

**HEALTH AND SAFETY COMMISSION
NUCLEAR SAFETY ADVISORY COMMITTEE
SUB-COMMITTEE ON RESEARCH**

16TH SEPTEMBER 2004

NUCLEAR CHEMICAL PLANT RESEARCH ARRANGEMENTS

JOINT PAPER BY HSE / BRITISH NUCLEAR GROUP - SELLAFIELD

BACKGROUND

1. Historically, Nuclear Chemical Plant safety research arrangements were managed through the Nuclear Chemical Plant Research Index (NCPRI). The NCPRI dates from an agreement in principle made with BNFL in 1995, that BNFL would make transparent its research where it addressed issues raised by NSD in the form of specific research proposals in the Index.
2. NuSAC SCR have made annual reviews of Nuclear Chemical Plant Research, both in the form of SCR papers and in the form of specialist presentations by BNFL Sellafield to individual SCR members.
3. Following review in 2002, it was agreed between NSD and BNFL that an improved process should be adopted to improve transparency and visibility; this retained key features of NCPRI which were appropriate for chemical plant research, but also adopted 'good practice' which had emerged from the development of the reactor arrangements.
4. In September 2003, NSD and BNFL presented paper NuSAC/SCR/03/13⁽²⁾ which described these new research arrangements for Nuclear Chemical Plant, specifically Sellafield Licensed Site. An updated version of this paper is attached as Appendix 1 in the form of an agreed Guidance Note. NuSAC SCR approved these arrangements in principle.
5. In April 2004, a Joint BNFL/HSE paper NuSAC/SCR/04/12⁽³⁾ was presented to NuSAC SCR confirming that a schedule had been produced

by BNFL⁽¹⁾ and agreed with HSE. The SCR noted that 'the arrangements for chemical plant research ... appeared to represent a model for other Licensees.'

FORM OF ARRANGEMENTS

6. Although differing in detail from the reactor research arrangements replacing IMC, many aspects of the Chemical Plant arrangements have similarities to the reactor arrangements. Some of the key features are :
 - Identification of priority safety research areas by HSE, across all technical topics, to be discussed and agreed with Licensee
 - Increased visibility of the priority areas of licensee's research in an annual licensee-specific 'Nuclear Research Schedule' (NRS).
 - The use of the NRS as a vehicle for identifying research projects where collaboration between licensees is appropriate or desirable.
 - Continued recognition of the importance of technical exchanges between specialists in the licensees and NSD, but within a framework that allows working level arrangements that are appropriate to the different technical areas.
 - The establishment of the role of 'Research Co-ordinator' within each licensee to provide a central focus for the implementation of the research arrangements and the delivery of the research arrangements.
 - A fundamental emphasis on the description and evaluation of the research carried out in terms of the safety requirements of, and enhancement achieved in, key priority areas identified by HSE.
 - Recognition that a single 'Industry' model of nuclear safety-related research arrangements is not appropriate, due to the very different contexts, scope and histories of different nuclear Licensees

NUCLEAR SAFETY RESEARCH IN BNFL

7. It is recognised that BNFL is amongst the top organisations in the world for R&D funding in the electricity sector. Specifically, in 2002–2003 the UK Government's Innovation Research and Development scoreboard listed BNFL as first in the UK and 2nd in the world league table of leading investors in technology in the electricity sector (in terms of R&D investment/sales). The total technology investment by BNFL in 2003/4 was over £247M, and BNFL spent £98M on R&D.
8. Sellafield is probably unique in the mix and concentration of different nuclear plants on one site. The site is only about 2 square miles and it contains over 1000 buildings with complex interconnections or dependencies. More than 200 radioactive facilities, redundant or operational, remain on the site.
9. BNFL invests ~£70M per year in research & development for supporting remediation and current operations on the Sellafield site. This is a major component of spend on the Sellafield site. Significant research & development work is being targeted in areas where the greatest hazard

reduction / environmental benefit can be achieved - the highly active liquor stock and the emptying of the legacy ponds & silos.

DEFINITION OF ARRANGEMENTS

10. An overview of arrangements is described in a joint NSD/BNFL Guidance Note, and is attached as Appendix 1.
11. The new arrangements are defined, at working level, in a series of guidance notes that have been produced jointly by HSE and BNFL, and communicated to their respective research representatives. The list of current BNFL/ NSD guidance notes is given in Table 2, Appendix 1. These are kept under review and updated as necessary.
12. Both the Sellafield Licensee Research Co-ordinator and NSD Division 4A staff have ensured that the new arrangements are communicated to and are understood by the significant numbers of staff affected within their respective organisations.
13. The framework of these revised arrangements enables NSD to establish appropriate research arrangements with other nuclear licensees, and this has been previously recognised by the SCR.

EXCHANGES WITH NSD AND REACTOR LICENSEES

14. Both previous and new research arrangements for Chemical Plants have always recognised the importance of good quality communications both between licensees and between the licensees and NSD. To maintain close links with the evolving reactor arrangements, BNFL has had technical representatives on key technical working groups e.g. C&I, Human Factors. In addition, BNFL Sellafield's Licensee Research Coordinator attends the regular meetings between NSD Division 4A staff and the reactor licensees' research co-ordinators (essentially the former IMC strategy group). Attendance at these meetings has enabled the learning and good practice from the evolving reactor arrangements to be used in developing chemical plant arrangements.
15. For the new chemical plant arrangements, the aim has always been to proceed by consensus between NSD and BNFL wherever possible (on Guidance Notes, Papers, Strategies and Schedules), and to be clear on the basis of any disagreement, and how it can be resolved. To date, this approach has been successful, as evidenced by the level of agreement reached in both the general arrangements and their implementation in all technical areas.
16. The satisfactory operation of the technical exchanges will remain under review by both the Licensee Research Co-ordinator and NSD staff.

IMPLEMENTATION IN 2003/4

17. In the first year of implementation, both Research Strategies (owned by NSD) and Research Schedules (owned by BNFL) have been produced and agreed for each of the 11 technical areas (Appendix 1, Table 1), in accordance with the agreed programme. The full set of Strategies and complete Schedule⁽¹⁾ have been distributed separately to NuSAC SCR.
18. A typical example of the way in which an issue is raised and addressed in the Strategy and Schedule respectively for the 'Process Technology' technical area is attached as Appendix 2. This illustrates
 - the detailed consideration given to each of the key identified safety research issues, noting that the documentation is just a summary of detailed technical exchanges and information being provided
 - the importance of establishing appropriate synergies, both national and international
 - the importance of BNFL maintaining and developing key competencies
 - the broad scope of technical issues being raised in NSD Strategies, and the corresponding responsibility of BNFL to respond in appropriately broad terms
 - most crucially, how the generic issue is closely informed by, and related back to, real on-plant safety issues, thereby maximising the safety benefit of research.
19. Discussion and exchange with HSE through these arrangements, making work programmes more visible and transparent, is enabling HSE to assess whether existing programmes are balanced and adequate. Over the whole range of issues raised in the HSE Research Strategies, no significant gaps in safety research have been identified to date. An annual review / evaluation paper will be presented to the NuSAC SCR Spring meeting to confirm the effective working of the arrangements.
20. The benefits of the 2003/4 implementation of arrangements include
 - Extensive dialogue and improved transparency of the Sellafield Licensee position on the key safety research issues raised within the NSD Research Strategy documents.
 - An annual demonstration to NSD and to the SCR that key safety research issues are being addressed in a balanced and adequate way.
 - The communication of the Schedule to reactor licensees, to help identify research areas where collaboration between licensees would be appropriate / desirable.

REVIEW OF NEW ARRANGEMENTS AGAINST SUCCESS CRITERIA IN NuSAC/SCR/02/12

21. The overall success of the new arrangements can be judged against the six factors declared in NuSAC/SCR/02/12:
22. **Impact on nuclear safety.** The direct effect of research programmes on nuclear safety is difficult to measure as witnessed by the discussions on the evaluation of research. However, BNFL maintains that it has long-established and effective processes in place for justifying its extensive R&D expenditure, which include impact on nuclear safety; the new arrangements are aimed in part at improving the transparency and visibility of these. Specifically, the new arrangements result in substantial, targeted and specific Licensee responses to issues raised by NSD, resulting in improved transparency of Sellafield Licensee's decisions on research, implementation and impact. The process by which issues are closed out, (which forms part of the new arrangements and is described in a Joint Guidance note) will ensure that sufficient information will be presented to demonstrate that the key research issues identified by NSD have been appropriately addressed by BNFL.
23. **Effectiveness of regulator/licensee interface.** As noted above, the effectiveness of this interface has been demonstrated by the level of agreement reached in both the general arrangements and their implementation in all technical areas. From NSD's perspective, there has been a step-change improvement in this interface compared with the previous NCPRI arrangements.
24. **Maintenance of Essential Research Capability.** BNFL maintain (in the introduction of reference 1) that capability issues have always been of key importance to BNFL, and have driven much pro-active research activity (e.g. creation of the University Research Alliances). As part of the new arrangements, to further improve visibility of these issues to NSD, a capability summary statement is included in each technical area schedule.
25. **Openness to address public concern.** There is no change as far as the public are concerned. The Strategies/Schedules are made available to NuSAC SCR, which presents greatly improved and extended openness and visibility compared with the previous NCPRI documentation.
26. **Transparency of research findings to NSD.** Significantly improved transparency has resulted from the new arrangements.
27. **Transparency to other licensees where this is in the interests of safety.** There is complete mutual transparency of research arrangements with the reactor Licensees, and there has already been detailed exchange with UKAEA on the waste and decommissioning research schedule. HSE and BNFL are agreed that further exchange with UKAEA could be beneficial (noting commercial considerations), and this is being reviewed.

28. It is still too early to determine the precise effect on the research arrangements of the introduction of the NDA, but detailed discussions are continuing. The general impact of NDA on BNFL is presented in NuSAC/SCR/04/15.

CONCLUSIONS

29. New Nuclear Chemical Plant Safety Research Arrangements have been established, developing elements of previous chemical plant arrangements, and benefiting from the experience of these and the evolving reactor licensee arrangements.

30. Both NSD and the BNFL Sellafield Licensee judge the implementation of new research arrangements to have been successful to date in providing greater transparency and clarity of BNFL's research activities compared with previous NCPRI arrangements.

31. The Arrangements are developing satisfactorily measured against the objectives and criteria previously established, and they support the earlier judgement by the SCR that 'they appeared to represent a model for other Licensees.'

32. There will be a Review/Evaluation paper presented to NuSAC SCR in Spring 2005, to demonstrate appropriate progress being made by BNFL in line with Licensee Research Schedules. This, together with the updated Schedules being produced by end 2004, will enable the adequacy of the new Arrangements to be confirmed.

33. The potential impact of NDA on these arrangements is under review.

ACTIONS BY MEMBERS

The Sub Committee is asked to note the successful implementation to date of the new Nuclear Chemical Plant Safety Research Arrangements.

REFERENCES

1. BNFL Nuclear Chemical Plants Nuclear Research Schedule 2004/5, April 2004, J. Hobson
2. NuSAC/SCR/03/13 'Nuclear Chemical Plant Research – New Arrangements' September 2003
3. NuSAC/SCR/04/04, 'Arrangements for Chemical Plant Research' April 2004

APPENDIX 1

Nuclear Chemical Plants Safety Research Arrangements	
Overview of Arrangements for Nuclear Chemical Plant Safety Research	
<i>Guidance Note No:</i>	NCPR GN 1
<i>Revision No:</i>	1
<i>Status :</i>	<i>Joint NSD/BNFL Guidance Note</i>
<i>Date:</i>	<i>29 July 2004</i>

Introduction

This GN gives an overview of the arrangements for BNFL Nuclear Chemical Plant Safety Research. It is derived from the material presented to NuSAC SCR on 19/9/03 in paper NuSAC/SCR/03/13.

The HSE Nuclear Safety Directorate's "Strategy for Nuclear Regulation in Great Britain" defines five fundamental Key Business Activities (KBA's) that it undertakes to fulfil its mission which is:

".to secure effective control of health, safety and radioactive waste management at nuclear sites for the protection of the public and workers and to further public confidence in the nuclear regulatory system by being open about what we do."

Four of the KBA's are: Assessment; Inspection and Enforcement; Licensing; and Standards and Advice. The fifth KBA, Research, is defined as:

"the process of identifying, commissioning and promulgating the results of research into nuclear safety issues so that licensees and NSD have the scientific and engineering knowledge to make judgements about the adequacy of safety measures."

Historical Background

In the research domain, HSE has concentrated on reactor safety research, because of the history of the transfer of responsibility from the Department of Energy (under the DTI Guidelines), and because of the relative hazard of the respective plants. It is ambiguous as to whether the DTI guidelines are restricted to nuclear power plant. Although written with NPPs in mind, it is now agreed that in the future the guidelines should become applicable more widely, with appropriate modifications.

However, HSE did establish an agreement with BNFL that BNFL would make its chemical plant research transparent to NII through the mechanism of the Nuclear Chemical Plant Research Index, first issued in 1995. This was modelled on the reactor Nuclear Research Index. In response, BNFL would inform NII of research that it was commissioning that addressed these issues. The NCPRI was presented annually to NuSAC SCR, together with a progress statement on closure and addition of issues.

Application

The term 'Chemical Plants' was adopted many years ago under the previous NCPRI research arrangements to describe all BNFL Licensed Sites without an operating nuclear reactor (as power generating research was covered under the separate IMC arrangements). This terminology is retained here for continuity as it is a widely used term (e.g. within NuSAC); however, it is important that this term is recognised as effectively applying to Sellafield and Drigg Licensed Sites only, although close liaison with Springfields Licensed Site is being maintained.

DTI Guidelines

The DTI Guidelines set out a number of objectives for the HSC, and consequently HSE, to meet in establishing and maintaining an effective programme which takes account of both the licensees' and regulator's needs. The primary objectives which apply to all Licensed Sites are:

- i) To ensure that an adequate level and balance of nuclear safety research continues to be carried out, based on a view of the safety issues likely to emerge both in the short and long term.
- ii) To ensure that, as far as reasonably practicable, the potential contribution which such research can make to securing higher standards of nuclear safety is maximised.
- iii) To ensure that the results of any such research having implications for nuclear safety are disseminated as appropriate.

Research Review

In 2002 HSE undertook a review of the research programme, largely aimed at altering the research system to reflect the changing industry. It was agreed that the reactor licensee joint Industry Management Committee would be phased out (subject to successful new arrangements being established), HSE would continue to produce the Nuclear Research Index (NRI), and the reactor operators would produce Research Schedules giving their research that addressed the NRI issues and their other safety research activities.

However the research review also addressed HSE's oversight of the safety research of other licensees. Hitherto, HSE has only assured HSC that the reactor safety research programme is balanced and adequate. HSC confirmed in October 2002 that HSE's oversight did indeed extend in principle to all licensees, subject to the availability of resources. All licensees have a duty to carry out appropriate safety research, and HSE has a duty to satisfy itself and assure HSC of the balance and adequacy of this research. The new arrangements developed with the reactor licensees were taken as an example of good practice, to be adapted to other licensees. The preference is for voluntary arrangements, in order to get the benefit of the licensee's input to the research and their acceptance of the results to facilitate implementation, and to make the best use of NII's resources.

HSE's first priority with respect to other licensees was BNFL chemical plant research, consistent with the NCPRI initiative. In 2002 BNFL agreed that the degree of transparency of

BNFL's research to HSE would be increased in response to HSE's request. Whereas HSE will endeavour to use the jointly agreed voluntary arrangements to address its research concerns, it reserves the right to commission its own research and to recover the charges from BNFL through a Levy. The circumstances when this is likely to happen are when HSE and BNFL fail to agree on how an issue should be resolved, where HSE wish to commission research to inform itself where independence from BNFL is seen to be important and where HSE may wish to directly fund research with its own independent team or to undertake research through an international agreement which requires the participation of the regulator. These examples should not be considered as exclusive of any other reasons which may arise but which cannot be foreseen at this time.

Purpose of Arrangements

The purpose of the arrangements is to formalise the Licensee response to those generic nuclear safety research issues that HSE considers are either specific, or of particular importance, to chemical plant. The HSE issues will be in three main areas:

- issues which HSE considers are of safety significance to BNFL's nuclear chemical plants and are principally generic issues that arise from inspection or assessment;
- generic issues which result from incidents and operational experience (lessons learned);
- issues which relate to lower risk activities but which have or could have high public and/or political interest.

Currently there is no explicit mention of new build related research in the strategy. HSE intend to review this issue as and when required.

Overview of Arrangements

The arrangements consist of the following stages, implemented in an annual cycle defined in an agreed programme (Guidance Note 7, Table 2) :

- HSE propose broad topic areas in each of a specified set of technical categories (Table 1) indicating priority areas of interest for potential research, documented in the form of 'Research Strategies' (Guidance Note 2, Table 2). The strategy concentrates on the safety issues and the expected benefits of the research results to improve safety, rather than describing research projects.
- BNFL look to agree these Research Strategies as being suitable and clear bases for dialogue and exchange, and to set the scope and objective for the BNFL response
- BNFL produce a response to the issues raised in these Strategies in the form of 'Research Schedules' (Guidance Note 5, Table 2), which describe how BNFL addresses the specified issues (whether by research or otherwise). The first Schedule was produced in April 2004 (ref.1).
- HSE review the balance and adequacy of the response to the HSE Strategies provided in the BNFL Schedule

A key principle of these Arrangements are that the HSE Strategies state the nature of regulatory issues and how research could potentially be relevant to address these. The responsibility for responding to these issues (by research or otherwise), and the detailed specification and management of any research, remains the clear responsibility of the Licensee.

Although these arrangements are similar to the reactor arrangements, they differ in the targeted/prioritised approach taken, which addresses key potential research issues in appropriate depth. This targeted approach has been agreed as being most effective, as BNFL's total safety-related research portfolio is known to be very extensive (summarised in Introduction to Reference 1). It would be inefficient and impractical for BNFL to attempt to

describe all the work which it carries out, as well as being resource intensive for HSE staff. The formal and very extensive regulatory scrutiny of Licensee Safety Cases provides a very detailed and informed perspective for identifying key research areas.

Scope of Arrangements

All of the research within the scope of the Arrangements is intended to contribute to safe operation of nuclear licensed sites in the short and long term. Both research and development are included, and both health as well as safety issues are considered, and the scope is driven by the purpose described above. The importance of potential research issues being raised are intended to reflect the relative hazards of the operations, and the contribution that research can make to safety in each case.

It is also recognised that HSE is interested in understanding BNFL's use of research results and having the opportunity to discuss them before they are presented in a safety case. This includes feedback of operational experience, validation of methods, and the work needed to determine how to apply new or existing research results, or to address new applications. Nevertheless, the issue of whether new knowledge obtained from research is being adequately applied is a regulatory issue rather than a research issue, and is outside the scope of these arrangements.

In general, the scope of the research arrangements is the appropriate specification and delivery of research which could have substantial potential safety benefits. The key issue of application/implementation of research is properly addressed within the formal regulatory framework rather than within the research arrangements, alongside all other implementation issues. Thus concerns about implementation of safety methodologies, procedures, management systems, skills management etc. would be addressed by a other regulatory routes/fora rather than through the research route.e.g. the Safety Case Review Forum.

In addition, the former Memorandum Of Arrangements states that 'the HSC Co-ordinated Programme excludes nuclear safety research commissioned by HSE's Nuclear Installations Inspectorate (NII) to enable it to take specific licensing decisions both today and in the future (covered by separate arrangements)'. Thus the research arrangements do not cover research work in support of specific plant safety cases as these would be dealt with through the normal licensing process (HSE would use its support programme for such work.)

Capability and Collaboration

The main emphasis of the research arrangements will be on research which is of direct safety benefit, but the issue of availability of technical capability will also be addressed (noting that BNFL has a large in-house R&T capability, and has set up University Research Alliances to safeguard its essential research capability in several areas).

In most cases, the capability issues will be addressed through compliance with Site Licence Condition 12, as the safety research capability is just one part of the total safety capability requirement. Nevertheless, BNFL will identify in the Nuclear Research Schedules if specific measures are needed to develop or maintain capabilities to support safety research, and the strategy that BNFL intends to adopt. The Research Schedule also includes a brief overall summary statement on technical capabilities (both internal and external), and would indicate where it is judged that use of external capabilities could cause difficulties for NII access to independent advice.

The present arrangements are not appropriate for dealing with access by HSE to independent technical capability. If this were felt to be a need, HSE would use the support budget if it were urgent, or would consider the use of the levy in the longer term, to be consistent with the reactor safety research approach and to ensure transparency to the licensees and HSC. In either case, prior and ongoing notification to Licensees would be expected.

Given the limited number of countries involved in nuclear chemical plant operation and the commercial competition between them, international cooperation has less importance in this field than for reactor research, although the international agencies have relevant activities, especially in the areas of waste management and decommissioning. However at a national level, there is common interest with the power reactor, oil, chemical or pharmaceutical industries in certain technical areas. National and international collaborations and technical exchanges will be addressed in the Research Schedules as appropriate.

Future changes

The arrangements described in this paper are appropriate for the current position of BNFL as owner-operator of its licensed sites. However, the creation of NDA will fundamentally change the position, with the NDA being the source of funding for site licensees, and with contracts between the NDA and the site licensees/operators having to address the need for, and importance of, research. In the current context, the issues arising from this change include:

- the management of long-term issues in the context of short-term contracts,
- the identification, control and implementation of generic safety research issues, and promulgation of best practice, in the context of increased emphasis on competition and the model of a separate operator for each site
- the role of research in protecting essential technical capability.

The Nuclear Chemical Plant Safety Research arrangements described in this paper will need to be kept under close review as these broad issues are addressed. HSE is involved in discussion with DTI and the other relevant government departments about the future arrangements for decommissioning and waste management research.

Technical Categories

The research arrangements are organised around a set of defined technical categories shown in Table 1. These areas were originally chosen for NCPRI to be consistent with the reactor NRI, recognising that some areas were not relevant. They have been slightly modified to reflect the organisation of HSE Nuclear Safety Directorate and BNFL, and the different technical nature of the topics. They may be further modified as appropriate.

Implementation of Arrangements

The arrangements are implemented in accordance with a set of Guidance Notes which have been agreed between BNFL and NII, and these are summarised in Table 2. In many respects, they are similar to the Reactor Arrangements Guidance Notes, and have a similar scope, although the differences in the Arrangements are clearly reflected in these notes.

References

1. BNFL Nuclear Chemical Plants Nuclear Research Schedule 2004/5 (April 2004)

Table 1

Nuclear Chemical Plant Safety Research Arrangements – Technical Categories

Civil Engineering
Plant materials (steel etc)
Human Factors
External Hazards
Internal events & Fire
Probabilistic Safety Analysis
Process Technology
Waste & Decommissioning
Nuclear Physics/Criticality
Radiological Protection
Control, Instrumentation & Electrical

Table 2

Joint BNFL/NII Guidance Notes – Chemical Plants

NSR GN No	Title
1	Overview of Arrangements
2	Technical area research strategies
3	Meetings
4	Roles and Responsibilities
5	Preparation of Research Schedules
6	Assessment of Research Schedules
7	Timetable
8	Technical Exchanges
9	Resolution of Disputes
10	Strategy Update and Issue Closure
11	Evaluation

APPENDIX 2

EXTRACT FROM HSE STRATEGY/BNFL SCHEDULE FOR PROCESS TECHNOLOGY – RED OIL ISSUE

Extract from HSE Research Strategy document :

Unstable Process by products

Red oil, produced by reaction of nitric acid and nitrates with organic solvents is an example of an unstable by product. It is a potential hazard to plant operations because it can undergo exothermic thermal decomposition, to yield a large volume of gaseous reaction products that could overwhelm the plant. Our understanding of the process safety aspects of intermediate product and waste storage (for example the storage of Plutonium Oxide and used organic solvents) is less well advanced than that for fuel and waste processing. These materials may undergo chemical degradation in storage to yield unstable by products.... BNFL needs to retain the capability of being able to understand and assess developments in the knowledge of the properties of these by-products. Such developments may derive from:

- operating experience in outside industry
- a proposal to change the operating regime of their plant for operational reasons.

The company has already undertaken an extensive research programme to understand the behaviour of 'red oil' and operates its fuel cycle plant in such a way that the plant is able to tolerate the consequences of a 'red oil' reaction ...Despite the past company strategy there remains the need for an on-going research programme to satisfy the regulatory goal.

Extract from BNFL Research Schedule :

2.2 Unstable Process By-Products

2.2.1 Introduction

The operation of evaporators may, under certain fault conditions, lead to the production of unstable products which can undergo violently exothermic decomposition. Such processes are known as 'Red Oil' reactions due to the coloration of a dense phase containing organic degradation produced as an intermediate product from the reaction between nitric acid and organic solvent at elevated temperature. Further reaction of the intermediate, due to its exothermic nature, may lead to a self-accelerating reaction when the heat evolved exceeds the capacity of the system to accommodate it.

2.2.2 Response to NSD Safety Strategy

Reactions of solvent with nitric acid and, in the extreme, Red Oil reactions have been investigated at scales ranging from a few to 650 millilitres. Calorimetric investigations have continued to investigate parameters relevant to High Active Evaporation during normal operations. A series of experiments, including an experimental design partial factorial group, have determined the heats of reaction and

volumes of non-condensable gases that would be liberated if the safe operating regime, in donor plants and HLWP, failed to prevent solvent entering the evaporators. The experimental design group of experiments has determined the parameters to which the reactions are most sensitive for both the heat and non-condensable gas evolution. The trials covered an extended operating range (65 to 90°C) and demonstrated that there is no scale up effect beyond proportionality. That is the heat and gas production appear to scale directly to volume. Analysis of the non-condensable gas produced at 90 °C failed to find any flammable gases.

A paper reviewing historical Red Oil incidents, recent work conducted in conjunction with South Bank University and the comparison with Sellafield evaporator operating conditions is currently being finalised¹. It is clear that human and or equipment error has been a contributory factor in all of the known events as the reaction requires relatively large amounts of solvent to be present which is by itself a maloperation. In several instances, temperature control or instrumentation had been compromised so that true process temperatures were unknown. It is clear that a complex mixture of chemical reactions occurs through the degradation of organic solvent and that a full understanding of the precise mechanism would be very difficult to reach. Such an understanding would be of questionable benefit in any case as because of the number of competing processes and various reaction pathways, it would be restricted to a very specific set of conditions. However, experimental work is giving insights into potentially significant intermediates and suggests that certain classes of volatile organic compounds may be implicated in the runaway reaction.

Support for a research project in this area² to be funded under the auspices of the International Science and Technology Centre in Moscow has been expressed to the European Commission.

A technical paper to support the safety case for continued operation of the HA evaporators is also in preparation. The need for any further work in this area is under consideration and will be determined once the assessment¹ has been reviewed.

Capability Issues

Significant capability is maintained in respect of support to the operating reprocessing and waste treatment plants both within NSTS and the operating units. Both theoretical and experimental capabilities are supported.

Links with the University Research Alliances, in particular Radiochemistry (Manchester) and Particle Science (Leeds) are in place and these groups have been involved in provision of specialist advice and equipment to projects referred to above. Recruitment of postgraduate and postdoctoral staff from the university alliances is occurring.

Industrial Research Fellowships in the fields of solvent extraction, radiation chemistry, tomography, chemical modelling and crystallisation are also supported.

¹ Red oil reactions: A summary of past incidents, experimental work and an assessment of requirements for further investigation, NSTS (03)4579

² ISTC project 2910, Research of characteristics and dynamics of exothermic reaction runaway of nitric acid with organic compounds