is available to facilitate D&D activities, to optimize of national resources, etc.

The Regulatory Body responsibilities are similar to other regulatory activities, however, regulatory actions should pay special attention to the risk evolution in the D&D projects. In this sense, the Regulatory Body should:

- Establish safety criteria for the decommissioning of nuclear facilities, including conditions on the end-points as well as conditions to manage safely the radioactive waste generated.
- Establish limits and conditions for the removal of controls from materials containing small amounts of radionuclides. It shall provide guidance for the authorized use of materials and for the authorized discharge of liquids and gases containing radionuclides. It shall also consider establishing criteria for the clearance of solid materials. Such limits, conditions and criteria, should be established taking into account international recommendations.
- Ensure that relevant documents and records are prepared, kept for an agreed time and maintained to a specified quality. It shall ensure that appropriate parties are responsible for this work.

The operator shall be responsible for all aspects of safety of the decommissioning activity until its completion. He may delegate any work associated with the afore mentioned responsibilities to other organizations, but shall retain overall responsibility and control. In order to provide an adequate level of safety, the operator should:

- Perform safety and environmental impact assessments; shall prepare and implement appropriate safety procedures; shall apply good engineering practices; shall ensure that staff are trained, qualified and competent; shall establish and implement a quality assurance programme; and shall keep records as required by the regulatory body.
- Establish and maintain decommissioning plans, which are commensurate with the type and status of the facility. The initial decommissioning plan shall be established in the design phase of the facility and shall be reviewed and updated regularly, as deemed necessary.
- Establish and implement an acceptable radioactive waste management plan, including acceptable destinations.
- A mechanism for providing adequate financial resources shall be established to cover the cost of decommissioning. It shall be put in place before operation and shall be updated as necessary. Consideration shall also be given to providing the necessary financial resources in the event of premature shutdown of the facility.
- Before decommissioning operations start the operator shall submit an application for permission to decommission a nuclear facility, for approval by the regulatory body, together with the proposed final decommissioning plan.
- At the completion of decommissioning and before the operator can be relieved of further responsibility for the facility or site in accordance with the national legal framework, the operator shall provide sufficient information to the Regulatory Body, as to allow justification of such relief or otherwise the need to maintain appropriate controls to ensure protection.

- *A D&D project can impact strongly in the surrounding of nuclear facility and stakeholders participation can be crucial in order to carried out successfully the project. Stakeholders participation can be useful during definition of policies and strategies, during licensing process especially during environmental impact assessment in the control activities after closure statement.*

B. Definition of policies and strategies of D&D should include aspects like: option selection, allocation of technical, human and financing resources in order to optimize national capabilities, election of D&D option, Special emphasis should be pay to interface between D&D projects and radioactive waste management national system

Planning of every project should be based in a risk assessment, which include nuclear, radiological, occupational and environmental in order to guarantee a reasonable level of safety during operations and after closure. A careful use of information from design and operational phase of the facility may result very useful to prepare a dismantling sequence inherently safe. Additionally, use of appropriate techniques and lessons learned from previous projects can contribute to enhancing the global safety.

The national strategic approaches to the decommissioning of nuclear facilities may vary, depending on specific considerations. Early or deferred decommissioning can be acceptable options and both are used world-wide.

Decommissioning may also be carried out in one continuous operation following shutdown or in a series of discrete operations over time (i.e. phased decommissioning).

Decommissioning is facilitated if planning and preparatory works are undertaken at the design phase of the nuclear facility and are continued throughout the entire lifetime of the facility.

C. The usual practices to control of safety corresponding to the operator and regulator can be extended to the D&D projects. The control of safety should be adequate to the level and evolution of risk during the different phases of a decommissioning process, including post-closure stage. A principle of proportionality between the risk and the safety requirement should inform the level of control established.

The concept of a “intensive” safety control measurement to prevent risk of criticality, heat generation, high radiation level and spent fuel safety and security, should be substituted by a “extensive” approach. This approach should take into account aspects such as: the lost of physical barriers, the existence of diffuse level of radiation during long period and in large zones, high generation of waste, reduction of high qualified personnel in the facility, reduction of financial resources, etc.

Safety control should be flexible to adapt it to changing situation of the facility, this flexibility can be reflected in the applicable regulations, licensing documents, regulatory positions and mentality, and enforcement policy.

Accident Assessment

Ivo Tripputi, SOGIN, Italy
Ingemar Lund, SSI, Sweden

There is a general feeling that decommissioning is an activity involving limited risks, compared to NPP operation, and in particular risks involving the general public. This is technically confirmed by licensing analysis and evaluations, where, once the spent fuel has been removed from the plant, the radioactivity inventory available to be released to the environment is very limited. Decommissioning activities performed so far in the world have also confirmed the first assumptions and no specific issue has been identified, in this field, to justify a completely new approach. Commercial interests in international harmonization, which could drive an in-depth discussion about the bases of this approach, are weak at the moment.

However, there are several reasons why a discussion in an international framework about the Safety Case for decommissioning (and, in particular, about Accident Assessment) may be considered necessary and important, and why it may show some specific and peculiar aspects.

1 - Risk for workers could increase

The need for a safety approach optimisation, considering both radiological accident and conventional industrial accidents, will be developed later in this discussion. However, it is common experience from practical decommissioning work but also feedback experience from annual outages and major refurbishment work at the power plants. Not only is it during these periods that the majority of the collective dose is realised but many accidents also occur when people are testing or changing the systems of a plant. Handling of hazardous material (alkaline metal coolants, lead, asbestos, mercury, beryllium) requires special attention and the industrial safety issues are also of prime concern (high pressure, corrosive liquids, lasers, electrical hazards, falls, vibrations from jackhammers and scrabblers).

2 - Regulations and technical guides are usually at an early stage in the development process

This is true in most of the OECD/NEA countries. This is an additional reason why the approach to Accident Assessment in decommissioning is considered at a case-by-case level and, as a consequence, significant differences exist among different situations.
For example the Swedish Radiation Protection Authority is presently preparing rulemaking on the issue of decommissioning planning but for instance clearance levels for decommissioning material and rules for site release are still lacking. In some countries, like the U.S., the regulation of decom has lately changed when practical experiences have accumulated. (Nancy E Durbin, Rebekah Harty, U.S. Experience with Organizational Issues During Decommissioning, SKI-report 98:3, January 1998, See also www.NRC.gov, NRC Regulations, 10 CFR, Parts 2, 50, and 51.)

3 - Peculiar issues exist

Accident assessment in decommissioning may be challenging, since a reference plant configuration practically does not exist and an accurate review of the decommissioning stages and activities shall be considered in order to assure that the analysis is conservative and all-enveloping. Additional peculiarities are, as mentioned above, the combination of radiological and industrial risks and uncertainties about quantification of releases.

4 - Harmonization advantages

A national and international harmonization process could imply positive outcome in terms of predictability of licensing processes, better public acceptance, reliable scheduling and cost reductions.

Identification, classification and grouping of events

The Identification, classification and grouping of events to be analysed is an early and one of the most important stage in the process of accident assessment. When people sit down and identify possible causes for accidents (Postulated Initiating Events or Initiating Events) it will also lead to an increased awareness of the problems at stake.

In order to perform a systematic and comprehensive listing of all events to be considered, the “rules of the game” should be clear. Experts involved in the safety analysis of operating plants might consider the same approach and rules (such as the defence in depth, the single failure, the safety classification of equipment, prevention versus mitigation, pervasive roles of Quality Assurance and Safety Culture), but it would be common sense to adapt these safety cornerstones to the real safety significance of decommissioning activities. This is certainly something that should be put on the table and discussed to arrive to a clear consensus. Also, it is possible to discuss whether the far reaching approach used for operating plants, including the so-called Beyond Design Basis Events, are to be considered also for decommissioning and how far we must go.

Of some interest could be also the type of approach considered applicable and practicable for decommissioning, i.e. probabilistic or deterministic or a combination of the two.

Human Factors and Organisational considerations

The period before and after termination of operation could be connected with stress and insecurity. The confidence in the management can deteriorate and the motivation can decrease - state of affairs which can affect safety and the decommissioning work. The process of decreasing the staff and the development of a decom organisation should be separated. Experience has shown that a special organisation for re-education and job finding could be helpful. The persons who will work with the decommissioning activities should be given the possibility to develop their knowledge and improve competence. Instead of detailed central planning it is better to work in a participative way and to have staff involved in the preparations of the decommissioning work from the beginning.

An open question is how to consider in the Accident assessment the human factors, i.e. what type of mistakes can be done, how many, for how long and what is their probability. As a difference with the plant Supervisors and plant operators, in the decommissioning personnel with lower education and shorter experience in the plant may be utilized, probably increasing the risk of radiological and conventional accidents. This is also the experience of operating plant maintenance work.

Emergency Planning – extension and content (fuel on-site)

Connected to the Accident Assessment is the question of the relevance of one of the mitigation features available, i.e. the Emergency Plan. The role (if any) of Emergency Plan in decommissioning is subject for discussion, considering both the case of a single unit in decommissioning or the case of 2 or more units part in operation and part in decommissioning.

This is an issue that has been discussed at some length in Sweden in connection with the closure of the power plant Barsebäck 1. If also the second unit at the site, Barsebäck 2, is closed how should the Emergency plan change? A working group consisting of people from the Skåne County Administrative Board, the municipality Kävlinge, Barsebäck Kraft AB (licensee), the Swedish Nuclear Power Inspectorate, and the Swedish Radiation Protection Authority have addressed this issue. One of the conclusions of the group was that after the spent fuel has been removed, there is no need for the Skåne Administrative Board to have a special emergency preparedness plan. Six months after a reactor has closed the content of iodine-131 in the fuel is so low so that iodine prophylaxis is no longer motivated. Information to the public about the activities at the site is needed at all stages in the decommissioning process. For reasons of public confidence and psychology, a strategy for the downsizing of the emergency plan should be carefully planned and each step should be well thought-out.

The IAEA report *Preparedness and Response for a Nuclear or Radiological Emergency, Draft* Safety Requirements No. GS-R-2, DS43 addresses this issue. In this report five different categories of nuclear or radiation threat are identified:

Category I – Installations for which events that can give rise to severe deterministic health effects off-site are postulated or have occurred in similar installations, including very low probability events.
Category II – Installations for which events that can give rise to off-site doses warranting urgent protective actions consistent with international standards are postulated or have occurred in similar installations. This category (as opposed to category I threats) has no credible events postulated that could give rise to off-site doses resulting in severe deterministic health effects.

Category III – Installations for which events could give rise to doses on-site resulting in severe deterministic health effects are postulated or have occurred within similar installations. This category (as opposed to category II threats) has no credible events postulated for which urgent off-site protective actions are warranted.
Category IV – Minimum level of threat assumed for all States and jurisdictions. This category includes events involving: Facilities for which events could give rise to doses warranting urgent actions consistent with international standards on-site but for which no credible events are postulated that could result in severe deterministic effect; mobile practices using dangerous sources; medical misadministration; transportation; and other events that could occur virtually anywhere (the public finding a source resulting in exposures and contamination, loss or theft of or damage to a dangerous source, re-entry of satellite, and illicit trafficking) that may warrant emergency intervention.
Category V – Areas that could be contaminated to levels necessitating food restrictions consistent with international standards as a result of events at installations in threat categories I or II, including installations in nearby States.

Decommissioning are the administrative and technical actions taken to achieve a progressive and systematic reduction in radiological hazards. These actions involve decontamination, dismantling and removal of radioactive materials. During the decommissioning process it should therefore, at specific, identified points of time, be possible and proper to re-evaluate the need for, and the content of the on- and off-site emergency plan.

Analysis assumptions and their bases

A number of data and assumptions are relevant to the Accident analysis. In several cases the database and the assumptions used for operational safety analysis are not relevant or not applicable. Examples are:

- Source term for radiation fields and release calculations
- Statistical data on human errors, on specific job conditions
- Computer codes for release and consequence calculations
- Approach to structural analysis for intermediate plant structural configuration
- Approach to fire protection
- Acceptance criteria also in terms of plant damages and mechanical stresses

Event classification and grouping

One the list of accidents to be considered is complete, there is the need of their classification in terms of expected frequency or probability, in order to associate appropriate acceptance criteria and their grouping in accident of similar cause/evolution/effect, in order to be able to identified the most representative and reduce consequently the number of calculations to be performed.

An example (just for illustrative purpose) of event grouping is presented below. Events are grouped according to the type of challenge and the type of activities involved.

Decommissioning activities

- Chemical and Mechanical Decontamination
- Dismantling
- Material handling (including heavy load drops)
- Loss of support systems
- Electrical supply
- Service water
- Compressed air
- Other internal events
- Criticality
- Fires
- Explosions

<u>External events (natural)</u>

- Earthquakes
- Lightning
- Flooding
- Winds and tornadoes
- Vulcanoes

<u>External events (man-made)</u>

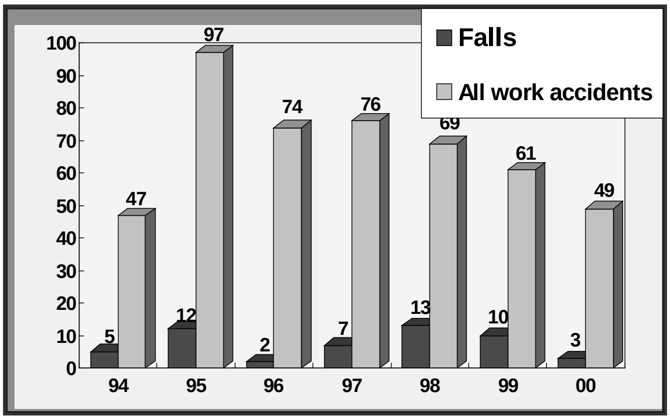
- External explosions
- Aircraft crash
- Security

Human errors

Some of the above events might not be applicable and some may fall below the credibility threshold in various countries and for various plants. However, it could be of interest to fill out a comprehensive list of events, from which in each specific case one could identify those to be considered. It is also of interest not to spend unnecessary resources on events of small probability and with small consequences, which could be difficult to quantify exactly. Therefore in the selection process experience and engineering judgment are of utmost importance.

Work accidents at Ringhals NPP

A specific case of the importance of considering also conventional safety in the accident assessment may be derived from the experience in Ringhals.



The graph shows work accident statistics at the Ringhals power plant, situated on the west coast of Sweden. Of these accidents, 10-15 per year are so serious that the worker cannot continue working for a period of time. The very few fatal accidents that have occurred at the Swedish nuclear power plants have also been non-radiological accidents (falls, electrical, related to pressure differences). It should be noted that during the same period no serious radiation accident has occurred. It is not likely that this picture will change during decommissioning.

Even if we in this presentation focus on the nuclear safety (i.e. protection from undue radiation hazards) the operator usually has to consider the overall hazards assessment. The hazards analysis should evaluate all hazards - radiological, chemical, biological, and physical hazards at the plant to be decommissioned. The assessment should preferentially be done by a team of people with experience and knowledge about all these issues.

Interesting thoughts about the holistic safety assessment can for instance be found in DOE/EM-0383 DOE Decommissioning Handbook, January 2000, p. 60 – 65.

References

Several references have been used to prepare this presentation and can be useful to develop further insights in the issue. However, the list below is not complete at all and more work would be necessary to have a comprehensive situation of the issue in the world.

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- Preparedness and Response for a Nuclear or Radiological Emergency, No. GS-R-2 (Draft Safety Requirements, DS 43)

European Union
- Management of Occupational Radiological and Non Radiological Risks, EAN Workshop, Antwerp, November 20 – 22, 2000

National

- US NRC - Various documents
- Decommissioning Handbook, US DOE, January 2000 (DOE P450.4, Safety Management System Policy)
- Various Plant specific Safety Analysis Reports

Conclusions/Observations/Proposals

An effort for a comprehensive and systematic D&D accident safety assessment of the decommissioning process is justified. It is necessary also to explore in a holistic way the aspects of industrial safety, and develop tools for the decision-making process optimization. The expected results are the implementation of appropriate and optimized protective measures in any event and of adequate on/off-site emergency plans for optimal public and workers protection. The experience from other decommissioning projects and large-scale industrial activities is essential to balance provisions and an Operating Experience review process (specific for decommissioning) should help to focus on real issues.

Management of radiological and non radiological risks in a decommissioning project

Pascal Deboodt, SCK•CEN, Belgium

Introduction

As already shown by Oudiz et al (1), the assessment of carcinogenic risk and the management of asbestos and ionising radiation needs to focus on three levels namely, the legal obligation level, the organisation and companies level and the work situation level. The main purpose of a paper is to provide a practical example of such management. Based on a set of four operations related to the removal of asbestos from working areas, we want to illustrate the general conclusions as presented in (1). After a short description of the SCK•CEN institution and of the BR3 decommissioning pilot project, we will present the general approach of the Health Physics and Safety at the SCK•CEN. Than, four sets of operations will be proposed. One should then stress on the driving forces and compare with the conclusions presented in (1). Lessons which have been learned will serve as conclusion, together with the remaining questions which are the questions the 4th European ALARA Network Workshop has to deal with.

Setting the scene

The Belgian Nuclear Research Centre (SCK•CEN)

The mission of the Belgian Nuclear Research Centre of Mol is mainly dealing with the peaceful uses of nuclear energy. As a federal institution, the SCK•CEN has 600 employees who are performing their function in the departments as shown in figure 1 . The SCK•CEN installations are mainly the four research reactors, the underground laboratory, the laboratories for the studies of the irradiated materials and for the measurements of very low activities. There is also a department dealing with the radiological protection and laboratories working with uranium and plutonium. The SCK•CEN is working in many programmes, for some of them as partner in European projects, for some other to provide support to the Belgian authority.

The Belgian Reactor 3

As already mentioned, four research reactors belong to the SCK•CEN installation. One of these, the BR3, is now under decommissioning. This reactor has been the first PWR build outside the USA. The BR3 reactor has been used for many purposes (training, research, and production of electricity) and has been definitely stopped in June 1987. Chosen as a pilot project on decommissioning of nuclear power plants by the European Union, the BR3 reactor has also been chosen by the SCK•CEN as a pilot project as far as the optimisation in concerned.
After a first decontamination of the primary loop, the dismantling has been performed. A few months ago, the pressure vessel has been extracted and has been cut for final storage.
Actually, the operators are busy with the cutting operation of the remaining primary circuit components (primary pipes, steam generator, pressurizer, etc….).
The examples we want to stress out in this paper have taken place at the BR3 installation.

The Health Physics and Safety Department at the SCK•CEN

Figure 2 shows the organisation of the Health Physics and Safety Department at the SCK•CEN. This organisation has recently been slightly modified to be in accordance with the last Belgian Royal Decree (3), which requires a better interdisciplinary approach of the health and safety on the workplaces. Almost fifty persons are working within the Health Physics and Safety Department. The missions of this department are described in the Belgian regulations. The head of this has to report to the General Manager, to the “Health Physics and Safety Committee” (representatives from the management line and from the trade unions) and also to the Competent Authority. As far as the nuclear topics are concerned, an independent Control Body that reports to the Belgian Competent Authority, namely to the Federal Agency for Nuclear Control, controls the Health Physics and Safety Department of our centre.

Figure 2: Organisationchart of the SCK•CEN

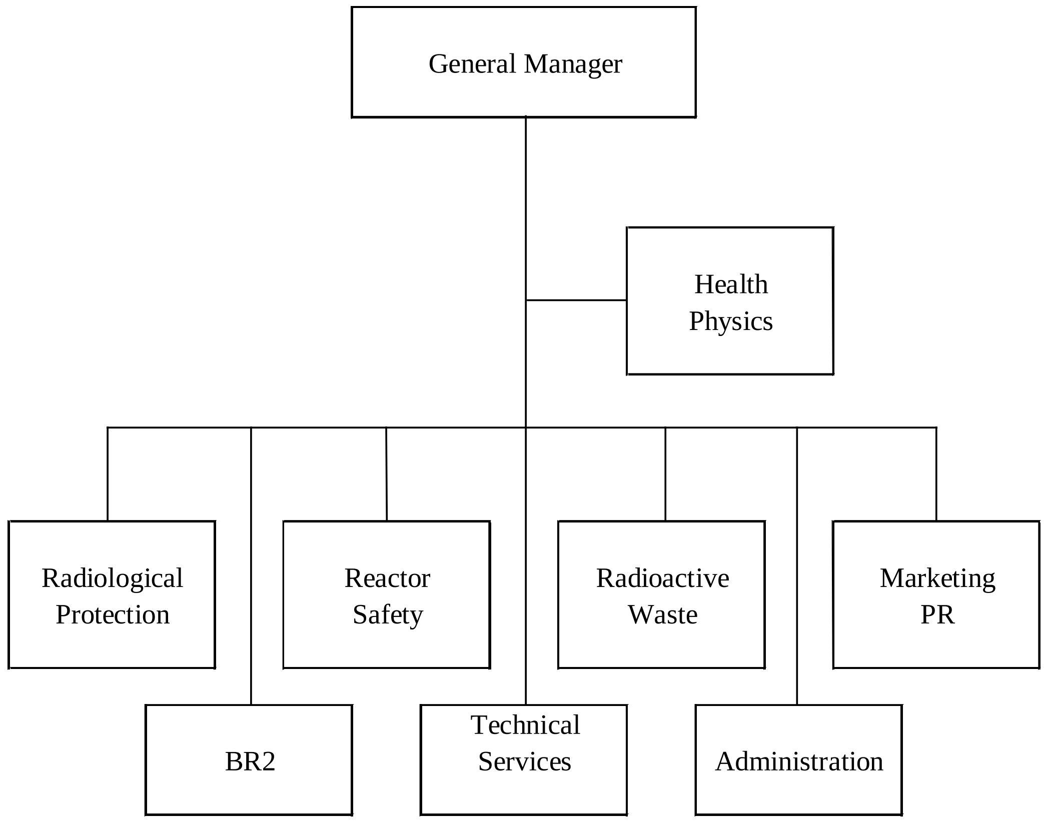
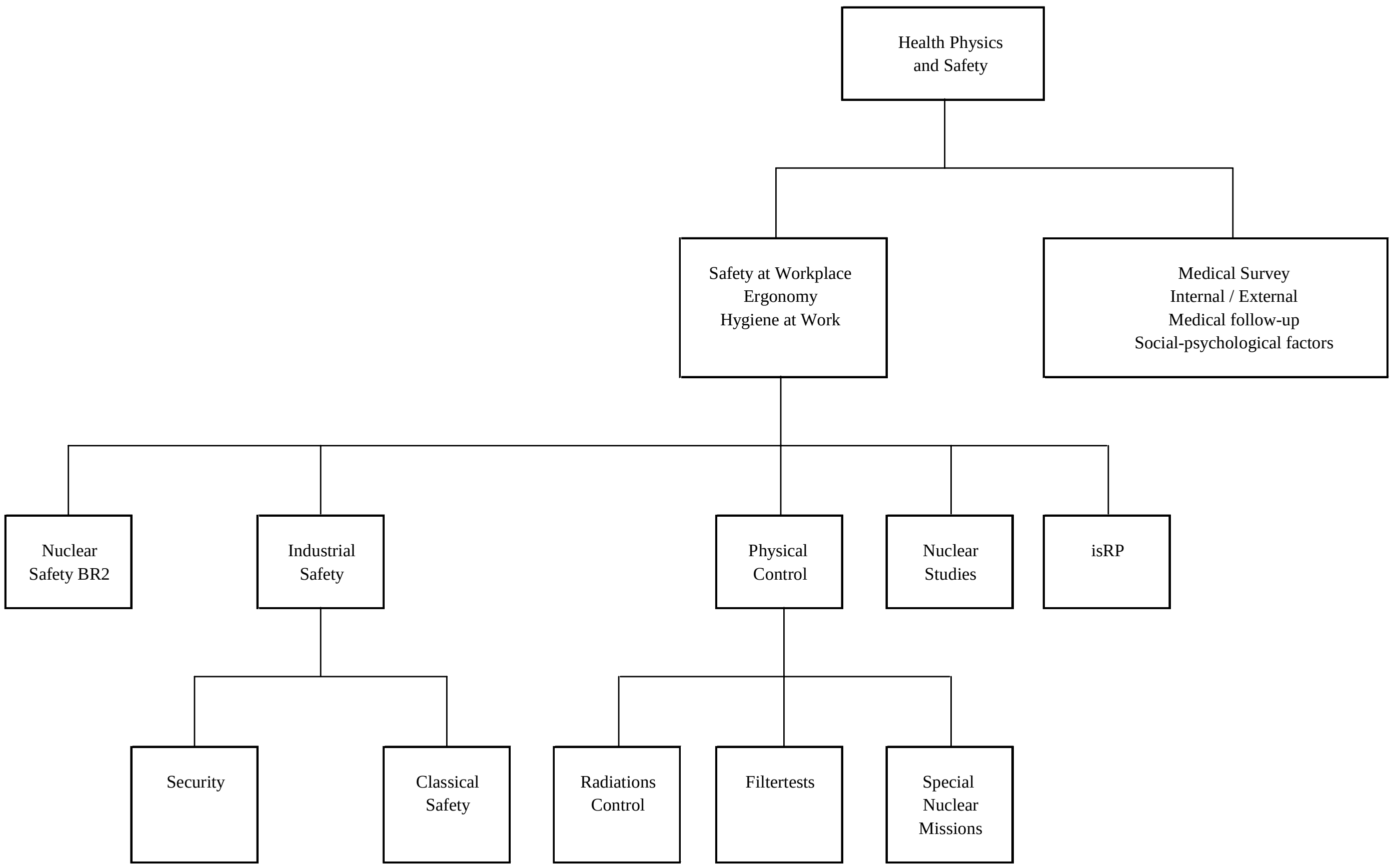


Figure 2: Organisationchart of the Health Physics Department



The ALARA approach

As already described, by the end of the eighties, the management line of the SCK•CEN has decided to put into practice the ALARA principle. Very shortly speaking, this decision has led to the designation of the local ALARA co-ordinators (one for each installation), of an "ALARA and Safety Committee" and, in 1993, to the implementation of an "ALARA procedure". One of the main characteristics of this procedure is that the conventional safety aspects were also dealt with. It is worthwhile to note that the first steps to launch this procedure were based on the pilot-project covering the decommissioning of the BR3 reactor. Since 1993, all the technical procedures have to be completed by an ALARA procedure. Outside the BR3 reactor, let us mention the whole optimisation of the refurbishment of the BR2 reactor which duration was almost eighteen months! The main conclusions of ten years ALARA practice at the SCK•CEN can be found in (2) and (3).

Elimination of asbestos at BR3

The problem

As many buildings built before the publication of the more restrictive regulations dealing with asbestos, use of asbestos bas been relatively important in the BR3 installations. As required by the Belgian regulations, an asbestos inventories needs to be established and one of the missions of the Health Physics and Safety Department is to control the level of asbestos contamination and to insure the completeness of

such inventories. In 1997, it appeared clearly to some workplaces in the BR3 building were, if not really contaminated, very close to the limiting value (10 fibre/litre). Furthermore, it also appeared that this level of asbestos concentration were almost reached, not only in some “cold areas”, but also in “controlled areas”.
The management of the BR3 and the Health Physics Department decided together to perform all the operations required for the removal of asbestos. Indeed, the planning of the following operations related to the dismantling showed without any doubt that the workers could be exposed to such risk in the next months.
Due to simultaneous presence of both risks, radiological and non-radiological, it has been decided to take time enough to define an adapted approach involving all the partners. This approach is presented now.

The approach

The first step for the definition of the approach was to identify the partners who had to be involved, the location of the risks and the legal requirement. Contact has then been taken with the administration of the Technical Work Inspection. A first meeting has been organised. A draft of the technical procedure has been proposed as well as the radiological topics. The representants of this administration were then invited to visit the workplaces. It has to be noted that this was their first experience in a nuclear area and that they were really interested persons!
Based on this first contact, the technical procedure and the ALARA procedure have been established. Together with the contract sent to the licensed firm that was chosen to perform the works, copies of the technical as well as the ALARA procedures have been distributed. For example, it was already mentioned that the contractor should take care of the training of his workers. For instance, it was decided to make use of the first day of the works to provide a short information about the radiological and the non-radiological risks. Furthermore, a visit to the controlled area has given the opportunity to the workers of this external firm to become aware of their “environment”. It also has to be noted that some modifications in the planning as proposed by the contractor have been imposed.

The works

These were performed as foreseen but some modifications were brought and some requirements were added too. For example, instead of working “top-down” as far as the removal of asbestos was concerned, the contractor accepted to begin in the middle of the steam generator. This decision was taken as a result of the pre-job ALARA study performed with the software VISIPLAN. Another example is related to the use of the full-face masks. After a few days, due to our additional check-up for internal contamination, it seemed that the masks in use in nuclear areas were more efficient and that they were more guaranteed for the safety of the workers. The use of cameras is certainly useful in such circumstances. A third example copes with “at random” check-up in the Whole Body Counter for potential internal contamination. This has led to the evidence of disfunctionments (or misuses) of the personal protection equipment and brought to more severe requirements. On the other side, this supplementary measurement was very well accepted by the workers. Their fear, as far as nuclear risks were concerned, has really decreased! Finally, the dose for each worker was daily recorded and transmitted to the partners (contractor, BR3, Health Physics and Safety Department).

The results

The main technical results need to be presented in two ways:

- the positive ones :

  - duration of the works: 35 days (instead of 50 days)
  - quantity evacuated: 6 567 kg (instead of 3 123 kg)
  - received collective dose: 19,2 man.mSv (instead of 88,9 man.mSv)
  - 7 working hours/day (instead of 6 working hours/day)
  - manual cleaning: most important source for the doses (time, distance)
  - depressurisation: 3 mm water (1 mm legal)
- the negative ones:
  - cost of the works:
    - 78 % → waste
    - 18 % → manpower
    - 4 % → varia
  - difficulty to realise the legal rate of ventilation

One may add to these results some other considerations; for instance, the role of the ventilation system is very important ("free release" measurement as far as asbestos is concerned). On the other side, the absolute filters (99,95 %) have been contaminated by asbestos, which will lead to problem when they will be replaced. Some changes in the behaviour of the external work force needed to be required. But the commitment of the project leader in this firm was really positive. Finally, after a few weeks, the owner of the BR3 installation has made another "clearance" measurement. This wasn't required by the regulators but… has been really appreciated by them! For more details, see also (4).

Other asbestos removal!

Since the first elimination of asbestos in 1997, three other operations, with the same goal, have taken place. Their duration, their localisation and their characteristics are quite different from those, which we just have mentioned. Let us shortly resume these operations.

- Elimination of the thermal insulation from the legs of the reactor pressure vessel at BR3. This set of operations took place during the month February 1999. Workers belonging to the staff of BR3 performed the related tasks. This was the result of preliminary discussions with the administration of the Technical Inspection on the Workplaces. Indeed, due to the limited quantities of asbestos which had to be taken away and to the very well defined tasks to be performed, she concludes that the nuclear know-how and the safety features usually applied were adequate and that the managers of the BR3 didn't have to work with a licensed external firm. The estimated collective dose was 3,3 man.mSv and the received collective dose was 2,8 man.mSv (9 days and 10 workers).
- Elimination of the thermal insulation from the turbine and from the Machine Hall at BR3. In this case, all the operations happened in the "cold" area of BR3 during the month August of 1999. The only particular topics we want to indicate is that the waste was very slightly contaminated but the values were low enough to proceed to the free release of this material. An external licensed firm has performed all the tasks. A mobile ventilation system, totally independent of the main ventilation circuit of BR3 has been used.
- Elimination of the remaining asbestos from the controlled area of BR3 (September 2000). In this case, an external firm has performed the works, which wasn't the same as in the first elimination. The operations were located into the controlled area and the same procedure as in the first case has been put into practice (technical procedure, ALARA study, training, follow-up). The estimated collective dose was 6,5 man.mSv and the received collective dose was equal to 2,5 man.mSv. It is worthwhile to note that the first technical procedure has been seriously amended by the ALARA and Safety Committee. Indeed, a first estimation of the collective dose gave 13 man.mSv. Furthermore the location where the job had to be done was really "confined" with as a consequence a more potential exposure of the fingers and arms. Finger dosimeters were imposed. Full-face masks were accepted under the condition

that these were SCK•CEN masks. The same daily control in the Whole Body Counter was applied. The administration of the Technical Inspection at the Workplaces was aware of our willingness to increase the safety of the workers and she really appreciated as well as our procedure as the final results!

Driving forces and lessons learned

Referring to what has been written up to now and taking advantage of diagram 1 as presented by Oudiz et al, we can observe that:

- each institution as identified by Mr. André Oudiz has effectively been involved in the BR3 operations for removal of asbestos; indeed, at the beginning of the operations, the so-called "Design phase", contacts have established between the authorities, the experts (radiological and non-radiological risks) and the licensee. These "kick-off" meetings provided to each partner the most significant factors that have to be taken into account during this first step (Design). It also has to be noted that the main result as far as the legal authority is concerned is that it become clear for her that "If asbestos had to be removed, the removal had to be performed taking into account another risk which for some operations seemed to be considered as the priority"!
- on the other hand, in accordance with the conclusion of Mr. André Oudiz, such works with "combined sources of risks" give the opportunity to the authority to learn something about such workplaces and work conditions. This has clearly lead to a more flexible interpretation of the existing legal requirements, under the condition that transparency can be guaranteed by the exploitant and the local Health Physics and Safety Department representants.
- as a third point, we want to emphasise the importance of such dialogue with the contractors. Also here, like the legal requirements, flexibility appears as a major need during the various steps of the removal's operations. The Health Physics and Safety Department have imposed some changes but this doesn't mean that the contractor will take care of these new requirements. In such case, the obligation to spent one day (for which there was no financial retribution!) for training is a sign of the level of confidence between both partners. To reach such level, the approach of safety by the SCK•CEN is of prior importance. The contractor acceptance in certainly increased if there is sufficient evidence of a high level of the general safety approach in the "host institution".
- as a fourth remark, at the work situation level, we also have been able to observe the necessary interactive and mutual support given to both partners. From our experience, based on the cases we presented here above, it appears clearly that the radiological approach has brought some fundamental changes in the safety approach of the "conventional" firm. For example, the modification of the chronology of the works, the use of the masks, the permanent control by use of cameras are of great significance.

Generally speaking, the driving forces, which seem to be working as guidelines in such work's circumstances, can be summarised as follows:

- willingness to comply with the legal requirements
- wish to work not on a short term basis
- wish to guarantee an efficient level of prevention
- will to optimise the whole approach but extended to new areas
- willingness to preserve the "brand image" of both partners

Let us examine much deeper each of these "forces". For what compliance with legal requirements concerns, we have shown that both risks have been treated in such a way to satisfy both kinds of regulations. This means that no special effort has been done to give more importance to the radiological or to the non-radiological risks.

Furthermore, the fact that the decision for removing asbestos before the legal value was reached may be considered as the sign of a long-term approach. Strictly speaking, this approach has nothing to do with the precautionary principle, which is more a static than a dynamic principle.
As also shown here above, all the partners involved in the operations were aware of the need for an effective prevention and that care had to be taken mostly for the health and the safety of the workers. Indeed, some modifications or improvements brought during the operations were mainly focusing on prevention more than protection.
It's really difficult to say that a real optimisation has been performed. Nevertheless, some parts of the operations have really been optimised. The modifications of the technical procedure in the first case (priority to the removal of asbestos from the central region of the steam generator instead of the lower regions) is a good example and don't have to be considered as only "good practice". On the other side, the "asbestos contamination" of the filtration units of the BR3 didn't have been considered in the ALARA pre-job study.
Last but not least, the "brand image" of all the partners was certainly of great importance. For the authority, this was the first workplace where they had to combine such radiological and non-radiological risks. For the external firm, the know how gained during such works was of prior importance. And of course for the owner of the BR3 installations and the H&S Department, these operations were also a very way to check their ability to manage on the field such risks.

Conclusions

The examples which have presented here are certainly too limited for deriving general conclusions. But, let us try to pay attention to some topics, which can appear as the lessons which have been learnt but which also can lead to further discussion.

The first remark we want to bring here deals with the importance of the communication at the different levels and at the different steps of the operations. Faced with unusual work circumstances, one certainly needs to develop adapted tools as far as communication is concerned. In this way, the level of the safety culture in the installations can act as a very efficient tool.

A second topic, which has to be pointed out, is the commitment of all management levels. All the partners have been faced in their past to circumstances where they have to take decision. So they have built their know how and also their usual way of thinking and/or working. As a consequence of this, some resistance can exist and it is not only a question of good communication. Here, it has to do with the behaviour of people. One's has to cope with these resistances by use of ... an other behaviour! This requires a real commitment of each partner.

We think that the ALARA approach is a very good way to provide an adapted language as well as such commitment. Without any doubt, this approach is mainly responsible for the good results we got!

Thirdly, as far as the removal of asbestos at BR3 is concerned, it is obvious that the "radiological approach" has brought some technical improvements to the "non radiological" approach. Examples can be found in the use of the masks, of in the daily control for potential contamination. But, on the other end, the workers of the BR3 installation are now more aware of the potential existence of other sources of risks and of the rules, which have to be followed in such cases. Working into the nuclear field leads sometimes to a lack of awareness regarding "industrial risks".

Some questions are still remaining as "open questions". Some of these have still been pointed out (5). How do we have to optimise such operations where more than one "recognized" risk is involved ? How did we cope up to now with such "interactive" situations ?

How far do we have to optimise ? What’s the meaning of “optimisation” in such cases?
These are examples of questions we hope to deal with during the discussions with partners from the radiological and non-radiological fields.

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Safety Case for Safestore

Paul B Woollam
Head of Decommissioning and Liabilities, Magnox Electric plc, UK

Magnox reactor sites in the UK

Magnox Electric plc (Magnox), a wholly owned subsidiary of BNFL, owns 26 gas-cooled, graphite-moderated units on 11 sites in the UK. Eight units have been permanently shutdown and the remainder will shut this decade in a currently declared closure programme. The first of these reactors went to power in 1952 and the fleet has generated typically 9% of the UK’s electricity during the last five decades.

BNFL's policy and strategy for reactor decommissioning

In accordance with UK Government policy, BNFL aims for a systematic and progressive reduction in hazards on its decommissioning sites. The end-point of the decommissioning process is that the reactors will be dismantled and their sites delicensed. This will be done through minimising both the risks to the public, workers and the environment and also the lifetime cost, consistent with world class safety. There will be passive safe storage during deferment periods and it is BNFL’s clear intent that the reactors will not be Safestored indefinitely.

The main hazard associated with any decommissioned nuclear site is the spent fuel. Hence the reactors will be defuelled as soon as practicable after shutdown. After this work is complete, Cs137 contaminated plant (e.g. fuel pools, effluent plant, and drains) will be dismantled when it is no longer needed. All other plant and buildings will also be dismantled when they are no longer needed, except for the reactor buildings which will be put into passive safe storage. Co60 contaminated plant, such as steam generators, will be dismantled with the reactors. The reactors will be dismantled in a sequenced programme, with a notional start time around 100 years from shutdown.

Overview of the Safestore safety case

The scope of this safety case covers the Safestored reactor buildings only. It is a preliminary safety assessment that identifies issues that will require consideration in the detailed Safestore design, intended to gain regulatory approval, in principle, for the Safestore plan. Additional cases are being developed for contaminated land and operational waste storage.

Because of the Company’s strategy to defer dismantling for around 100 years, we must demonstrate safety over this extended time period. But the regulators are unlikely to agree only a 100-year case, hence we have adopted a two-part approach: a short term and a long-term safety case.

The same basic safety principles apply in decommissioning as for an operating site's safety case: prevention, protection and mitigation of the effects of faults. The quality of the safety case relies on the radioactive inventory of the reactors and the adequacy of the hazard identification process. Before the safety case can be produced, the Safestore design concept must be understood.

Radioactive inventory

It cannot be emphasised too strongly that the inventory of a decommissioned site must be thoroughly characterised. If the decommissioning site has not been adequately characterised it is simply not possible to generate an adequate safety case.

Activation originated activity is, within Magnox, assessed by calculating the 3-D neutron flux and measuring the elemental concentrations in the reactor structural components. The activity concentrations are subsequently confirmed by *in-situ* measurements, using a combination of germanium spectrometry and dose rate measurements. Typically the calculations and measurements agree to within a factor three.

Contamination within the primary circuits (and other plant dismantled early) is measured by *in-situ* high-resolution gamma spectrometry and also by sample removal for subsequent laboratory analysis.

Safestore design concept

The intention is to recall existing reactor buildings as appropriate for the site, taking account, for example, of visual and other environmental issues, ensuring they are both weather proof and intruder proof. It is intended that there will be no permanent manned security. However, there will be routine inspection, monitoring and maintenance throughout the deferral period.

The design features on which the safety case relies include the general structural integrity of the massive buildings, with a new double skinned roof and new building cladding. This ensures the structure is weatherproof. It is essential to keep the reactor buildings dry hence there will be basement sealing and provision for drainage in the event of groundwater ingress. Landscaping and site drainage will assist in preventing ingress of surface water. Because of the need to prevent condensation there will be natural circulation of air within the building and around the pressure vessel and primary circuit pipework. The gas circuit will be sealed, except for one special vent.

Removal of combustible materials before the deferral period will significantly reduce the chance of fire.

There will be an ongoing care and maintenance regime with a secure access route to minimise and detect intrusion. Security systems will be built into the reactor buildings and, together with a range of other parameters, monitored remotely from a permanently manned location.

Hazard identification

The first stage of producing any safety case is hazard identification. A methodology was developed to ensure this was comprehensive and systematic. It took the form of a structured brainstorm with a broad range of experts. Over 400 potential hazards were identified: these were then grouped according to exposure pathway and hazard type. Following this internal process an independent peer review of hazard identification was carried out.

Hazards were grouped by type such as: degradation of the plant and structure, fires, explosions, impacts and human intrusion and by pathway through airborne and groundwater releases and direct radiation. This is an approach similar to that used for operational safety cases.

Human intrusion is of particular concern given the timescale over which it is proposed to defer dismantling. The scenarios considered were deliberate but temporary intrusion, including political protest, vandalism and entry for theft of materials; deliberate and continuous intrusion, such as squatters and unsuspecting intrusion, like the entry of children after deliberate adult intrusion. Site entry (but not into buildings) such as camping and dog walking is also addressed.

A number of assumptions are made about the safety management regime during the deferral period. Amongst these are that the site license remains during the entire deferral period. The whole decommissioning strategy is based on the concept of passive safety. This means that safety should not rely on rapid human intervention.

Short-term safety case: the first 25 years

The safety case is a rolling case valid for a 25-year period, with a periodic safety review every 10 years. At each review there will be an assessment of safety features against current criteria, with identification and analysis of hazards. The safety case defines inspection and monitoring requirements, assuming that the ongoing safety management system is maintained. At no time is reactor dismantling foreclosed: if it were not possible to make an acceptable safety case the only alternative might be to dismantle the reactors.

The residual radioactive inventory is immobile and locked into massive components. Significant experience from monitoring currently shutdown reactors shows that only standing water can cause structural corrosion. In addition, there is multiple containment of higher active materials. Integrity is assured by ongoing inspection and repair and there is a low risk if the safety management system fails or in the event of an external threat.

Central to the overall safety case is the inspection and monitoring regime. This covers condition monitoring, radioactive environment monitoring and the specification for civil inspections.

Parameters considered for condition monitoring are temperature, humidity, corrosion rate, seismic accelerations, basement sump levels and of course security. There will be remote monitoring, with data telemetry to a single permanently manned location.

Radioactive environmental monitoring will be designed to assure the Company that the system behaves as we expect, to meet or exceed legal requirements, to convince our Regulators and the public and to provide assurance against unforeseen events. It is anticipated that this will be a sample survey, similar to current operational surveys, but reducing in scope and frequency as confidence builds during the deferral period.

Civil structure inspections are currently envisaged to have frequencies of one week for site security, initially six months for building inspections and 10 to 20 years for major structural surveys. All inspection and monitoring results will be built into the 10-year safety case review.

Long-term safety case (around 100 years)

This case first examines the 25-year case for cliff edge effects. It is clear that radioactive decay will reduce the source term, thus reducing the hazard. However, it might be anticipated that changes to acceptance criteria might occur. Magnox assumes that dose limits will reduce by x10 around 2030. There may be physical and chemical degradation mechanisms that might be exacerbated by global warming and consequent extreme weather or by increased ageing effects. There are also potential changes to intrusion risks caused by familiarity, such that the perceived hazard decreases.

The long-term safety case relies on the robustness of safety management systems. However this could be compromised if there were failures, for example, of the Company to carry out its responsibilities, of the Regulator to enforce the law, of the UK (or the world as a whole) to maintain nuclear competence.

Our assessments show that the largest potential doses to the public are associated with a large aircraft crash and subsequent fire that sets the graphite moderator alight. The critical group dose from such an event is expected to be <25 mSv. By contrast, failure of the safety management system is expected to give a dose of 1-3 mSv and deliberate intrusion <1 mSv. The total risk to individual member of the public is judged to be $<3x10^{-9}$/yr. Inspection worker dose rates are estimated to be <6 person-mSv/yr. Hence the risks to the critical group are negligible even if the safety management system fails.

Stakeholder perspectives

The UK nuclear regulators' views on dismantling timing are that licensees should dismantle when deferral no longer offers a safety benefit. UK Government policy is that the rate at which decommissioning work proceeds will be determined by potential hazards, the availability of disposal routes and the financial implications of different timescales. The Government agrees that Safestore is feasible. However, the NII has not yet (February 2002) completed its assessment of the Safestore safety case described here.

BNFL' Magnox Electric is participating in Stakeholder Dialogue to understand the views of a wide cross-section of the population on reactor decommissioning. This is a facilitated process run by an independent non-profit organisation. Stakeholders include national and local anti-nuclear groups, local liaison council members, regulators, government and the nuclear industry. The primary focus is the timing of eventual reactor dismantling. Dialogue rules are that discussions inside the process can be reported but not attributed; however it is "business as usual" outside the confines of the Dialogue. All parties involved are striving to reach a consensus.

Conclusions

Magnox Electric is ensuring that the reactors and primary circuits on all its sites are well characterised. We have carried out a detailed, peer reviewed hazard identification on the lead site from which we have generated a rolling 25-year basic safety case. We have then searched for cliff edge effects and possible long-term changes to generate the 100-year case that our strategy requires. The safety case, which will define the inspection and monitoring regime, assumes there will be an ongoing safety management system but shows negligible consequences if there is a failure.