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HSE INPUT TO THE 2009/10 PROGRAMME OF NUCLEAR SAFETY RESEARCH

Paper by Nuclear Directorate (ND) Research Unit

Introduction

1. This paper discusses the input ND makes to the safety research programme for the next financial year. Consideration is given to the reactor licensees, clean-up licensees and defence licensees.

Reactor Nuclear Research Index

2. The Nuclear Research Index (NRI) is a compilation of generic nuclear safety research issues generated by the NII as a result of its knowledge gained in regulating nuclear reactor sites and its broader dealings with other organisations, both nationally and internationally. This Index is updated annually by the nominated NII Technical Representatives in each technical area, in consultation with the reactor licensees and by ND Unit 6f.

3. This paper presents a review of the 2008 update to the NRI and provides a basis for making the judgement that the scope of the issues, present on the NRI after the 2008 update, will enable the research programme that addresses them to comply with the DTI Guidelines for the HSC programme and with ND's own strategic and regulatory objectives.

4. Some of the technical areas, such as Plant Life Management (Steels), Plant Life Management (Civil Engineering), Radiological protection, Radionuclides, Nuclear physics, Fuel & Core and Nuclear Systems & Equipment are very mature and there is little that further research can contribute beyond intelligence gathering and support for essential research capability. For the 2008 update, these areas have therefore been re-written in a strategic format, using the 2006/06 update of the Plant Life Management

(steels) section as a model, rather than the prescriptive format traditionally used.

5. Other areas, such as Graphite, Control and Instrumentation, Human Factors and Chemical processes are still very active on account of the need to address problems caused by plant ageing or to exploit the benefits of new technologies for reactor safety. These areas have retained the traditional prescriptive format. The W&D chapter has been written as a common research strategy statement that applies across all nuclear licensees.

6. NII has set up a new Division that is currently undertaking a Generic Design Assessment (GDA) of three new reactor types. It is ND's expectation that the submissions for GDA will include the evidence from adequate safety research to substantiate the safety claims. In order to confirm this, ND may consider commissioning independent analyses through the support programme, it will review the results of any relevant confirmatory research carried out by overseas regulators who have also reviewed or are reviewing the design and it will review multilateral research programmes such as those of the NEA-CSNI and its membership of them. In the longer term, after completion of the GDA, further research that is needed to confirm the requesting parties' safety claims could become part of the HSE Coordinated Programme of Nuclear Safety Research.

7. The update of each of the technical areas for 2008 is reviewed below.

Chemical processes

8. This is an active technical area where the research activity has reached its peak and may start to decline as current issues are closed faster than new ones arise. The emphasis of the programme is the chemistry of primary, secondary and auxiliary gas or water coolants in PWRs, AGRs and Magnox reactors during normal operation and design basis accidents. The current programme includes proactive research and development in the areas of PWR and AGR secondary chemistry and PWR coolant radiation chemistry as well as extensive programmes of intelligence gathering and international collaboration under the other open issues. The Magnox closure programme means that any remaining research programmes for Magnox stations will solely benefit Wylfa.

9. The 2004 update of this section benefited from the NII Technical Representative employing two consultants who are knowledgeable on reactor coolant chemistry issues both in UK reactors and overseas, to review this technical area of the NRI. The result of this review was to produce a chemical processes section of the NRI in which the requirements for the sub-issues that still need to be addressed were more clearly defined than in the NRI for previous years. It has not been felt necessary to make any changes in the Index since then by opening or closing issues, although two issues will be considered for closure over the next year. The sub-issues fall into the topics of PWR primary cooling water chemistry, PWR, AGR and Magnox secondary side water chemistry, AGR gas coolant chemistry and graphite oxidation, low temperature corrosion (in reactor auxiliary cooling circuits and fuel storage ponds) and support for essential research capability (ERC) in radiation

chemistry. The programme has been designed to maximise the potential benefits of international collaboration, particularly on PWR issues.

Control and instrumentation

10. This area is still very active. Due to resource constraints, this section was not reviewed during 2008. However, ND judge this section to be fit for purpose on account of it being well maintained in previous years and regular technical exchanges between ND's specialists and the licensees are still taking place. The main driver for research in this area is the need to replace ageing control and instrumentation systems and the obsolescence of such electronic equipment. Updating technology can bring many benefits but also raises new issues, in particular that introducing new technologies can preserve the safety performance of the obsolete equipment without introducing new modes of failure.

External events

11. This section consists of two subsections, External Hazards and Internal Hazards. The HSE Safety Assessment Principles for Nuclear facilities (2006) define Internal Hazards as those hazards that the licensee can control, whereas External Hazards are defined as those over which the licensee does not have any control. On multi-facility sites an internal hazard for one facility can become an external hazard for another facility on the same (or adjacent) site. External hazards arise from earthquakes, high winds, extreme temperatures and manmade hazards such as aircraft crash, fire and explosion. The programme focuses on the need to gather intelligence on the required seismic performance of safety related plant and buildings for nuclear installations. Research has also concentrated on establishing the limitations and uncertainties associated with fire hazard analysis and upon monitoring activities and developments in this area both nationally and internationally. Attempts are being made to integrate the NRI, Sellafield and Decommissioning Sites External Hazards research programmes into a generic programme. This integration has already started with climate change issues.

12. ND's technical specialist for External Hazards recently attended an international workshop that was aimed at reviewing research in this area. He was of the opinion that the workshop was an adequate review of work being undertaken or required in this area and that there was no need for additional consultation. The External Hazards Section was rewritten in the new strategic format making use of the workshop proceedings and ancillary meetings that the ND specialist attended.

13. After the external and internal hazards sub-sections were changed to a strategic format, it was decided that it would be an improvement if these sub-sections are presented separately in the NRI as Sections 8a and 8b respectively.

Fuel and core, Radionuclides and Radiological Protection

14. These sections are mature areas in terms of research, especially Sections 4 (Radionuclides) and 12 (Radiological Protection). The ND technical specialist responsible for these areas agreed that they would benefit from changing the approach from prescriptive to strategic. He saw this as an opportunity to undertake a strategic review of research relevant to Section 3 (Fuel and Core). A 'research day' was arranged with the licensee (British Energy) on 9 July at British Energy Group offices; Barnwood, Gloucester. The purpose of the meeting was to discuss the BE research programme and HSE ND research requirements relating to nuclear fuel issues. Following this meeting it was decided to combine all three sections into one new Section 3 of the NRI with the title 'Fuel Issues'.

15. The new Fuel Issues section represents a significant change from the previous issue of the NRI. However, the status of the new section should be regarded as 'interim', as there are still several topics that need to be considered for possible inclusion in this section. For instance, some parts of Section 6 (Plant Modelling) could possibly be moved to the new Fuel Issues section for greater coherence, but it is difficult to affect so many changes at once. This possibility will therefore be further investigated with the next update of the NRI (2009/10). Also, there are still uncertainties about the research that might be required in the new build program. The Fuel Issues Section will be aligned with the new build program in the next issue of the NRI (2009/10).

Graphite

16. This is one of the major research programmes. The driver for this work is the ageing of graphite cores resulting in increased complexity of safety cases, particularly as plant operates beyond its design intent. Maintenance of essential research capability and independent advice for NII is of critical importance in this area. Independent advice has been secured through the establishment of the Graphite Technical Advisory Committee (GTAC) in January 2004,

17. The technical specialist responsible for this area is in the process of undertaking a strategic review of research relating to the graphite section, so the Graphite section of the 2008 NRI should be regarded as an interim position. As part of this review, a review was undertaken by the GTAC to determine:

- *To what extent does the Nuclear Research Index reflect the challenges identified by GTAC;*
- *To what extent do the licensees' Nuclear Research Schedules, and Research and Development Project address the challenges identified by GTAC; and*
- *Are there any omitted research topics in the NRI, or in the licensee's responses that GTAC consider could provide reasonably practical*

improvements to current understanding to support continued operation of Magnox and AGR stations?

18. GTAC has made a total number of 137 recommendations in previous reports to the NII for further work required from the licensees. The current issue of the Nuclear Research Index Graphite Section (2008/09) appears to be a good reflection of the challenges identified by GTAC, as is evident in the fact that only 2 of 137 recommendations are not currently being addressed in the NRI. A further 5 recommendations need to be added as sub-issues to the NRI; whilst 13 recommendations need to be described better in specific sub-issues

19. The next step is a review of all the research reports relating to graphite during the last six years. The purpose of the review is to determine:

- What were the objectives of the research projects;
- Are there any outstanding objectives that still need to be met; and
- Areas of research that have not been addressed by these research projects.

20. Once this has been completed the NRI Graphite Section will be updated, taking account of the findings from both reviews. The anticipated date of completion is January 2009; to give licensees the opportunity to consider the updated NRI in the final issue of the licensee Nuclear Research Schedule.

21. In view of the above, in the current update (2008) this section merely underwent routine updating to ensure that statements are up to date.

<u>Human factors</u>

22. The Human Factors section of the NRI was subject to a fundamental internal review during the 2007 period. This review was undertaken to implement recommendations from NuSAC/SCR and to address concerns from ND's Human Factors Nuclear Topic Group (HFNTG). The review concluded that a change in strategy and approach was needed to ensure that human factors research reflects the current nuclear landscape in terms of relevancy of issues and appropriate alignment of licensees.

23. During 2007/08 ND's Human Factors specialists had extensive consultations with the licensees and other interested stakeholders over the presentation of the issues in the NRI and the Sellafield Human Factors Research Strategy Statement. Following that consultation, the idea of a single unified research strategy statement for Human actors was abandoned in favour of a Human Factors section of the NRI that focuses specifically upon the research needs for operating reactor licensees. The 2008 NRI presents the issues, using the traditional prescriptive format, in a style that is compatible with the culture of operating power reactors.

Nuclear science (formerly Nuclear physics)

24. Research in this area is mostly driven by ageing issues. The technical specialist for this area was of the opinion that most of the issues in this section could be closed out and the remaining ones redrafted in the new strategic format. He also decided to change the title of the section to Nuclear Science as this title is more accurate. This section is about the application of reactor physics, as well as criticality and shielding computer analysis codes rather than nuclear physics (i.e. understanding the fundamental physics of the structure of the atomic nucleus). The improvement, validation and maintenance of specific codes and the co-ordination of national and international activities is an important aim for this area.

Nuclear systems and equipment

25. All issues in this area are closed. No new issues are expected to be proposed in this area. If any should arise, they would be allocated to one of the other technical areas and as a result this area will be closed and no longer appear in the NRI.

Plant life management - civil engineering

26. Civil structures are expected to provide a safety function not only for operating reactors but also post-closure. Post-closure work is currently addressed through the Waste and Decommissioning Section of the NRI. The drivers for research in this area are therefore the development of analytical techniques to predict the behaviour of ageing civil structures under normal and fault conditions, materials data, particularly for time dependent changes, non-destructive examination techniques to detect defects and the development of techniques for maintenance and repair to arrest deterioration of nuclear related structures. Following the 2008 review this area was rewritten to incorporate the remaining sub issues into a strategic format, after an extensive consultation with the civil engineering specialists in the reactor licensees.

Plant life management - steel components

27. Following an extensive review of the research requirements for this technical area by Serco, the Plant Life Management (Steel components) chapter of the NRI was changed from a prescriptive to a strategic format during 2005/06.During the 2008 review the technical representative for this area identified only a few minor changes to this section.

28. There are seven research drivers in this area; the development of stress analysis and fracture mechanics methods, high temperature assessment methods, validation of inspection techniques, characterisation of materials and fabrication (including ageing, corrosion and oxidation issues) and management of safety related issues (including capturing and maintaining expertise in the area and safety performance indicators). The ability of the Magnox stations to benefit from new research is limited, especially following the closure of the ones with steel reactor pressure vessels. This programme will continue to make use of collaboration through the EU Framework Programmes.

Plant modelling

29. This technical area covers heat transfer and thermal hydraulics modelling and severe accident issues. This is a mature area where the main challenge is for PWR is ensuring access to international developments. For both GCRs and PWRs the aim is to reduce uncertainties in the modelling through a programme of targeted experimental and validation work. Collaboration with OECD and USNRC programmes has been important here, for PWR models.

30. During the 2008 review, one issue was closed and the remaining seven redrafted in the new strategic format, reflecting the maturity of this area. The possibility of combining this section with the nuclear science section was considered. This possibility will be revisited during the 2009 update as will the possibility of transferring those parts of this section that relate to PWRs, to the new Fuel Issues section.

Probabilistic safety analysis

31. The need for further research in basic PRA techniques has diminished although there is now an increased interest in improving existing PRAs so that they better support safety decisions at nuclear installations. To this end, there is extensive collaboration overseas with the IAEA, EU, OECD/NEA and the USNRC.

32. Two sub issues under the Level 2 PSA for gas cooled reactors sub section were closed out and the remainder of this sub section redrafted in a strategic format. The two sub issues under the PSA Methods sub section were however retained in a prescriptive format because the project officer needed to retain some leverage to ensure that the licensees undertake the required research.

Waste and decommissioning

33. Ensuring a sound technical basis for the safe management and containment of radioactive wastes on nuclear power station sites over a long timescale is the prime driver for research in this area. In 2004, this section of the NRI was completely restructured, following a series of workshops, to provide a logical and transparent identification of research issues. It is recognised that in many cases, full closure of research issues in the W&D field will not take place until decommissioning is complete and relevant wastes have finally been disposed of.

34. In the 2007 review, this Section was presented as an expanded strategy that draws upon the observations of the above Workshops, in recognition of the different nature of the W&D chapter of the NRI, and the applicability of research in this area across the whole range of UK Licensees. This common W&D research strategy is intended to provide a framework within which all individual Licensees can derive their Nuclear Research Schedules (for British Energy) or Technology Baselines and Underpinning R&D (TBuRD) needs (for Sellafield Ltd, decommissioning Magnox sites, Dounreay and Research sites (formerly UKAEA)) documents. Research priorities are determined by where plants on each Licensed Site are in their life cycle, and the arrangements

have been developed to satisfy both ND and NDA requirements for research planning and commissioning.

35. Opportunities for international collaboration are being sought where programmes are tailored to the specific circumstances or types of waste that apply to the UK, in order to optimise the benefits of research funding and reduce the possibility of duplication of effort.

36. During the 2008 review, the project officer concluded that this section was still fit for purpose but recommended an extensive revision to the section during the 2009 review may be necessary to reflect new working arrangements.

Sellafield safety research strategies

37. The Sellafield Nuclear Safety Research Strategy Statements are a compilation of generic nuclear safety research issues generated by the NII as a result of its knowledge gained in regulating the Sellafield site and its broader dealings with other organisations, both nationally and internationally. These Strategies are reviewed annually and updated as judged necessary by the nominated NII Technical Representatives in each technical area, in consultation with the nominated Sellafield Technical Contacts and by ND Research Unit. This strategy review represents the start of the fifth cycle of reviewing the nuclear safety research needs of Sellafield Ltd. under the arrangements put in place in 2003.

38. This paper presents an overview of the 2007 update to the Sellafield Research Strategy statements. These strategies have been prepared with a view to enabling the Sellafield Technical Contacts to develop the Technology Baseline and R&D needs document which is used to inform the NDA about what R&D needs funding. Those parts of the Sellafield Ltd. research and development programme that address the ND strategies will be highlighted in this document. In the autumn, ND's Technical Representatives will assess the part of the Sellafield Research Programme that addresses ND's Strategy statements against the DTI Guidelines for the HSC programme and ND's own strategic and regulatory objectives.

39. The shorter term requirements of the licensee programmes may change significantly from year-to-year to reflect past progress in addressing identified Sellafield site safety concerns and emerging issues for the year ahead. The licensee will need to respond to its shorter term issues and longer term issues some of which will arise from ND's strategy requirements. ND Research Strategies, by contrast, will be expected to evolve more slowly on account of some issues requiring several years of research to close them out. Changes to Research Strategies are to be expected only when research to address an issue is considered to be complete or unlikely to benefit from further research. The strategies will also change when regulatory interactions with the site, with reactor licensees or with outside industry have raised concerns that could be applicable to the Sellafield site.

40. Hence the Research strategies in the Civil Engineering, External Hazards, Plant Materials and Fault modelling and risk analysis (PSA), Nuclear Physics, and Radiological Protection areas remain unchanged from 2006,

whilst those for Control and Instrumentation, have undergone some small modification. The strategy for Process Technology has undergone further revision this year to incorporate additional waste and decommissioning issues, namely novel waste treatment process options and waste characterisation.

41. The updates of each of the technical areas for 2007 are reviewed below.

Civil engineering

42. Civil engineering structures form the infrastructure which houses the processes completed within nuclear chemical plants. To ensure that safety is maintained existing structures will need to be assessed, maintained and repaired during an extended life when operational conditions may not match those assumed during original design. Decommissioning and provision of interim safe store facilities will generate a need for new structures with design specifications, which reflect intended use operational life.

43. Specific issues addressed in this technical area include ageing and degradation factors of construction materials and the development of strategies to identify and mitigate any degradation leading to leakage, particularly from ponds. There is also a requirement for the development of codes and to extend Eurocodes and National Applications Documents for use within the nuclear application, especially for Sellafield and the large amount of new build facilities required to support decommissioning.

Control and instrumentation

44. This area addresses safety issues associated with production, installation, modification or replacement of computer-based systems important to safety, maintenance of legacy and ageing C&I equipment, technological development in the area of C&I systems (e.g. SMART sensors and use of commercial off the shelf software based systems) and development of non-programmable hardware based C&I systems important to safety. C&I is an area that is subject to continuing (often rapid) technological evolution and development. While it is not expected that safety issues in new plants will require significantly different substantiation methods or techniques, it is recognised that there are emerging issues that require resolution. These include:

- the impact of evolving national and international standards,
- substantiation methods for complex systems,
- substantiation of available equipment for new application or obsolescence replacement with current technology equipment, which has now displaced unavailable traditional technologies.

45. Work is required to keep under review new developments in the approach to C&I safety cases, standards and methodologies both nationally and internationally to ensure implications for the UK are addressed. The chemical plant and reactor programmes will collaborate where appropriate to deliver cost-effective research and to build upon benefits of previous arrangements. There are mechanisms for information exchange with other

HSE research programmes enabling duplication to be avoided and opportunities for potential collaboration to be identified.

External events

46. Nuclear facility safety cases must demonstrate adequate robustness against both natural and man-made external hazards. The most significant hazards are considered to be earthquake, extreme weather (especially wind and flooding) and aircraft crash. Sellafield Ltd. currently uses sophisticated, largely deterministic, methods to analyse their plants for the effects of external hazards. Much of the potential research requirements in this area are developments of already on-going research in the reactors area. However, there are gaps in the analysis methods applicable to nuclear chemical plant that prevents a comprehensive assessment of plant safety, mostly in relation to seismic hazard.

47. The research goals proposed here primarily concern the potential need to develop improved methods and data for use in external hazards safety submissions. Seismic PSA as a method is not well developed within the chemical plant licensee safety cases. Sellafield Ltd. is currently developing a seismic PSA method with the emphasis on use in ALARP studies. However, additional work to develop a method to demonstrate compliance with risk criteria should be considered. There is a requirement to take the methodology, developed to handle the calculation of seismic fragilities on Nuclear Chemical Plant to support their seismic PSA and to develop application guidance by trial on a real project such at a Long-Term Periodic Safety Review.

48. Potential research aimed at reducing uncertainties and improving existing seismic PSA methods include a need to refine and reduce the uncertainties associated with formulating site-specific uniform risk spectra used to characterise the seismic hazard at a site, especially in the areas of attenuation relations, characterisation of site conditions and collection and interpretation of expert judgement. In particular, research may be required to determine the most suitable seismic walkdown method for use at chemical plant sites. This should recognise the unusual equipment/structural types that exist with chemical plants and the multiplicity of interactions between structures and equipment that also exist.

49. Specific to Sellafield, there is a need to review evidence for and if necessary, develop methods to assess the wind loads on buildings, where the site is densely packed with tall buildings, so significant aerodynamic interaction with adjacent structures is possible. There is also a need to review evidence applicable to specific chemical plant sites, and derive appropriate design basis extreme weather conditions, suitably conservative for use in nuclear safety case.

50. Research may be useful to review existing approaches and, if necessary, develop a practical method for assessment of beyond design basis external hazards in chemical plant safety cases. Forthcoming codes and standards should also be reviewed to assess their impact on future deterministic safety assessments of plants.

51. Other issues include a review of Sellafield Ltd’s current information and development of their site-wide ground classification used in seismic analysis,

a development of their site investigation methodologies to ensure that all data obtained, regardless of purpose is consolidated into site models and to update their aircraft crash data and review their aircraft crash methodologies, to take account of their unusual scenario of having a large number of hazardous plants within a concentrated area.

Fault Modelling and Risk Analysis (PSA)

52. Fault modelling and risk analysis is an important contributor to safety cases for nuclear chemical plant. There is a general challenge to improve safety and increase confidence in safety cases by improvements in the use of modelling methods and the data supporting them. This research strategy replaces that for probabilistic safety analysis (PSA) from earlier years. The area has been expanded to give more emphasis to the consequence modelling which is essential to both deterministic and probabilistic safety cases. Several research issues associated purely with the probabilistic analysis have been resolved in previous years.

53. Fault modelling and risk analysis as applied to chemical plant safety cases can be split into three topic areas.

- Difficulty to demonstrate the absence of unidentified hazards. Currently there are no specific research activities in hazard identification techniques, as a wide variety of techniques are well established in the nuclear and chemical industries. However, research may be warranted on the applicability to nuclear chemical plant of new methods developed elsewhere which appear to offer significant advantages either in effectiveness or efficiency.
- Radiological consequences of each hazard or fault are a fundamental input into nuclear chemical plant safety cases. While an extensive database has been compiled that enables the radiological consequences of fault scenarios to be calculated, data in some specific areas may be lacking or not directly applicable. The strategy is to carry out a phased review of the adequacy of the current data, to seek new sources of relevant data, and to produce new experimental data in specific areas. It is important to ensure that the computer models used in safety cases to predict the dispersion and uptake of radionuclides remain valid and that significant uncertainties continue to be reduced, through comparisons with industry standards, incorporation of new data, and where feasible direct experimental validation.
- Risk analysis is taken to include the determination of fault sequences linking initiating events to outcomes with the radiological consequences. This includes the identification of safety measures or barriers to the fault progression. Design-basis and probabilistic analysis is required to demonstrate that deterministic and risk criteria defined in the NII Safety Assessment Principles are met. Data and tools needed for fault analysis include initiating event frequency data, failure probability data for safety systems, fault and event tree analysis, dependent failure analysis and human reliability analysis. Currently the areas where there is greatest potential for research specific to chemical plant safety cases are Human Action Representation and Safety margins in criticality safety cases.

Human factors

54. In common with the Human Factors Chapter of the NRI, the Human Factors Section of the Sellafield Extended Research Strategy Statements underwent an extensive rewrite. Details are given in paragraphs 22 and 23 above.

Internal hazards

55. All internal hazards are considered in principle, but only fire has been identified as a topic. Fires are potentially very significant events to Sellafield Ltd., and are recognised as such. The prediction of the effects of fires is problematical, but fire issues do need to be adequately covered in all safety cases. Since 2006, the remaining research issue related to fire has been incorporated into the Process Technology Area Strategy.

Nuclear Physics

56. The general area of nuclear physics covers criticality, shielding, burn-up credit and source terms. Criticality safety is a mature technical discipline in which Sellafield Ltd. has a good safety record. The cornerstone of this research strategy is the extension and review of Sellafield Ltd.'s existing arrangements for the setting down of industry good practice; although it is recognised that many aspects of this are addressed outside research arrangements.

57. HSE's assessment and inspection activities have identified several areas where further development could potentially bring about long term improvements in safety, including:

- a review of the technology available for moderator non-intrusive assay techniques to measure moderator content of drum and packages for process materials and waste streams;
- a review of the techniques for the validation of fissile non-destructive assay measurements, which may be subject to large uncertainties;
- a review of underlying assumptions made in assessments for plutonium can storage, particularly with regard to moisture content, may enable limits on numbers of out-of-specification cans to be removed thus improving storage arrangements;
- a review of the adequacy of the current nuclear data to support the B205-specific plutonium activities and;
- consideration of extending the above work on fissile ILW to develop guidance for assessors on applications.

Plant Materials

58. This area of the Sellafield Research Strategy is concerned with the areas of materials performance, where ongoing research underpins ongoing operating plant safety and the storage of spent fuel and radioactive waste packages. Knowledge of plant materials integrity and their degradation is an important contributor to safety cases for nuclear installations, particularly where deterministic safety cases are considered important. Reliable

inspection techniques and deployment methods also become increasingly important, both to support the life-prediction methodologies and to confirm that other degradation mechanisms are not operating

59. Topics being addressed include the corrosion of Zircaloy/Stainless steel transition joints exposed to Plutonium Nitrate in solution, the corrosion of plant materials exposed to highly active liquors, the benefits of nitrate dosing of cooling water on the corrosion of plant materials in cooling coils, the corrosion of AGR fuel in storage ponds and the corrosion of ILW storage drums (in cooperation with the Waste and Decommissioning programme).

Processes Technology

60. Process Technology research deals with the specific hazards that affect chemical plant operations and as such do not apply to nuclear reactors. For example, those hazards that arising from physical changes or chemical reactions in fuel cycle and waste processing plants or the storage of process products and residues prior to their manufacture into fuel and of process wastes, prior to their being converted into less mobile forms by encapsulation, vitrification or their disposal or discharge. Fire is included amongst these hazards. Typical hazards, and the research programmes to address them are discussed below:

- Flammable gases represent one of the biggest chemical hazards on Sellafield site and has been addressed by a comprehensive research programme into the mechanisms of hydrogen formation in their fuel cycle plant, its accumulation, dispersal, deflagration and detonation and of the means available to control the concentration of the gas in plant ullage spaces, so that hydrogen ignition can be prevented. A further issue is the quantification and understanding of the significance of potential hydrogen accumulation in sludges. Continued development of this programme in the field of ignition and suppression is essential to wider UK industry and Sellafield would have an appropriate involvement in this. ND wishes to see the formation of a UK wide forum on hydrogen.

- To address the hazards associated with unstable by-products, ND has identified issues relating to the formation of Uranium Hydride and the storage of Plutonium Dioxide.

- The deposition of highly radioactive solids from two-phase mixtures in saturated solutions, such as the highly active liquor stored in tanks in B215, upon the surfaces of the storage tanks could lead to enhanced corrosion of the tank materials of construction. To ensure the safety of such operations, work to identify optimum conditions, which may minimise the deposition of such radioactive solids, is being undertaken. ND will keep this issue under review.

- Given the ability of these radiologically significant radionuclides to convert to volatile forms during plant fault conditions, NII recognise the benefit of on-going Sellafield Ltd. research programmes, to maintain its expertise in iodine and ruthenium chemistry and to maintain its worldwide contacts.

- A cross industry project is currently reviewing nuclear ventilation design codes, with the intent to agree revised cross-industry standards. The need

for a rational approach to fires within should be addressed by that project. It is possible that the review of existing design codes may identify further research needs.

Radiological protection

61. Sellafield Ltd is one of the most experienced employers in the UK in radiological protection matters and has well developed procedures based upon the UK Environment, Health Safety and Quality Manual. However, it is also the case that Sellafield Ltd faces the most difficult technical challenges. Further research should be considered to meet these challenges.

62. It is proposed that the cornerstone of the radiological protection research strategy should be the extension and review of Sellafield's existing arrangements for the setting down of industry good practice and guidance to assist in the development of plant safety cases / risk assessment. Examples of on-going guidance development include:

- guidance to judge the effectiveness of glovebox cleaning operations
- development of guidance on principles for the protection of employees following a radiation accident.

63. A key difficulty in carrying out an adequate dose assessment for individuals who receive an internal dose from inhalation of plutonium particulates arises because of the uncertainty surrounding the solubility of the plutonium material. Sellafield Ltd. should review the solubility data available on the materials present at the Sellafield site and consider whether they are adequately able to characterise the materials that could arise from operational and decommissioning processes. They should consider whether further research is required to fill any gaps in current knowledge. It is also recommended that Sellafield Ltd. should fully contribute to the development of industry guidance on ventilation standards (replacement of AECP 1054).

Waste and decommissioning

64. The Waste and Decommissioning strategy has been prepared to consider generic safety Issues relevant to outstanding NII concerns on the Sellafield site and relate to both operating plant, including operational waste storage facilities, and those that have been shutdown and are being decommissioned. Research in this area is co-ordinated with the Magnox Electric and more recently with UKAEA, BE and AWE research programmes through the Nuclear Waste Research Forum (NWRF). This Forum reports directly to the NDA Research Board. For this reason a common Waste and Decommissioning Research Strategy statement has been written that applies to all licensees. Details of this strategy are presented in Paragraphs 33 to 36.

65. R&D issues covered in the field of W&D differ in some ways from those addressed in other areas. In most fields the issues identified are directly concerned with the safety of chemical plant in the comparatively short term (essentially during their remaining operational lifetime). Because of the long-term nature of many of the issues in W&D, however, many of these are not readily associated with safety in the short term, though in general there will be an underlying safety-related component. Short-term safety issues concerning

radioactive waste management, such as hydrogen management, are covered in the process technology area.

66. At present there is effectively no UK programme to develop a deep repository for those radioactive wastes that are not suitable for disposal to the national near-surface Low Level Waste Repository near Drigg, although CoRWM has expressed its preference for geological disposal in a repository. In addition there are concerns over the long-term viability of the LLWR as an authorised disposal site. In these circumstances, producers of radioactive waste cannot plan on the assumption that a route will become available for ILW disposal or for the final disposal of LLW not suitable for the LLWR in the short-term. In the medium and long term it is generally accepted that the UK nuclear industry will need to take steps to ensure the availability of adequate knowledge and expertise in order manage radioactive wastes and decommissioning safely.

67. Future Licensee R&D activities need to be structured to ensure significant gaps in the knowledge base are anticipated and relevant work is actioned. Factors likely to affect future research needs include the short-term unavailability of an ILW disposal facility and the consequential storage of raw/conditioned wastes for long periods, the implications of the OSPAR agreement and the closure programme for UK reactors. No immediate problems are anticipated in maintaining essential capability or independence but this will be reviewed regularly to ensure any such scarce resource can be protected as necessary. In view of the significant commitments made to waste and decommissioning by the EU, OECD/NEA and IAEA, all UK decommissioning licensees should look for opportunities to develop collaborative programs with UK and overseas organizations to optimise the benefits of research funding and reduce the possibility of duplication of effort.

Former UKAEA and Decommissioning Magnox Sites

68. ND makes its research requirements known to these licensees through the common Waste and Decommissioning research strategy statement discussed above in Paragraphs 33 to 36. Dounreay site Restoration Ltd., Research Sites Restoration Ltd. and Magnox Electric respond to this strategy statement through their annual updates of their Technical Baseline and Underpinning R&D needs (TB&URD) documents.

Defence licensees

69. ND has informal nuclear safety research technical exchange arrangements with MoD and defence licensees. Defence licensees are not part of the HSE coordinated programme, although they do share research information with ND and the civil licensees and contribute to some technical exchange groups. AWE voluntarily participates in the C&I and W&D technical fora with the reactor and clean-up licensees. Under the nuclear propulsion part of the defence programme, Rolls Royce voluntarily participates in the R6 Panel (a Plant Life Management (Steels) technical area technical exchange forum) and the UK Nuclear Science Forum. However ND has not stated any research requirements specifically for AWE or Rolls Royce.

Conclusions

70. The reactor Nuclear Reactor Index remains focused upon developing the data, methodologies and codes required to reduce uncertainty, confirm the conservatism of or improve the safety of operating power reactors, thereby meeting the DTI guidelines to the HSE.

71. Some technical areas are very mature and all that is required to demonstrate adequacy and balance is continued support for ERC or intelligence gathering, to obtain up to date understanding of developments in the technical area internationally. These residual issues are not amenable to closure whilst plant remains operational. During the 2008 NRI review the remaining issues in these sections were rewritten in a strategic rather than the traditional prescriptive format.

72. About one-third of the technical areas still have substantial levels of research activity and in some areas, the problems associated with justifying the safety of ageing plant components has resulted in a need for increased research and development.

73. The above Sellafield research strategies reflect the needs of an appropriate Licensee research programme to support plant operations, waste management and decommissioning activities on a site where most of the operational and safety management arrangements are well developed. Hence the constituent parts are:

- continuously refining and improving risk assessment methodologies.
- reducing the uncertainties in data and assumptions used to develop safety submissions for plant at Sellafield.
- keeping abreast of worldwide technological developments and safety standards in the various technical areas.
- contributing to the development of these technologies and standards and the underlying fundamental science.

74. There is co-operation between the reactor licensees and Sellafield in those areas where there are interests in common, such as Control and Instrumentation, External Events, Human Factors and Waste and Decommissioning. Defence licensees also share information with the civil nuclear safety research programme in the Control and Instrumentation and Waste and Decommissioning technical areas.

Action by Members

75. Review Group 6 is invited to note and comment on the contents of this paper.