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HEALTH AND SAFETY COMMISSION

HSC Coordinated programme of Nuclear Safety Research Evaluation report for 2004/05

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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 2004/05.

Timing

2. Routine.

Recommendation

3. HSC is invited to note this paper.

Background

4. 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.

5. 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.

6. In 2004/05 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.

Arrangements for managing this coordination 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.

7. HSE did not commission any research under its Levy programme in relation to BNFL Chemical Plant sites. Although HSC does not approve the BNFL Sellafield nuclear safety research programme, it was advised that HSE would audit the Sellafield 2004/05 programme. Therefore an evaluation of the 2004/05 Sellafield programme has been attached at Annex 4.

Argument

8. 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	1174	1187	1.01
BE	3105	2707	0.87
Magnox	3619	3150	0.87
Total	7898	7044	0.92

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.

9. 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 95% was considered of safety benefit to operating nuclear power plants. The research was successful in informing HSE on international developments on Pressurised Water Reactor technology and was important in securing access for both HSE and the nuclear licensees to essential sources of nuclear safety research capability.

10. The shortfall in the British Energy programme was due largely to British Energy staff being diverted to emerging operational issues, resulting in delays in implementing projects with external contractors. This also resulted in delays in research projects being undertaken by BE internal resource. There was a continuing tendency for budget forecasts to be "upper bound" rather than "best estimate". Commercial pressures within British Energy introduced in late 2004 led to restrictions on external spending that led to some projects not being started and external spending on others being reduced. Annex 2 provides some good examples of where the research has been of benefit to nuclear safety.

11. During the year work on 87 Magnox Electric projects took place including 38 collaborative projects undertaken with British Energy. The 11% under-spend was mainly due to a reduction in the scope of work in the Waste and Decommissioning technical area, as well as work being delivered below the originally estimated values.

All significant changes to the projects were discussed with NII research representatives as part of the normal Technical Exchange arrangements. 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

12. The Nuclear Safety Advisory Committee, through its sub-committee on research (NuSAC SCR) has considered the three evaluation reports at its September 2005 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

13. HSE is committed to disseminating research results that have implications for nuclear safety, and has previously developed a strategy for the dissemination of information that 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

14. 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

15. The cost of the research commissioned by HSE and the programme management charges has been recovered by a levy on the reactor licensees. The costs of oversight of the BNFL programme were recovered through the regulatory route. There are no additional financial implications for HSE.

Other implications

16. N/A

Next steps

17. HSC is asked to note the evaluation of the 2004/05 NSR programme.

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ANNEX 1 EVALUATION OF HSE LEVY PROGRAMME

Safety benefits generally

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

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

These descriptions are fairly subjective, and the results were rather different from last year, although that may be due to the small number of projects. However, the high position of knowledge maintenance, and the preponderance of long-term benefits over short-term benefits was maintained. (Research is not the only route for maintaining expertise for the regulator, and other routes include attendance at conferences or working groups of international agencies, and bilateral meetings with other regulators.)

2. 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.

3. 95% of the projects (all but one) were regarded as providing actual or potential safety benefits to operating stations. However it is intrinsic in any true research that the outcome is in doubt, and this is regarded as an acceptable success rate.

Maintenance of expertise projects

(HSE Independent Technical Capability and Licensee Essential Research Capability)

4. The projects are categorised by technical area.

Chemical Processes

- HSE funded licensee Essential Research Capability (ERC) work on PWR coolant radiation chemistry, which improved understanding of the deposition of activated corrosion products, including boron, which affects reactivity control. The results may be applied by modifying coolant chemistry and putting limits on reactor operation.
- 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. Phenomenology is being replaced by a mechanistic understanding. This work underpins the safety case for operational changes, adjusting the coolant composition to slow down core degradation.
- HSE funded ITC work with a consultant on secondary side corrosion chemistry. This addressed some short-term issues such as boiler corrosion and also increased understanding of longer term degradation issues.
- HSE funded ITC work on PWR primary side water chemistry. This increased the understanding of the effect of this on out-of-core doses, deposition on fuel and corrosion of primary circuit materials. It has applications to setting conditions and limits on PWR coolant composition.

Control & Instrumentation

- HSE funded licensee ERC work on reactor protection equipment, preserving the ability to maintain Laddic logic systems for protection equipment used by BE and Magnox. There is only one UK supplier. New equipment is being installed, and the need for this capability will continue until the end of the station's operation.

Graphite

- HSE funded work at Manchester University on stress analysis of graphite which assists HSE to assess the validity of graphite stress calculations.

- HSE funded work at Manchester University on graphite cracking. The results were of no significant benefit, but contributed to the maintenance of the Independent Technical Capability in graphite at Manchester University.

Conclusions on Independent Technical Capability

5. 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 04-05 was its third 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 gave 2 years notice over a year ago 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. HSE's main independent source of technical advice on graphite is now the Graphite Technical Advisory Committee.

Conclusions on Essential Research Capability

6. 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 and mentioned above, from 04-05 essentially all ERC was included in the licensees' programme. The three remaining ERC projects evaluated here have now been transferred to the licensees.

International collaboration projects

7. The projects are categorised by the technical area.

External Events

- HSE funded participation in an international evaluation of fire models for nuclear power plants, organised by USNRC. This gave a greater understanding of the behaviour of fires within compartments, and the results can be applied in design of new plant and modification of existing plant.
- HSE funded participation in an IAEA Coordinated Research Project, benchmarking methods for 'pushover' non-linear analysis for the seismic performance of concrete structures. The results will be disseminated as an IAEA TECDOC. The method has already been proposed by licensees, but HSE needs further validation.

Plant Life Management (steels)

- HSE funded 2 projects in the FP5 ADIMEW programme, on Assessment of Dissimilar Metal Welds (DMWs). ADIMEW identified failure modes in DMWs, and the results are being incorporated in the validation of the R6 structural integrity assessment method.
- HSE funded 2 projects in the FP5 PISA programme, on Phosphorus Influence on Steel Ageing. Phosphorus segregation leading to intergranular fracture is an embrittlement mechanism of irradiated RPV steels recently discovered by work associated with Trawsfynydd. The PISA programme gave a better understanding of this mechanism over a range of steels and irradiation conditions. It is an additional embrittlement mechanism potentially leading to increased shifts in the ductile-to-brittle transition temperature, which are important in determining the pressure / temperature limits on RPV operation. It has been included in the dose / damage relationships underpinning reactor safety cases.
- HSE funded 2 projects in the FP5 SPIQNAR programme, on improved methods of inspecting intergranular Stress Corrosion Cracking in austenitic steels. The capability of detecting such defects was evaluated, including as assessment of signal processing techniques to enhance signal-to-noise ratio.

Plant Modelling

- HSE funded participation in the NEA SETH project (Senior Experts Thermal Hydraulics). This was in two parts:
 1. PKL (Primaer Kreislauf) - Tests on boron dilution in fault sequences were done at Framatome ANP in Germany, addressing an emergent safety issue. The results are directly applicable to current safety assessments.
 2. PANDA – Tests at PSI in Switzerland gave information on buoyant jets in large spaces, useful for validating CFD codes and models, highlighting outstanding issues of numerical accuracy and time averaging. The data is potentially useful if the need for such validation arises in the future.

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 (learning from experience from individual events) and the production or validation of CCF probability estimates for PSAs.

Conclusions on International collaboration

16. Two thirds of the evaluated projects are international, and a similar proportion of the 04-05 levy programme is multi-year international projects. Examples of the use to which these are put were given in paper 05/9. There was significant participation in FP5 and NEA projects and databases, plus limited participation in FP6. The evaluation here confirmed the view that they offer good gearing and a demonstration that the UK is abreast with the state of the art. This year there was less concern than last year that they can be slow and inflexible, and may be rendered irrelevant by changed national circumstances.

17. They are mainly PWR oriented, and BE state that they should not pay 100% of the cost when the Sizewell B safety concerns are low and there is an element of Keeping the Nuclear Option Open in UK participation. HSE policy on PWR safety research is largely to keep a watching brief on developments abroad and to participate in appropriate international projects when the opportunity arises. DTI policy is evolving in this area, and it should be reconsidered.

Gap filling / Punitive top-up

9. No projects came into this category, reflecting the policy of obtaining consensus as far as possible.

Issue closure

10. Issue closure is one of HSE's main measures for evaluation of the total programme. 50% of the issues related to the evaluated levy projects could be closed, which is an increase from the previous year's figure (25%). 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 has added a field to the NRI database, indicating whether individual issues are closable by specific projects, or whether they are continuing duties, such as keeping a watching brief internationally or maintaining a capability.

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

<i>Technical Area</i>	<i>INT'L</i>	<i>ERC</i>	<i>ITC</i>	<i>Gap filling</i>	<i>Other</i>	<i>TOTAL</i>
Chemical Processes		2	2			4
Civil Engineering						0
Control and Instrumentation		1				1
External Events	2					2
Fission Products						0
Fuel and Core						0
Graphite			2			2
Human Factors						0
Nuclear Science						0
Nuclear Systems & Equipment						0
Plant Life Management	6					6
Plant Modelling	1					1
Probabilistic Safety Assessment	2					2
Radiological Safety						0
Waste Management & Decommissioning						0
<i>Totals</i>	<i>11</i>	<i>3</i>	<i>4</i>	<i>0</i>	<i>0</i>	<i>18</i>

Notes

INT'L = International Collaboration

ERC = Essential Research Capability

ITC = Independent Technical Capability(for HSE)

Table 2 –Summary of evaluation results

<i>Research category</i>		<i>03-04</i>
International activity	61	50%
NSD Independent Technical Capability	22	22.5%
Licensee Essential Research Capability	17	17.5%
Filling gap in licensee programme	0	0
Other	0	10%

<i>Safety benefits to operating stations</i>		<i>03-04</i>
None	5	25%
Already applied	17	20%
Immediately applicable	14	25%
Applicable in next 5 years	31	30%
Applicable in more than 5 years	14	0
When Required	19	0

<i>Safety benefits generally (%)</i>	
Long term safety benefits	89
Maintaining knowledge and expertise in the regulator and licensees	72
Reducing uncertainties	67
Short term safety benefits	44
Providing information for new safety cases	39
Underpinning existing safety cases	33
Development of safety standards / guidelines	22



<i>Contractor performance (%)</i>			<i>(03-04)</i>			
	Good	Acceptable	Poor	(G.)	(A.)	(P.)
Meeting specification	83	17	0	(65)	(25)	(5)
Meeting objective	83	17	0	(70)	(20)	(5)
Scientific quality	78	17	5	(75)	(15)	(0)
Report Standard	72	17	5	(50)	(40)	(0)
Value for money	56	39	5	(50)	(35)	(0)
Meeting budget costs	95	5	0	(55)	(35)	(0)
Meeting timescales	50	39	5	(45)	(35)	(15)
Keeping project officer informed	61	28	5	(60)	(25)	(5)

The figures do not necessarily total 100%.



➔ ***This information has been removed under Exemption 13 of the Code of Practice on Access to Government Information (commercial confidentiality)*** ←

ANNEX 2 EVALUATION OF BRITISH ENERGY 2004/05 NUCLEAR SAFETY RELATED RESEARCH PROGRAMME

BENEFIT TO NUCLEAR SAFETY

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.

The programme on Control & Instrumentation continued to support key teams in the fields of Nucleonics and Reactor Protection. A major success in this area was the re-establishment of the capability to manufacture DC12 Flux Detectors and their associated cables.

Projects on multiaxial testing of PCPV concrete, participation in the international analysis exercise for a model Containment Building, a non-NRI project on structural capacity of reinforced concrete and a non-NRI EURATOM project on modelling the response of concrete PCPVs / containments to faults were completed. The benefit to nuclear safety from these projects in the Civil Engineering area is the incremental improvement of the licensee's understanding of the various processes and techniques studied.

In the Fault Studies and Fuel area, work has generally progressed as expected. Major Projects that have gone well included: MACE and PANTHER work undertaken internally leading to maintenance of expertise and substantiation of underlying methodology; fuel work on underwriting PANTHER and ENIGMA and developing and maintaining AGR Fuel design expertise; and M5 clad and ENIGMA development.

In the Fuel Handling area: seal endurance data are regularly used to support plant assessments and to make forward lifetime predictions; the work on diagnostics and expert systems is strongly focussed on monitoring graphite core degradation via the interpretation of fuelling machine hoist load traces; revised instrumentation cables have been successfully developed and installed in the fuelling machines at Heysham 2, Torness, Hinkley Point and Hunterston, providing significantly increased lifetimes, reducing the safety challenge of frequent cable changes; and the new design of tie bar cutters has been installed at Heysham 2 and at Torness, with greatly improved reliability and the immediate safety benefit of reduced operator doses from less frequent cutter exchanges and lower activity levels in the irradiated fuel disposal cells from reduced shard production.

There were several joint projects with BNFL Magnox on Graphite that were very successful and underline the view that within the graphite area, there are common research interests.

On Structural Integrity, progress went close to plan and in the area of Improvement in Assessment Techniques, all projects were addressed. The expected spend on the major R5 and R6 programmes was close to the budget estimates. A revision to the R6 procedure was sent out and work on the effects of interactions between

primary and secondary loads on creep crack growth allowed benefits to be taken from relaxation of secondary stresses, demonstrating increased safety margins. The CFD transfer of technology project has improved the accuracy of vertical, buoyancy affected flow calculations, which will be used during a re-assessment of the boiler spine safety case in 2005/06. Increased knowledge of the capability of radiography and ultrasonic inspection techniques on thin-section welds has been useful when assessing capabilities of inspections and the results are being fed into Capability Statements and Handbooks of Evidence.¹

ANNEX 3 EVALUATION OF THE MAGNOX GENERATION 2004/5 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's effectiveness. In order to help evaluate the outcome of the 2004-5 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

- **Software Test Coverage and Formal Proof**

Dynamic Analysis: Its Use in Safety-Critical Software Compared with Static Analysis

The project was undertaken in order to clarify the relative contributions to software assessment of dynamic testing and formal analysis. Such a clarification would potentially lead to more cost-effective assessment strategies and greater confidence in the conclusions drawn by assessment programmes.

This project has provided a better understanding of what the assessment programme for a given safety or safety-related system should be. In the case of systems having a low or medium target integrity, these insights should result in a better-focussed and therefore more cost-effective set of assessment activities.

Results will make a contribution to future assessment programmes in support of safety justifications.

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, and proposed the definition of fault spanning sets of detection techniques. The approach has yielded insights into what makes a software standard effective and what would constitute a range of assessment techniques appropriate for a required safety integrity level.

3. Fuel

- **Creep Failure of Fuel**

Experimental data on the formation of defects in unirradiated fuel cans were reviewed and the prediction of clad deformation using creep rate laws examined. It was shown that the clad deformation could be modelled using standard expressions for the creep of Magnox AL80. Empirical observations showed that hole size is inversely proportional to time-to-failure or strain rate, giving an empirical method for predicting hole size in a fault. Two modes of weld failure were identified, intergranular fracture at low strain rates and transgranular fracture at high strain rates. Attempts to predict hole size from accumulated strain predicted hole sizes that were far smaller than those observed in experiments. This work enhances confidence that off-site doses in a depressurisation fault will be small.

- Investigation of $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section

The $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section currently used in MCBEND has been compared with the data in the new 2002 International Reactor Dosimetry File (IRFD2002), and differences noted. An alternative evaluation of the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section has been reported. Both cross sections have been produced in a format suitable for input to the MCBEND code.

MCBEND calculations of $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ reaction rates have been performed using the new cross section, IRDF-2002 and the existing cross section data. These calculations were carried out for the following reactor locations representing the neutron dosimetry applications in UK power stations:

- Magnox side-core
- Magnox sub-core
- PWR surveillance capsule

It was found that all three cross sections gave good agreement in Magnox side-core and PWR surveillance locations, which are characterised by hard fast neutron spectra. In the Magnox sub-core location, which is characterised by a softer fast neutron spectrum, the new cross section was found to differ from the existing data and IRDF-2002 by an amount which is comparable with the uncertainty contribution currently applied to this reaction.

It is concluded that:

- Uncertainties in response cross section are unlikely to have contributed to the relative under-prediction of the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ reaction observed at the sides of Magnox reactors
- In PWR surveillance locations, $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ reaction rates are not sensitive to the cross section data
- The relative under-prediction of $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ reaction rates observed in Magnox sub-core locations is due to a different mechanism to the under-

prediction observed in Magnox side-core locations. Uncertainties in the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section remain a potential cause of this under-prediction.

- Neutron dose recommendations remain secure and no changes to data or methodology arise as a result of this investigation.

It has been shown that in Magnox side-core locations, and PWR surveillance locations, existing dose recommendations are not sensitive to uncertainties on the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section.

In Magnox sub-core locations, uncertainties in the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ cross section may help explain the recently observed under-prediction of the $^{93}\text{Nb}(n,n')^{93\text{m}}\text{Nb}$ reaction. Moreover, dose recommendations in such locations remain secure.

4. Graphite

A large programme of research investigating various aspects of graphite ageing and the development of new material testing techniques for graphite at high weight losses continued during 2004/5. The projects generally continue into 2005/6.

5. Chemistry

- No NRI related projects were completed in this area.

6. Radiological Safety

- No NRI related projects were completed in this area.

7. Plant Life Management

- NDT Workbench Development

The intelligent approach to inspection qualification has provided tools to

- determine inspection coverage,
- determine the “worst case” defect, i.e. the most difficult defect for that inspection
- model the response from the “worst case defect” using an expert system to select the appropriate model
- use evidence from previous practical trials as evidence of the capability of the current procedure.

These tools have been integrated into NDT Workbench which is an extensive software package developed for Magnox/BE by NDTSoft. The data processing and display functions of this software have been formally qualified

following the ENIQ methodology for analysis of data for Wylfa standpipe inspections.

The equivalence of data analysis using both GUIDE (the current software) and NDT Workbench provides further confidence in existing automated ultrasonic inspection procedures.

- Leak before break applications (R6)

The project aim was to investigate various aspects of leak-before-break analysis, including reference stress methods, crack opening areas, defect recharacterisation rules and leak rate estimation leading to improved advice.

1. The reference stress methods can be used to estimate crack opening area with appropriate definition of the reference stress.
2. Leak rate calculation methods have been specified in greater detail.
3. Defect recharacterisation rules were developed within the SINTAP project.
4. High temperature leak-before-break methods have been specified.

The work supports and enhances the R6 Procedure which has been updated to incorporate the results of this work.

8. Human Factors

- The issue of organisational drift was raised as a possible area for nuclear safety research by Magnox (first in 1999). The issue was expressed as a concern that an organisation might not pick up on its drifting standards either through operating experience feedback, self-assessment or external review. Whilst there are many tools and approaches which are deployed in the nuclear industry to carry out such monitoring and assessments, it was felt that organisational drift might only be identified using them if there was sufficient awareness of the issue within the organisation and the assessors. That is, the real issue was one of awareness of organisational drift, rather than any real weakness in the tools and approaches being applied. But it was felt that some work to review available tools to identify any potential gaps in their structure would be a useful means of raising awareness to the issues.

Since then, however, there have been several very high profile events both in the nuclear industry and outside which have in themselves raised awareness about such organisational weaknesses. These include the Davis Besse vessel head corrosion and the Columbia Shuttle accident. In both cases, there was major organisational failure. These events, and also some strategic thinking, have prompted a considerable response from the nuclear industry generally (INPO and WANO) and in both Magnox and British Energy. The report was therefore commissioned to review the issue of organisational drift and the effectiveness of currently used approaches to monitor for it.

- A model of Organisational Drift (OD) is proposed. There are two necessary conditions for OD to occur: degradation of key aspects of operational standards and failure of oversight processes (and both are vulnerable to common cause failure). The precursors are often put in place many years before the failure manifests itself. Current monitoring approaches are assessed in terms of degree of defence against OD, including WANO/INPO peer reviews, SCART (Safety Culture Assessment and Rating Tool), ISRS (International Safety Rating System), Performance Indicators, OEF (operating Experience Feedback), Nuclear Oversight Department (British Energy), Corporate reviews. The conclusion is that effective oversight process needs to be capable of both detecting deterioration in technical standards and in safety culture. It must also be independent from influences that could degrade the process itself. And it needs to be strongly linked to arrangements that ensure that actions are appropriate and implemented. None of the methods reviewed fully meet these requirements, but do address certain aspects.

9. Waste and Decommissioning

The Waste and Decommissioning section of the NRS formed by far the largest component of the research portfolio consisting of 40% of project numbers and 49% of the cost. 38 projects, or significant phases of projects, were completed during the year.

- Long-Term Monitoring of Cemented Waste Samples 2004/2005

The long-term behaviour of cemented samples containing simulated waste is a vital component of the 'Letter of Comfort' (LoC) process to enable the retrieval and packaging of waste for disposal to the Nirex specifications.

Long-term monitoring of cemented radioactive waste simulants is indicating that in the majority of cases there is little deterioration of the matrix over a number of years despite periodic problems with the storage environment and the non-representative nature of small samples compared with full-scale waste packages. Such failures as have been seen can be explained and are being addressed. These results would make a contribution to part of the Nirex LoC process and would be a component of the safety case for interim storage.

- Dismantling of Prestressed Concrete Pressure Vessel

An initial review of the consequences of destressing the Oldbury and Wylfa PCPVs, at the end of their service life, identified a number of areas for further review.

The purpose of the 04/05 project was to make further studies into the following:

- Developing outline method statements and associated budget costs for both destressing the Oldbury and Wylfa PCPVs, following defuelling, and for maintaining the stressing, to assist in any subsequent optioneering exercises.

- Assessing vessel liner stresses/strains following destressing
- Assessing the implications of any relevant external hazard loading, such as a seismic event, during the C&M Phase.

The options for managing the pre-stressing tendons in the Oldbury and Wylfa concrete pressure vessels have been examined. This included a study of the potential effects on the vessel liner, the costs and programme requirements.

The destressing sequence proposed is generally a reverse of the original stressing sequence with a small number of modifications, including taking advantage of the greater accessibility available for the operations. This sequence will be easy to substantiate and will minimise differential loading between the PCPV's components.

10. It can be seen from these examples that the output of the research programme is being, or will be, used to enhance nuclear safety, as intended.

ANNEX 4 EVALUATION OF THE BNFL SELLAFIELD 2004/05 NUCLEAR SAFETY RESEARCH RELATED PROGRAMME

1. This Evaluation Report identifies progress made in topics identified in the NRS for each technical area. In accordance with the Arrangements, appropriate contact has been maintained throughout the year between BNGSL and HSE technical personnel to communicate and monitor progress. The reviews below illustrate the success of the Arrangements in 2004/5 in increasing the visibility and transparency of key Sellafield research to HSE and NuSAC SCR.

TECHNICAL AREA REVIEWS

- Civil Engineering
- Aging and Degradation Mechanisms - Data base for key documents has been set up and Learning from experience sessions organized
- Pond containment - Further work carried out on water bars, empirical formula used with turbulent flow to establish potential leakage after a seismic event
- Application of nuclear structural design codes - training course on Eurocodes was set up involving BNGSL and HSE, and Magnox are being kept appropriately involved.
- Long Life Structures - improvements in the Generic Specification for Concrete based on the studies carried out in support of a Sellafield project which requires a 100 year design life
- Maintenance and Repair techniques - Report issued to the NII, and over 150 building surveys have been undertaken at the Sellafield Site.

- External Hazards
- Seismic Probabilistic Risk Assessment – A process for establishing the relative safety significance of potential seismic improvements has been implemented and trialled on plant.
- Seismic ALARP Methodology - Discussions were held with NII on Seismic ALARP for new and existing plants and a copy of the BNFL Guide BNF.EG.0074_6 “Application of BNFL Seismic Methodology for existing plants, modification, POCO and Decommissioning Projects” was issued to NII.
- Climate Change - A report “Review of Design Implications for Climate Change” was discussed with NII. A summary report covering the studies on climate change and the design implications has been completed.
- Seismic Hazard Techniques - Report RP/CSA/01829 “The Review of Seismic Hazard Studies for Chapelcross, Sellafield and Springfields Sites”, January 2005 was completed and discussed with NII.
- “Beyond Design Basis Events” Assessment Techniques - Guidance for new structures has been included in the recently completed revision to British Nuclear Group’s Design Criteria for Earthquake Resistance of Qualified Plants.

- Human Factors
- The NII research strategy identified the key area of Operational Experience Feedback. In particular it was felt that benefit could be gained examining the role of feedback engineers and feedback co-ordinators and in reviewing factors that influence the effectiveness of these key people. A research specification was issued by Sellafield to a research contractor in June 2004, and a proposal was received in August 2004 and placing a contract was progressed. Unfortunately, progress was slowed considerably by the unforeseen absence of key HSE and BNGSL personnel; subsequently, the task was reviewed, and it was agreed to slightly increase the scope of the research and to re-issue the research specification in 2005/6.
- Internal Events/Fire
 - Analysis and understanding of fire incidents on nuclear chemical plant - review of data collection process utilised by Sellafield fire and rescue and proposals to investigate other incident analysis tools already in operation at Sellafield.
 - Sharing best practices in fire assessment and management between Licensed sites - achieved through continued active membership of the Nuclear industry fire safety coordinating committee which has representatives from the U.K nuclear industry and the regulator.
 - Design fire challenges to ventilation systems used on nuclear chemical plant – Review of design processes for ventilation systems response to fire in nuclear chemical plant. Further enhancements to improve these are being actively considered.
- Plant Materials
 - An effective interchange was established between the NII and NSTS technical representative for the Plant Materials area in 04-05. Key technical areas were agreed for plutonium plants, highly active plants, long term fuel storage (in pond) and long term ILW storage. The programme for research in the HA plant corrosion was endorsed by NII both in terms of its foresight and the quality of the research. The programme for plutonium plants was also endorsed and seen as a mature one which was now delivering effective plant monitoring based on effective previous research.
 - The strategy for ILW is being developed and is benefiting from continuing discussions with NII. The programme for long-term storage is still under internal discussion but continues to be a focus for BNFL/NII interaction to derive a mutually acceptable programme.
- Process Technology
 - Flammable gases - Work included studies relating to ignition sources, mitigation by water sprays, explosive production of aerosols and static elimination. During 04/05 laboratory studies relating to ignition and in particular the role of impact and friction were conducted and a review of mechanical and electrical ignition sources completed. Laboratory studies on the effect of water misting as an inerting tool were performed and the effect of radiation on eliminating static was also assessed. These investigations

increased knowledge and reduced uncertainties in several key areas and will continue to help refine the safety approach to flammable gas issues.

- Unstable process by-products - A programme of work was undertaken investigating solvent-acid reactions which led to improved data underpinning safe HA Evaporator operation at higher temperature ranges.
- Two-phase mixtures of solids in saturated solutions - During 04/05 studies of the following phenomena were conducted: kinetics of caesium phosphomolybdate to zirconium molybdate, crystallisation of magnesium rare earth nitrates, effects of magnesium and aluminium on crystallisation, barium-strontium nitrate crystallisation and effects of air retention within cooling jackets on thermal behaviour. These studies have helped to refine understanding relating to the behaviour of materials during evaporation and storage and lead to improvements in operation performance.
- Probabilistic Safety Assessment
- Use of Operating Experience Feedback to supplement standard hazard identification techniques (e.g. HAZOP) and validate reliability data has progressed to the point where it has become part of the standard toolbox for input into safety cases.
- The use of importance measures was evaluated and considered for use in future assessments.
- Guidance has been issued on the use of fault sequence progression diagrams to aid understanding of significant faults.
- A review of the Sellafield Reliability Database was undertaken and a new version has been issued. The review also covered topics of the issue of ageing and a review of crane data from Thorp operations. The area of human action representation and dependency of actions is being reviewed and an update to technical manuals is being prepared.
- Nuclear Physics
 - Initial work was performed by BNFL to develop a methodology for the long term storage and disposal of Intermediate Level Waste. This was presented at the UK Working Party on Criticality (WPC) to enable other interested parties the opportunity to comment. Positive feedback led to the formation of a WPC sub-group on the topic, including attendance by other licensees and regulators.
 - The methodology developed for areas of inherently low criticality risk has been incorporated into a draft version of a S&ERM Technical Guide. This was also presented at WPC for information and to facilitate discussion on sharing of best practice in this area with other attendees.
 - A number of meetings were held with NII through the year supplemented by regular communication to assist in the development of the Research Strategy and the subsequent Research Schedule.
- Radiological Protection
- Validation of in-house codes and data used for radiological assessments - The specific concern with regard to the dispersion code ASTRA has been resolved as a consequence of a validation exercise undertaken by Westlakes. The generic question of code validation remains an ongoing issue.

- Resuspension and deposition factors in dispersion modelling calculations. This has been addressed by a study undertaken at Westlakes into the likely particle sizes for future operations and whether these will impact on the data in question.
- Restriction of the spread of activity - Various guidance documentation has been produced on this topic, both at the MSS and Industry level. The guidance is being systematically implemented.
- Waste and Decommissioning
 - The primary emphasis has been one of developing a collaborative approach on common waste & decommissioning problems. Most of the tasks in 2004/5 were to evaluate that effectiveness of existing collaborative working and to recommend how to address gaps or take advantages of emerging opportunities.
 - There is strong collaboration within British Nuclear Group on contaminated land, effluent treatment and cementation of ILW. Individual contacts between appropriate technical experts was increased in a number of areas. The need for greater interchange of ideas on decommissioning was agreed. The Reactor Waste & Decommissioning Industry Group (RWDIG) is providing a valuable forum for discussions that include UKAEA, NII, British Energy and AWE.
- Control and Instrumentation
 - The majority of the CE&I Nuclear Research Issues are addressed in collaboration with British Energy and British Nuclear Group Reactor Sites through the C&I Nuclear Industry Forum (CINIF). This collaborative approach not only brings benefits in terms of shared costs, but it also facilitates interaction between licencees whilst addressing the NRI issues, thereby bringing a consistency to the solutions to similar problems.
 - All of the research projects identified in the CE&I Schedule were undertaken as planned. The majority of these projects have been ongoing for some time, reflecting the novelty and complexity of the issues being addressed.
 - Research on two issues (the 'Cost Effective Modernisation of Systems Important to Safety' – CEMSIS, and the 'Application of COTS to Low SIL Systems') have been used on British Nuclear Group projects.
 - Work being undertaken through CINIF to provide a practical approach to the Statistical Testing of Software Based Systems has been used to inform an internal Code of Practice on this subject.