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HEALTH AND SAFETY COMMISSION

HSC Coordinated programme of Nuclear Safety Research
Evaluation report for 2003/04

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Issue

1. This paper is the report on the annual evaluation of the HSC Coordinated programme of nuclear safety research, commissioned by HSE and the reactor licensees in 2003/04. This is a report on an ongoing programme, overseen by HSE under guidelines agreed by HSC with the DTI and assesses the efficiency, effectiveness and benefit to nuclear safety of the Nuclear Power Reactor Programme which forms part of the HSC's Nuclear Safety Research (NSR) Programme.

Timing

2. Routine.

Recommendation

3. HSC is invited to note this paper.

Background

4. HSE is responsible for coordinating a NSR programme that satisfies the objectives of guidelines agreed with the DTI. These are:

- primary objectives: to be balanced and adequate, to maximise contributions to nuclear safety, to be disseminated appropriately
- secondary objectives: to support independent capability, to take suitable advantage of international collaboration.

5. In 2003/04 this NSR programme included the nuclear power reactor sites and the BNFL Chemical Plant sites. HSE coordinates the programme for nuclear power reactor sites with the nuclear licensees British Energy (BE) and Magnox Electric. New arrangements for managing this coordination were approved by the HSC (paper HSC/02/89) and put in place for 2003/04. They reflected the significant changes in the industry and the divergence of interests of British Energy and Magnox Electric as magnox reactors are progressively phased out. These arrangements have been reviewed subsequently by the Nuclear safety Advisory Committee (paper

NuSAC/SCR/04/1) and found to be operating satisfactorily. The arrangements require that at the end of the annual programme HSE and the nuclear licensees evaluate the effectiveness, efficiency and benefit to nuclear safety of the research that was commissioned and that HSE coordinates a report to HSC.

6. HSE did not commission any research under its Levy programme with relation to BNFL Chemical Plant sites and moreover the more recent arrangements by which BNFL responds to HSE's concerns are less prescriptive than for the nuclear power sites that are historically based on the original DTI funded programme. As a result a detailed programme is not required to be agreed with the HSC. For these reasons an evaluation of the BNFL Chemical Plant sites research would not be appropriate.

Argument

7. The plan and outturn (excluding VAT and management charges) for the nuclear power reactor sites programme are compared below.

£k	Plan	Outturn	Outturn/plan
HSE	1562	1595	1.02
BE	3337	2689	0.81
Magnox	3635	3224	0.89
Total	8534	7508	0.88

The reductions in the licensees' programmes were agreed with HSE but were largely due to operational work on the plants taking precedent over research and technical difficulties causing delays in contracting the research.

8. In summarising the evaluation of the HSE levy programme (Annex 1) it is concluded that the research was commissioned to plan and budget. For the great majority of the research the performance of the contractors was considered good or acceptable and 100% of the research outcomes were made available to the nuclear licensees of which 75% was considered of safety benefit to operating nuclear power plants. The research was successful in informing HSE on international developments on PWR technology and was important in securing access for both HSE and the nuclear licensees to essential sources of nuclear safety research capability.

9. The shortfall in the BE programme was due largely to BE staff being diverted onto operational structural integrity and graphite issues resulting in both internal and external projects being delayed. Some other projects did not proceed any further when the outcome of previous work was known. All changes to the programme were agreed with HSE. The technical exchanges with BNFL and HSE worked effectively and 100% of the research outcomes were made available to HSE. Annex 2 provides some good examples of where the research has been of benefit to nuclear safety.

10. Nearly all the Magnox Electric projects proceeded to plan and a high proportion of these were done in collaboration with BE. The 9% underspend was due mostly to a single large project in the area of waste and decommissioning not proceeding although part of the available budget was reused to fund other research on waste and decommissioning and graphite. All the research outcomes were made available to HSE and some of the benefits to nuclear safety are given as examples in Annex 3.

Consultation

11. The Nuclear Safety Advisory Committee, through its sub-committee on research (NuSAC SCR) has considered the three evaluation reports at its September 2004 meeting. MOD and DTI also attended the meeting as observers. The outcome of the programme has been made available to other parts of HSE.

Presentation

12. HSE is committed to disseminating research results that have implications for nuclear safety, and has previously developed a strategy for the dissemination of information which has been endorsed by the NuSAC SCR. The HSE website is used to provide information on the strategies and research issues which drive the programme. This information provides the means for identifying and requesting further information on research that HSE and the licensees have undertaken. In addition, HSE provides a list of research reports and have plans to put research reports more than 2 years old on the website. Nuclear safety research is shared with the rest of HSE through HSE's Science Coordinators network. HSE recognises licensees' ownership of intellectual property derived from their programmes and has agreed how requests for results are considered. Communications directorate has cleared the presentational aspects of this paper.

Costs and Benefits

13. The research outcomes are shared more widely in HSE and with external technical community through the website. However, HSE is more proactive in sharing outcomes such as on control system modernisation across HSE and non-destructive testing of concretes with the Highways Agency.

Financial/Resource Implications for HSE

14. The cost of the research commissioned by HSE and the programme management charges has been recovered by a levy on the reactor licensees. There are no additional financial implications for HSE.

Other implications

15. N/A

Next steps

16. HSC is asked to note the evaluation of the 2003/04 NSR programme.

ANNEX 1 EVALUATION OF HSE LEVY PROGRAMME

Safety benefits generally

1. The projects are categorised in table 1 and the quantitative results are summarised in Table 2. Various descriptions of the safety benefit were considered, not mutually exclusive. They considered to be, in descending order of frequency of mention:

- Maintaining knowledge and expertise in the regulator and licensees
- Underpinning existing safety cases
- Providing information for new safety cases
- Reducing uncertainties
- Long term safety benefits
- Short term safety benefits

2. Research is not the only route for maintaining expertise, and other routes for the regulator include conferences, working groups of international agencies and bilateral meetings with other regulators.

3. There was a slight bias towards longer-term benefits as opposed to immediate short-term safety gains. This may be contrasted with USNRC research policy, where the aim is to have about 80% confirmatory (short term) research and 20% anticipatory (long term) research. However because of the greater degree of collaboration in the UK research system, the industry is expected to commission the majority of the short-term research, in order to ensure early and effective impact. The regulator also uses the support programme for confirmatory work.

4. 75% of the projects were regarded as providing actual or potential safety benefits to operating stations. There were various reasons for failure to produce any safety benefit:

- announcement of closure of Magnox stations overtaking need for research,
- failure of proposed international activity to happen,
- PhD theses did not yield any significant results.

However it is intrinsic in any true research that the outcome is in doubt, and this is regarded as an acceptable success rate. The first of these reasons is

an externality beyond the control of the programme. International activities are a higher risk, but because of the advantages of gearing and international benchmarking are still worthwhile. Similarly, funding PhD students is a higher risk, but because of the low cost and the support given to a university department, is also worthwhile.

Maintenance of expertise projects (Independent Technical Capability and Essential Research Capability)

5. The projects are categorised by the technical area.

Chemical Processes

- HSE funded licensee Essential Research Capability (ERC) work on PWR coolant radiation chemistry, which improved understanding of the transport of activated corrosion products, which impacts occupational radiation exposure. The results may be applied possibly by modifying coolant chemistry and putting limits on core design. Two contracts were given, one being to a consultant to provide additional advice to support the work.
- HSE funded licensee ERC work on AGR radiation chemistry and this increased understanding of the chemical mechanisms leading to oxidation of the graphite core and subsequent deposit of carbon around the gas circuit. This work underpins the safety case for operational changes, such as the injection of carbonyl sulphide, to combat these problems.
- HSE funded licensee ERC work on iodine chemistry which improved the understanding the behaviour of iodine in Design Basis Accidents and during shutdown. The results can be applied in improvement of the PWR safety cases.

All the chemistry ERC support has now been transferred to the licensees.

Control & Instrumentation

- HSE funded work on AGR neutron flux detectors. There are not enough spares for the lifetime of the reactors, and the manufacturing capability has not been used for a number of years. Research has developed new processes and associated manufacturing specifications for producing seals for detector chambers that overcame the problem of gas leaks. The UK has lost the capacity to manufacture high quality cables and alternative

sources and approaches are being considered. The operational requirements for the cables are also being reviewed.

Fuel and Core

- HSE funded a PhD thesis on the evaluation of volatile fission product mechanisms for limiting or enhancing release, but the results were not usable, and the student did not join the nuclear industry afterwards.

Graphite

- HSE funded work at Manchester University on stress analysis of graphite which identified the limitations of existing computer codes and produced a new module for the commercial code ABAQUS. This supports decisions on safety case assessments.
- HSE funded a PhD thesis on graphite at Manchester. The results were of limited direct benefit and the student did not join the nuclear industry afterwards.

<u>International collaboration projects</u>

6. The projects are categorised by the technical area.

Civil Engineering

- HSE organised UK participation in an OECD-NEA round robin post-test analysis of a Pre-stressed Concrete Containment Vessel test. This gave experience of using Finite Element analysis at the limit of its current capability for cracked concrete, and will inform judgement on future safety cases. The UK performed well and the licensee is funding further work in this area.
- HSE organised UK participation in the Reunion Internationale des Laboratoires et Experts des Materiaux, Systemes de Constructions et Ouvrages (RILEM) Technical Committee on Non Destructive Examination of concrete, but the activity failed to occur as proposed.

Control & Instrumentation

- HSE funded UK participation in the FP5 Cost Effective Modernisation of Systems Important to Safety (CEMSIS). The general principles of the goal-based approach can be applied to existing refurbishments, but further work

is needed for detailed application of the formal methods to real plant upgrades.

Fuel and Core

- The UK participates in the OECD-IRSN Cabri project, testing high burn-up fuel under reactivity insertion accidents. Work was carried out at Winfrith analysing proposed thermocouple measuring system, to ensure that the test conditions were prototypical of PWRs and to remove uncertainties about the correlation between the measurements and the plant conditions. The results will be applied to plant eventually, through better confidence in the results of the Cabri project. IRSN accepted these as part payment in kind for Cabri, so the work was cost neutral and helped to maintain UK expertise.

Nuclear Physics

- HSE organises UK membership of the NEA Databank through the levy. Nuclear data is needed for reactor physics, transport, core-shuffling, shielding, criticality and fuel burn-up calculations. Old nuclear data was not quality assured, and was artificially corrected to integral tests. The new Joint Evaluated Fission and Fusion (JEFF) data uses unadjusted basic data and combines the fission and fusion data. HSE recovers part of the subscription from other UK interested parties. The UK needs to use modern data if it wishes to be competitive in this field internationally.
- HSE organises UK membership of the European WG on Reactor Dosimetry. This provides calibration and validation of the MCBEND code used by the licensees, and enables comparisons with the international code MCNP. The results are needed for the calculation of the properties of steel and graphite. The results are disseminated through the UK Nuclear Shielding Forum and its associated website.

Plant Life Management (steels)

- HSE funded 2 projects in the FP5 VOCALIST project on the effect of constraint on the fracture behaviour of steel (including overall coordination). This was expected to provide benefit for the analysis of

Magnox RPVs, but in the event this was overtaken by the announcement of the Magnox closures.

PSA

- HSE organises UK membership of the OECD-NEA International Common Cause Failure (CCF) Data Exchange (ICDE), and gives a contract to a consultant to do the data collection from the licensees and contribute to reports published by NEA. The database can be used to identify unusual mechanisms of failure and to generate statistics on the frequencies of CCFs and their causes. The results can be applied by operational experience feedback and the production or validation of CCF probability estimates for PSAs.

Radiological Safety

- HSE funded liaison and technical support with the Cadarache Phebus project on fission product release. This might help to quantify uncertainties in source term release with respect to organic iodine. As the cost was high in comparison with the limited relevance of the research to UK safety issues, it has been decided not to continue with Phebus liaison, although the Phebus project continues.

<u>Other projects</u>

7. The projects are categorised by the technical area.

Plant modelling

- A PhD student at Imperial College was funded to work on large break LOCA issues. Previous models only analysed one sub channel, but now for the first time there is a model that can analyse 12 sub channels, studying multi-rod behaviour for clad ballooning and core blockage. This has already allowed sensitivity studies to be done for proposed French advanced fuel cladding for Sizewell B. Further development is needed before the method can be used as a principal safety case tool. An application has been made for EPSRC ‘Keeping the Nuclear Option Open’ funding for this work.
- Analysis of post critical heat flux using the US code RELAP5 was funded to demonstrate the fuel clad temperature margin under Design Basis

Accidents. This has been used as a sensitivity analysis to support the Sizewell B safety case

Issue closure

8. Issue closure is HSE's primary measure for evaluation of the total programme. 25% of the related issues could be closed, which is a reduction from the previous year's figure. The levy programme arises mainly from issues of maintenance of capability and maintenance of contact with international activities. These are by their nature often ongoing for considerable periods of time, and not amenable to closure by a single project, so HSE does not regard issue closure as an important criterion for levy projects. HSE could consider distinguishing such issues in the new format of NRI under development, in order to obtain a better measure of progress in closing issues. Resource constraints have continued to delay changes to the NRI database.

PROGRAMME STRATEGY AND OBJECTIVES

10. These may be taken from the strategy in the 2003 issue of the NRI. It may be seen that the levy programme directly executes the relevant parts of the strategy for the two supporting objectives of the DTI Guidelines, on maintaining access to independent capability, and international collaboration. Some general remarks about the 03-04 levy programme (not just the completed projects) are made here:

Independent Technical Capability

11. This is the subject of an annual review by HSE, reported to NuSAC SCR. The main consideration is the graphite team at Manchester, which was set up at the end of 01-02, and 03-04 was its second full year of operation. It has now been successfully established. HSE conducted an internal review and decided that the team should be encouraged to seek work from the licensees. With this aim, HSE has given 2 years notice that the agreement to guarantee minimum funding for the team will be ended, and the protocol restricting use of the team by the licensees has been terminated.

Essential Research Capability

12. This is the subject of an annual review by the licensees, reported to NuSAC SCR. There was continued maintenance of those teams identified by the review. As reported previously to the SCR, from 04-05 essentially all ERC will be included in the licensees' programme.

International collaboration

13. About half of the levy programme is multi-year international projects, and examples of the use to which these are put were given in paper 04/7. There was significant participation in FP5 and NEA projects and databases. The evaluation here confirmed the view that although they may offer good gearing and a demonstration that the UK is abreast with the state of the art, they can be slow and inflexible, and may be rendered irrelevant by changed national circumstances. DTI/OST has recently published a report on the impact of the EU framework programmes in the UK (http://www.ost.gov.uk/ostinternational/fp7/pdfs/evaluation.pdf), which addresses FP4 and FP5. HSE is currently carrying out a UK consultation on the possible content of a Euratom FP7 programme on safety of reactor systems to provide advice to the EC.

Table 1 - Completed and evaluated projects classified by technical area and research category

Technical Area	*INT'L*	*ERC*	*ITC*	*Gap filling*	*Other*	*TOTAL*
Chemical Processes		4				*4*
Civil Engineering	2					*2*
Control and Instrumentation	1	.5	.5			*2*
External Events						*0*
Fission Products						*0*
Fuel and Core	1		1			*2*
Graphite			2			*2*
Human Factors						*0*
Nuclear Science	2					*2*
Nuclear Systems & Equipment						*0*
Plant Life Management	2					*2*
Plant Modelling					2	*2*
Probabilistic Safety Assessment	1					*1*
Radiological Safety	1					*1*
Waste Management & Decommissioning						*0*
Totals	*10*	*4.5*	*3.5*	*0*	*2*	*20*

Notes
INT'L = International Collaboration
ERC = Essential Research Capability
ITC = Independent Technical Capability

Table 2 –Summary of evaluation results

Research category	
International activity	50%
NSD Independent Technical Capability	22.5%
Licensee Essential Research Capability	17.5%
Filling gap in licensee programme	0
Other	10%

Safety benefits to operating stations	
None	25%
Already applied	20%
Immediately applicable	25%
Applicable in next 5 years	30%
Applicable in more than 5 years	0

Contractor performance (%)			
	Good	Acceptable	Poor
Meeting specification	65	25	5
Meeting objective	70	20	5
Scientific quality	75	15	0
Report Standard	50	40	0
Value for money (incomplete response)	50	35	0
Meeting budget costs	55	35	0
Meeting timescales	45	35	15
Keeping project officer informed	60	25	5

The figures do not necessarily total 100%.

ANNEX 2 EVALUATION OF BRITISH ENERGY 2003/04 NUCLEAR SAFETY RELATED RESEARCH PROGRAMME

BENEFIT TO NUCLEAR SAFETY

1. It is recognised that the benefits provided to nuclear safety are a key indicator in assessing programme effectiveness. Although contributions to nuclear safety are not monitored on a regular basis, examples are provided of where the research programme has contributed to nuclear safety.

2. Projects in the Plant Life Management area have contributed to a major re-issue of the R5 Procedures: Assessment of Structural Integrity at High Temperatures. The R5 Procedure is the principal methodology used by BE to assess the integrity of AGR components operating at high temperatures. It applies to both defect-free components and components containing defects.

3. In the Control and Instrumentation area the project on Improvements in Legacy Code Analysis (ILCA) has provided a more efficient and focused method for statically analysing software (MALPAS) for safety critical applications and has re-hosted MALPAS on a modern platform. It also captured knowledge about British Energy's source/code comparison process to support the technique after key staff retire, enabling code and data constituting the Sizewell B PPS to be checked against its source files.

4. In the Chemistry area a project using the Wythenshawe Boiler Rig was part of a programme of work to evaluate the consequences of iron transport in AGR boilers and to develop countermeasures. One candidate countermeasure is the use of an alternative amine to ammonia as the alkalising agent in boiler feed water at two AGR stations. The project addressed potential damage to boiler tubes in the event of a chemistry fault and showed that the potential for damage was no worse than when using ammonia.

5. In the Graphite area, details of the programme were presented to the April 2004 NUSAC-SCR meeting. The results from the Crack Shear testing project were used directly in the graphite core safety case on Early Life Bore Cracking. It has also led to further work on irradiated graphite. The results from the project on the Investigation of Partially Cracked Bricks was used to support the safety case judgement (in the cliff edge) for the behaviour of partially cracked bricks.

6. In the Plant Modelling area, the project on quality and trust in the Computational Fluid Dynamics Calculations was used to significantly reduce uncertainties in numerical predictions of weld temperatures in boiler spines in AGR stations.

7. In the Nuclear Systems and Equipment area, alternatives to SIL 80, an elastomer seal formulation used in pressure boundary applications, which

is being discontinued by the supplier have been evaluated. The maintenance of technical expertise is also supported, which has been deployed throughout the year on fuel route and conventional plant operational problems.

8. In the Human Factors area it was recognised that the current approach to quantifying operator actions in safety cases would benefit from updating so as to take advantage of recently available human reliability data and the experience gained from the periodic safety review probabilistic safety analyses. This has resulted in a project to develop the Nuclear Action Reliability Assessment (NARA) technique. The initial phase of developing the technical basis for NARA is now complete and a user manual has been piloted at a workshop attended by BE and NII staff. Whilst the new technique is seen as being an improvement on current quantification techniques its suitability for use in future safety cases needs to be established. To this end BE and NII are working together to arrange for an independent peer review of NARA.

9. In the Civil Engineering area, the unique multiaxial concrete test rig at Sheffield University continued to gather data on the mechanical behaviour of concrete that is relevant to potential fault conditions in PCPVs. This work continues to improve the capability to model and understand such events, which supports safety case development and can lead to development of guidance on appropriate actions following an event.

ANNEX 3 EVALUATION OF THE MAGNOX GENERATION 2003/4 NUCLEAR SAFETY RELATED RESEARCH PROGRAMME

BENEFIT TO NUCLEAR SAFETY

1. It is recognised that the benefits provided to nuclear safety are a key indicator in assessing the programme effectiveness. In order to help evaluate the outcome of the 2003-4 research programme and to provide some further detail of the type of work undertaken, some examples of the projects which were completed are provided below together with their actual or potential application in improving nuclear safety.

2. Control and Instrumentation

   Significant phases of projects related to the use and evaluation of high-integrity software were completed during 2003/4.

   - Research into the comparative merits of dynamic testing and formal analysis in software assessment was undertaken with the aim of focussing assessment effort and giving greater confidence that the range of assessment techniques applied to a given system would identify potential faults. The project reviewed a wide range of dynamic and static techniques and produced a categorisation of defects and the techniques having the potential to reveal them. It concluded that a range of techniques should be applied in order to detect faults in each category. It proposed a framework to assist projects in their choice of appropriate techniques. The continuation project running during Financial Year 2004-5 will further develop the framework, underpinned by detailed justification, and will apply it to a case study.

   - Research into the safety implications of using Personal Computers in low Safety Integrity Level applications was undertaken in response to the trend towards use of PC-based solutions for data-gathering and plant status monitoring in performance of functions having a low target integrity. The project had two objectives. These were: to carry out a brief survey of the use of PCs in such applications and to review possible strategies for safety justification of such systems (having regard to the potential complexity of such an implementation and the difficulty of building a safety justification for a commercial operating system). The project examined the ways in which such justifications have been made in several industrial sectors and has identified the inherent difficulties involved as well as the advantages, primarily in the human factors aspects. An outline approach for justification of a PC-based system was proposed. The project provided a sound basis for future work; a continuation project running during Financial Year 2004-5 will build on this to produce a detailed justification strategy and will apply it to a case study.

   - It is becoming increasingly difficult to obtain analogue instruments to replace obsolete instruments currently installed in stations, and it is often the case that ‘smart’ instruments provide superior performance in

some respects (e.g. their self-test functionality is generally much superior to that of analogue instruments). There are problems in justifying the use of these instruments for safety-related functions; the results of this project indicate how a safety justification for such an instrument might be constructed. ‘Smart’ instruments are generally not used in nuclear safety related applications, however, alternatives may cease to be available. This area of work is therefore of significant interest to Reactor Sites.

The work completed to date has demonstrated significant progress in establishing typical properties of smart sensor software and the feasibility of analysis methods that can be applied. Further work is needed which in conjunction with the other related projects should provide specific proposals for tools and techniques that can be used to support the use of ‘smart’ devices.

3. Fuel

Research into uranium ignition was completed. It was found that in conditions of poor heat transfer, such as cooling by natural convection, the current safety limit of 250°C was conservative. The model proposed can be applied to specific scenarios/locations in the fuel route to reduce waiting times before air is admitted. This work has enhanced confidence in existing safety cases.

4. Graphite

A large programme of research investigating various aspects of graphite ageing was undertaken during 2003/4. This work area was the subject of a technical presentation at the previous meeting of the Sub-Committee. Much of the work programme continues into 2004/5. However the following projects were completed.

- A project investigating the effect of small sample size on mechanical property measurements was completed. The aim of the project was to underwrite current measurement techniques used to support the Magnox core safety cases. It was found that sample size does have an effect on the value of the measured property. However, for a variety of reasons sample size effect is not expected to influence results currently obtained from standard graphite monitoring campaigns. The data are consistent with data obtained from compliant tests and/or certified standards.

- A project to investigate the suitability of using bending tensile strength as the basis for the structural tensile strength of graphite was completed. It was confirmed that the current safety case assumption that flexural strength was the appropriate measure of strength was correct. However it was concluded that flexural strength values should be adjusted to account for the effects of stress volume and biaxial stressing. This new knowledge has already been incorporated into several graphite core safety cases.

5. Nuclear Systems

Research and development into several new camera and manipulator systems was completed

- Infra red (IR) imaging for in reactor inspection is becoming an established technique. IR imaging is also used in BNFL process cells for fire detection. This project is developing an IR camera that is compact and radiation resistant and can be delivered into hostile environments by remote manipulators. The potential gain in terms of increased frequency of inspection and reduced operator exposure are clear provided high reliability can be realised. Improved non-destructive examination of reactor insulation and components will also support the production of high quality safety cases and a better understanding of failure mechanisms. New designs of Infra-Red camera have been developed using ferroelectric and microbolometer technologies. The former is already being used very successfully for Magnox reactor inspections and the latter is being considered for similar AGR use in conjunction with the Triumph manipulator.

- The Crane Free Delivery System (CFDS) is a vertical delivery system. The aim of the project was to extend this crane-free capability by the provision of an extending arm mounted on the base of a CFDS manipulator. This will permit inspections and other activities up to 5metres from the vertical axis of the delivery manipulator. It will also be usable with other manipulators of conventional designs. The arm is capable of carrying a lightweight inspection (television and lighting) or other workpackage of up to 2 kg when fully extended to 5 metres.

6. Chemistry

- Significant work was completed to improve the understanding of mechanisms of Magnox and Uranium corrosion in the Magnox fuel route, in particular in station ponds and fuel transport flasks. The results are being used to assess the corrosion rates of Magnox clad and exposed uranium in Magnox fuel cooling ponds and supports the maintenance of good pond chemistry control.

- A phase of a project was completed on the mechanisms of filtration which occur in sand bed filters. The resulting data supports the maintenance of particulate control in station ponds and liquid effluent control.

7. Radiological Safety

    - A project designed to provide a practicable means of detection, characterisation and assessment of the doses from hot particles was completed. Although no direct enhancement of safety at power stations will result, the work has enhanced confidence by providing a more robust method for calculating doses from hot particles.

    - Work aimed at determining the effect of ruthenium on the efficiency of charcoal to retain iodine was completed. Two theoretical studies and

two series of experimental tests have shown that activated charcoal, installed at Magnox and AGR stations to remove fission product iodine from a gas stream, would also be effective in removing fission product ruthenium. The adsorption of ruthenium would not significantly impair the ability of the charcoal to adsorb iodine from the gas nor cause the release of previously adsorbed iodine. For the quantities of ruthenium of interest, the retention of ruthenium would cause no significant increase in bed temperature.

8. Plant Life Management

- No NRI related projects were completed in this area.

9. Human Factors

- Magnox Electric decided on the basis of experience with other approaches, that it needed a more useful and engaging tool to assess its safety culture. It needed to be simple to use by non-experts, help to set and compare against an appropriate standard, be able to target areas for improvement, engage with staff and help to communicate the safety improvement strategy. A new Safety Culture Assessment and Rating Tool (SCART) has been developed. Part of the SCART approach is to identify how improvements can be made, and these options can then be discussed by senior management to help develop action plans. NII have expressed the view that SCART represents a significant step forward.

- Magnox Electric believes it has a good understanding of the Human Factors issues as they impact on normal nuclear generation activities. However, with stations now reaching the end of this phase and entering defuelling and decommissioning, it was felt necessary to explore whether some of these factors gained added significance or whether there were new factors to be taken into account for these new phases. The project produced a structured review of the HF issues in defuelling and decommissioning. It also gave some suggestions as to how these issues could be addressed. The output should provide increased management awareness of issues and better management of those issues.

10. Waste and Decommissioning

The Waste and Decommissioning section of the NRS formed by far the largest component of the research portfolio consisting of 33% of project numbers and 60% of the cost. 21 projects, or significant phases of projects, were completed during the year.

- Initial work was completed to investigate the likely behaviour of the pre-stressed concrete pressure vessels at Oldbury and Wylfa under various loading scenarios so that maintenance requirements during the Care and Maintenance phase of their life and any subsequent final dismantling and site clearance requirements are fully understood. The

implication of removing the pre-stress load by detensioning the pre-stress cables was examined.

- Work was completed on further development of the ‘MAGGAS’ computer code which aims to provide a calculational method of the estimation of gas generation rates from cement encapsulated wastes.

- Further work was completed to better understand the effect of waste drum movements on corrosion rates. It has previously been found that, following movement of the drum, the internal drum corrosion rate increased by a factor of 30 and remained high for a period of weeks. A fully instrumented test drum has been built and will be used to establish whether the effect observed is real. If it is, the strategy for drum movement will be reviewed.

- A review of the implications for seismic safety cases of the information contained in the European Strong Motion Database was completed. Potentially, the results of the study could be used to identify the apparently significant margins in seismic assessments using existing formal methods.