HSE
Health & Safety Executive
HM Nuclear Installations Inspectorate

The storage of liquid high level waste at BNFL, Sellafield

Addendum to February 2000 Report

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FOREWORD

This document is issued as an addendum to NII's report published by HSE in February 2000 on the review of the safety of storage of liquid high level waste at Sellafield.

It reports on BNFL's progress in addressing the recommendations contained within the February 2000 report. These recommendations covered two main areas: (i) improvements to the safety case for the storage plant and (ii) the reduction of the stocks of liquid waste held at Sellafield to a minimum buffer level by around 2015.

This addendum draws on information in BNFL's safety case which is proprietary information. Nevertheless it is our intention through this report to supply sufficient information to assist the interested reader in understanding:

- the improvements which BNFL has already incorporated, or is now committed to incorporating, into its plant and safety case;
- the basis of the work carried out by BNFL in predicting future stock levels associated with a range of assumptions;
- NII's view of BNFL's submissions and the further work required as stock levels are reduced; and
- the regulatory action that has been taken to ensure compliance with the stock reduction programme and further work programme.

The addendum does not replicate the content of the original report which describes the regulatory system applied to the operations at Sellafield, the plants and operations at Sellafield, and the basis of the original plant safety case. For these the reader is referred back to the original report.

EXECUTIVE SUMMARY

Introduction

On 18 February 2000 the Health and Safety Executive (HSE) published a report on the work of its Nuclear Installations Inspectorate (NII) in regulating the storage of liquid high level waste at the BNFL Sellafield site (ref 1).

Within the report NII gave two undertakings. One was to publish an addendum around 1 year later covering its assessment of the new safety case for the storage plant and the second was to publish a further addendum when progress had been made with options studies for reducing the stocks of liquid high level waste (HLW), also referred to as highly active liquor (HAL), to a buffer level.

A progress report (ref 2) was published in February 2001 which included a summary of the assessment of the new safety case and NII's regulatory action to enforce liquid HLW stock reductions. This addendum provides a more detailed update on the position reached based on consideration of BNFL's responses to the recommendations from the February 2000 HLW report since its publication. It embodies the two addenda referred to above integrated into a single document for publication.

Background

Both the plant and its safety case have undergone significant enhancements over the years. A major review of the plant and its safety case was undertaken by BNFL in 1994; such reviews are required by Conditions attached to Nuclear Site Licences. In 1995 we published a report of our reviews on the major safety issues on HAL storage at Sellafield (ref 3). This took account of our initial assessment of BNFL's major reviews. Subsequent to this we engaged BNFL in generic discussions on improving safety cases which led to BNFL implementing a safety case improvement programme to produce "Continued Operation Safety Cases" or COSRs. This work bore fruit in September 1999 when BNFL submitted to us a revised safety case in the COSR format for the highly active liquor evaporation and storage plant, B215. Also at this time we were finalising our revised set of views on HAL storage at Sellafield, building on the work undertaken since 1994/95. These were subsequently published in the form of the February 2000 report. As a matter of course we kept BNFL up to speed with our developing thoughts and its September 1999 COSR took account of them such that they covered many aspects of the recommendations made in our February 2000 report.

In the February 2000 report we concluded that operations in the highly active liquor evaporation and storage plant, B215, were acceptably safe but that there were a number of areas in which the justification provided by the safety case could be enhanced in scope and content. The review identified 22 recommendations in total, 17 of which were essentially associated with development of the safety case and 5 of which specifically addressed the reductions of liquid HLW stocks. We set a target date of 18 August 2000 for BNFL to respond.

Before the target date, BNFL provided its responses to all 22 recommendations building on its September 1999 submission. These responses included further safety case improvements, provisions for implementation of a ventilation upgrade project and proposals for HAL stock reductions.

We have held regular project meetings with the BNFL project team to review assessments and progress issues with both the safety case and the HAL stock reduction proposals. As a result of this, and BNFL responses, all 22 recommendations had essentially been closed out by January 2001 subject to an ongoing programme of work. This included one or two specific elements of the original recommendations carried over to give BNFL more time to respond in detail. This position was recorded in the progress report published in February 2001 (ref 2).

The close out of the recommendations was based in part on a programme to implement the updated safety case coincident with the reconfiguration of the ventilation system. In the event, an incident occurred on 26 January 2001 whilst the reconfiguration work was being undertaken and as the progress report went to press. As a result of this, implementation of the upgrade and the updated safety case was subjected to a further delay.

However, the reconfiguration of the ventilation system was finally carried out safely and successfully at the end of April and implementation arrangements for the new safety case have now been completed.

The Plant and Its Safety Case

As described above, recommendations 1 - 17 of NII's February 2000 report on liquid HLW were largely aimed at enhancements to the scope and content of the safety case for the B215 plant. Since then we have assessed BNFL's B215 COSR in more detail and the responses to our February 2000 report recommendations.

In advance of the submission of the updated safety case in September 1999, a number of significant engineering and operational improvements to the plant were identified through the safety case periodic review process. A programme for their implementation was set in motion in accordance with arrangements set up under the Nuclear Site Licence Conditions. Many of the more significant areas of work have already largely been implemented. These include cooling water pipework replacement, extra cooling water isolation valves, and improved tank temperature monitoring. All of these represent significant and tangible improvements to the safety of the plant. Others, are the subject of on-going project work.

Our overall conclusion of the assessment of this case and the responses to the 17 NII recommendations is that nothing has been identified which should prevent operation of the plant until the next periodic review, given the continuing programme of work identified as part of the periodic review process. Thus we have concluded that the plant remains safe.

Since then, one of the safety issues considered in arriving at this conclusion has increased in prominence as a result of the discovery of a localised elevated temperature in one of the storage tanks. This does not impinge immediately upon the safe case for the continued operation of the tank but could affect consideration of its life. Therefore the implications on the safety case for long term integrity of the tanks and BNFL's actions to investigate and deal with the issue are being closely monitored.

The initial target for clearance and implementation of this latest update of the safety case for continued operation (the COSR), was 29 September 2000. This was revised to 31 January 2001 to allow BNFL to implement the training and documentation changes associated with the ventilation upgrade work in a structured and thorough manner. However, certain of the commitments made to enhance the robustness of the safety case were delayed as a result of effort having to be focussed on resolution of the issues arising from the ventilation incident. This matter has now been addressed and the improved safety case takes effect from July 2001.

Liquid HLW Stock Reductions

In January 2001 we issued BNFL with a Specification (a legal requirement for the licensee to take action) to formalise the programme to reduce levels of HAL stored at Sellafield. The stock reduction plan is aimed at minimising the amount of HAL and achieving the residual or 'buffer' stock required to feed the vitrification (glass-making) process by the year 2015. This formalises a stock reduction strategy which has been the subject of extensive discussions with BNFL. It marks a major step forward in an ongoing regulatory process aimed at securing the conversion of the current stocks of HAL to a passively safe form (as glass blocks) as soon as reasonably practicable.

The proposals are linked to the performance of the vitrification plant in such a way as to require restriction of inputs from reprocessing if performance does not meet expectations. Consequently, we will not hesitate to use our regulatory powers to halt THORP reprocessing, should that be necessary, in order to keep BNFL within the Specification.

With the Specification the maximum permitted holding will reduce from 1575m^3 by about 35m^3 per year until 2012 when it is decreased rapidly to the buffer stock limit of 200m^3 in 2015. BNFL is expected to keep the actual volume below the upper stock reduction limits. This allows for the dilution that occurs from time to time, from additions of inactive water and acid for operational reasons. These do not contribute to the radioactivity in the tanks but add to the volume. We expect BNFL to control the real HAL quantities, i.e. actual volume less the dilution, by standardising the volume for control purposes, once an agreed method is developed.

The major contributor to the hazard potential comes from Thermal Oxide Reprocessing Plant (THORP) derived HAL. Thus, we have also specified controls on the amount originating from THORP. BNFL blend this material as soon as possible to optimise vitrification throughput. The holding therefore relates to both THORP HALs and THORP HALs blended with Magnox HAL. The maximum holding of such HAL will be reduced from 770 m^3 currently to nominally 500 m^3 by 2007. This has the effect of tying THORP output to vitrification plant throughput.

Associated with the Specification is a programme of commitments from BNFL aimed at developing further improvements in the stock reduction programme; in particular, ensuring the throughput in the vitrification plant is improved and eliminating operational constraints so as to reduce even further the buffer stock and improve the rate of reduction of the remaining HAL stocks.

BNFL committed significant resources to developing the modelling needed to evaluate options for stock reductions and resultant buffer volumes. At an early stage in the project the BNFL modelling of options identified 200m^3 as a realistic level of HAL stocks in B215 needed to support plant operation and the vitrification of HAL as it arose. This was based on the existing engineering and processes. In parallel, a framework of potential developments and options for alternative plant and processes was developed with the object of determining the feasibility of even further reductions in the projected buffer stock.

To take account of such developments in technology and the changing circumstances of BNFL's own business plans, we intend to carry out a critical review of the strategy and overall programme every two years in order to identify further reasonably practicable reductions. Such reviews may lead to a further tightening of the legal requirements on BNFL. BNFL is also required to provide an annual review of progress against the specified limits and programme of committed improvements. We will report our findings of the reviews as part of our normal regulatory activities to the Sellafield Local Liaison Committee.

INTRODUCTION

1. In February 2000, HSE published NII's report giving an updated review of the safety of the storage of Highly Active Liquors (HAL) at BNFL Sellafield in the Highly Active Liquor Evaporation and Storage (HALES) plant, B215 (ref 1).

2. This committed HSE to reporting progress against the recommendations. contained within it. At that time it was intended that this should be done via two separate addenda. The first addendum would report on the improvements in the safety case and associated technical justifications of safety around 12 months on. The second would report on progress with the options studies for HAL reductions around 12 - 18 months on. In the event a summary report of progress in both areas was provided within an HSE publication (ref 2) in February this year.

3. This current report however provides more detailed information on both topics and embodies the two addenda referred to above in the form of a single addendum. It is structured into 3 main parts followed by the conclusions.

4. The first part describes the background giving a review of the history leading up to current position and the project arrangements for implementation of the work.

5. The second part discusses the Plant Safety Case and provides an overview of the developments in the justification of safety of the plant as well as a more detailed review of the responses to the safety case related recommendations (Nos.1 - 17) from NII's February 2000 report.

6. The third part covers the work on HAL stock reduction proposals and discusses the developments in stock management modelling & options to reduce the stored HAL to a minimum buffer level as soon as is reasonably practicable. It thus addresses the responses to recommendations 18 - 22 of the NII February 2000 report.

BACKGROUND

History

7. Around 1994, issues associated with HAL storage at Sellafield arising from considerations of the safety case and recognition of mounting public interest, led to the HSE (NII) decision to report its review of them through a published document. This was issued in 1995 (Ref 3).

8. Also, starting around that time, generic work on safety case development was being pursued in parallel through joint licensee/regulator dialogue. This was aimed at addressing differences in approach & concepts, improving the efficiency of the licensee/regulator interactions, and establishing agreed protocols & methodologies for the production and implementation of safety cases. This resulted in the safety case format now referred to as a Continued Operations Safety Report (COSR) (Ref 4).

9. BNFL agreed to embrace these developments early - substantially in advance of the normal 10 yearly periodic review date required through licence condition arrangements. It submitted updated Safety Case documentation in the COSR format for the B215 plant in September 1999. At this time NII was finalising its review on HAL storage at Sellafield building on the work undertaken since 1994/95. The review was subsequently published in

the form of the February 2000 report. As a matter of course we kept BNFL up to speed with our developing thoughts such that its September 1999 COSR was able to take account of them and thereby covered many aspects of the recommendations which emerged in our February 2000 report.

10. The overall conclusions of that report with regard to the storage arrangements were essentially two-fold:

(i) that immobilisation of liquid HLW is the most appropriate long term approach and immobilisation should be effected by around 2015 for all but a buffer stock necessary for near real time vitrification; and

(ii) that the storage plant was acceptably safe but that nevertheless, further work should be done to see if safety and its demonstration could be further improved.

11. Within the report, 22 recommendations were made of which 17 were related to technical justifications in the Safety Case and associated plant improvements, and 5 were related to the definition of the buffer stock and options for achieving it.

12. BNFL responded to the recommendations in the report with formal submissions in July 2000 and supplementary submissions in August 2000 and January 2001.

13. Arising from NII's assessment of these responses BNFL has now developed formal proposals for achieving acceptable reductions (Ref 5) to the HAL stocks at Sellafield. NII has issued a legal 'Specification' with effect from 1 January 2001 to enforce these reductions. Also, NII has recognised BNFL's updated safety case (summarised in the Continued Operation Safety Report - 'COSR') as the basis for future operation subject to a programme of ongoing work and the implementation of the ventilation reconfiguration and upgrading. The latter was delayed to the end of April 2001 as the result of an incident on 26 January 2001 during the reconfiguration work (see Appendix 2) but this has now been safely completed.

Project Implementation

14. BNFL's approach to responding to the NII February 2000 report was to establish a dedicated Project Team for both the HAL stocks issues and the Safety Case development issues and to produce a framework document against which options could be considered.

15. BNFL developed and enhanced its computerised HAL stocks management model for simulating stock reduction projections. A range of options for HAL storage were evaluated against the company's business needs and ALARP considerations were explored using this model.

16. The Safety Case Periodic Review arrangements, developed as part of a joint regulator/licensee forum to improve interactions, provided for early implementation of any significant plant improvements identified whilst the safety case documentation revisions and updates were being prepared. These revisions were then incorporated and submitted as the COSR in September 1999 and a package of supporting documents. This package contained a large number of recommendations for further improvements to the plant, procedures and Safety Case. The plant improvements were drawn out into an Engineering Work Programme for the HALES plant. Separate submissions were subsequently prepared by the

Project team to respond to each of the 22 recommendations in NII's February 2000 report and to develop the detail of the safety case further where necessary. Progress was tracked through regular NII/BNFL progress meetings.

17. Further recommendations for improvements arising from these submissions were incorporated into either the HALES Engineering Work Programme, a separate engineering improvements programme for Waste Vitrification Plants (WVP), or into a further programme for Operational Developments for the High Level Waste Plants as appropriate.

18. The engineering programmes & COSR (Safety Case) implementation are regulated by means of arrangements under the Site Licence. These require formal categorised Plant Modification Proposals covering the programme of plant engineering modifications and the introduction of a new Clearance Certificate (CC). The latter identifies important safety systems and their maintenance requirements, and relevant Operating Rules and operating instructions. The COSR was implemented in July 2001.

19. Implementation of the HAL stock reductions is being regulated via a 'Specification' made under a licence condition. It incorporates legal limits and tracking controls. Development by BNFL of another operational control parameter will be undertaken to tighten operational controls further within the framework of the 'Specification'. The Operational Developments programme is being implemented through the BNFL Project Team and will be monitored through formal reviews at agreed milestone dates.

THE PLANT SAFETY CASE

20. This section of the report outlines our assessment and findings in relation to BNFL's latest Safety Case for the B215 plant. It addresses the NII view of both the formal 'COSR' safety case submissions and the responses to the NII Report recommendations 1 - 17.

Overview of Safety Case Findings

21. The safety case, as summarised in the 'COSR', was formally submitted for assessment in September 1999 to schedule and in accordance with site licence arrangements for Periodic Safety Reviews. This safety case anticipated many of the enhancements identified for progress in Recommendations 1 - 17 of NII's February 2000 report.

22. The NII assessment resource is finite and traditionally NII adopts a sampling approach to regulation to gain sufficient assurance that a licensee understands the hazards with its operations and how to control them. Therefore, in respect of the formal safety case submission it was agreed to focus assessment on those aspects with the potential for faults with high consequences. These were:

- the radiological safety assessment hazard analyses (HAZANs) for:
  - loss of cooling;
  - activity breakthrough into cooling water;
  - spillage in cells;
  - Red-oil & Ammonium Nitrate reactions; and
  - hydrogen build-up and vessel ventilation.

- the mechanical ventilation Design Assessment Report (DAR) and the related Caustic Scrubber proposals;

- the services DAR (compressed air & cooling water aspects); and

- the external hazards assessment.

23. Nothing was identified which would prejudice operation of the plant during the interval until the next periodic safety review but as with any periodic safety review, a number of areas of further work have emerged in which the safety case demonstration and engineering could be further enhanced. In particular, see also paragraph 31 below.

24. These areas of further work are in addition to the engineering work already completed or programmed by BNFL as part of the safety case Periodic Review process and include deliverables in the form of further development studies, analyses, and justifications.

25. The revised COSR incorporates the work done in response to many of the NII HAL report recommendations 1-17. Where responses have not been directly incorporated into the COSR documentation, they form elements of the ongoing work programme associated with COSR implementation.

26. Some significant plant improvements already completed are the cooling water (CW) pipework/valve replacement project, and improved tank temperature monitoring.

27. Examples of deliverables called for through further work include:

- Additional CW systems reliability analysis and a review of isolations procedures;

- Seismic walkdown and safety margins analysis;

- Process justification review, and evaporator wash regime arrangements.

28. For some areas of the safety case, such as Human Factors (HF), process engineering options, radiological protection, and C&I, the NII assessment samples have been kept to the minimum level consistent with making an adequate judgement. Although no significant concerns have arisen from the assessments carried out in these areas, it is considered worthwhile pursuing a further, wider sample for these aspects to provide additional reassurance of the Safety Case justifications.

29. An example of this, for which a programme has been set up, is further assessment of control/instrumentation interactions with HF on a range of issues including:

- BNFL's own HF walkdown report recommendations;

- control of in-tank evaporation; and

- operator emergency responses.

30. A recent ventilation incident which occurred on 26 January whilst reconfiguring the ventilation system raised issues on the response of operators to alarms and has reinforced the importance of this already planned work.

31. Since drawing to a conclusion our views on the adequacy of the new safety case one of the safety issues considered has increased in prominence as a result of the discovery of a localised elevated temperature in one of the storage tanks. This does not impinge immediately upon the safety case for the continued operation of the tank but could affect consideration of its

life. Therefore the implications of this on the safety case for the long term integrity of the tanks and BNFL's actions to investigate and deal with the issue are being closely monitored.

Safety Case Assessment (Recommendations 1 to 17)

General:

32. As well as assessing the main elements of the COSR, assessments have been made of BNFL's responses to the recommendations in the NII report relating to safety case improvements (recommendations 1-17). These are addressed in more detail below.

33. BNFL provided responses to all 17 of these recommendations. It is inevitable that a number of additional issues will arise from the ongoing assessment of these responses where further enhancements could be made. In some areas such issues have already been identified while in others they may only emerge as part of the ongoing assessment process associated with the continuing safety case development.

34. BNFL has drawn up a programme of engineering work which has arisen from the safety case review process to date and from its consideration of NII's recommendations 1-17. In all, around 500 improvements have been identified and in excess of 400 of these have been prioritised for inclusion in the BNFL project implementation programme over the next 2-3 years. Added to the programme will be the deliverables identified by NII for further development of the overall safety case for the plant.

35. The review of progress will now be presented against each of the individual recommendations:

Recommendation 1:

BNFL should continue to develop and issue by Autumn 1999 a further periodic review of the B215 safety case to meet its revised corporate safety criteria and standards, such that when assessed the safety case demonstrates that the plants meet the intent of NII's Safety Assessment Principles (SAPs) so far as is reasonably practicable.

36. BNFL produced a revised safety case in which the top tier document was in the form of a Continued Operation Safety Report or 'COSR' as described earlier. This incorporated BNFL's assessments against its revised corporate standards, formulated to provide justification of equivalence of plant designs to NII's Safety Assessment Principles (SAPs). Where differences from the standard were revealed, it also incorporated judgements of the reasonable practicability of eliminating or minimising these. Such judgements are often referred to as 'ALARP' (As Low As Reasonably Practicable) judgements. This latest safety case from BNFL is much improved and addresses most of the important issues identified in the earlier safety case. Development of the case is ongoing and will continue as new methodologies and technological advances are made and as the results of research/development work become available for incorporation. The COSR is subject to annual review when improvements and changes can be incorporated.

37. The assessment carried out on the case has confirmed the judgement that the plant is safe for continued operation. Achievement of the intent of the SAPs so far as is reasonably practicable will be effected through the ALARP judgements made in relation to the ongoing programmes of improvements,

and through the implementation of the revised Clearance Certificate, derived from the safety case, which took effect from July 2001.

<u>*Recommendations 2 :*</u>

BNFL should, in presenting a reviewed and revised safety case, include a much enhanced consideration of engineering justification.

38. BNFL has specifically addressed the issue of engineering substantiation (ie the justification that the plant and equipment, as designed and maintained, is fit for purpose and will fulfil its required safety functions) in a dedicated section of the new safety case. The starting point was the desk-top review of current operations, the assignment of safety functions to these and then identifying the engineering equipment needed to meet those functions. In parallel to this was a radiological safety assessment study identifying a wide range of fault scenarios against which the key safety provisions were identified. The engineering provisions (structures, systems and components) identified from both of these studies were categorised according to the consequences of their failure and combined into an Engineering Schedule. Substantiation of the adequacy of these provisions to fulfil their required safety functions was evaluated through technical capability reviews in Design Assessment Reports (DARs), and through walkdown inspections. The results highlighted areas in which potential improvements were identified although almost all such improvements were considered to be of a minor nature. Only a few of these were considered essential, the vast majority being viewed as improvements towards modern standards or desirable. Justification of these views is supported by a sentencing procedure which includes consideration of ALARP judgements and in which the engineering improvement work has been prioritised. NII's review of the detail of this process will continue as part of normal regulation.

39. BNFL has adopted a systematic approach to the safety case including clarification of safety functional requirements and the engineering demonstration that these will be met. The effects of ageing and general degradation of structures systems and components has been considered within this approach.

40. Emerging from this is BNFL’s current engineering work programme justified using its ALARP criteria and involving plant upgrades, such as the ventilation system improvements and seismic enhancement of the building structure, cooling towers and CW systems.

<u>*Recommendation 3:*</u>

BNFL should complete the revised fault analysis for the loss of cooling fault on HASTs 1 - 8 with the aim of including improved ventilation system reliability benefits from the ongoing system upgrade project.

41. At the time of the 1995 report, BNFL had embarked upon a project to upgrade the HALES plant ventilation systems to reduce aerial discharges, bring the plant towards modern standards and provide a dedicated discharge route for vessel ventilation from B215. The modernisation and improvement work would also enhance the reliability of the system. In the 1994/5 safety case review of B215, BNFL carried out a loss of cooling analysis showing that the contents of HASTs 1-8 would not boil on loss of

cooling. Nevertheless, it was recommended in the February 2000 review that this loss of cooling fault analysis should be further revised to incorporate the above reliability benefits from the vessel ventilation system, thereby demonstrating the safety margins available. BNFL has satisfactorily completed this analysis work and submitted it in the July response to the NII February 2000 Report on HAL storage. The original analysis was already conservative and this further analysis has provided the additional confidence in the conclusions relating to HASTs 1-8.

Recommendation 4:

BNFL should carry out further work to address the longer term safety implications of coil failures and include the effect of increased cooling loads due to the receipt of HAL from potential future THORP higher burn up fuel reprocessing.

42. In respect of cooling coil/jacket failure the HASTs are divided into 3 populations; first, tanks 1-8 with no failures; second, tanks 9 -11 with a number of failures (approaching ten); and third, tanks 12-21 with very few failures. BNFL's approach to accommodating coil failures has been an informal one involving operation of a 'spare tank' policy (see Ref 1) in conjunction with a single failure criterion for cooling load. In this regime, if coil failures result in a tank's cooling capability reducing such that on failure of a further single coil it would not meet the required cooling load, then the tank would be emptied into spare capacity where the load can be met. (The 1-in-4 spare tank policy would ensure that there will always be tankage available for such purposes). Although this is not directly relevant to tanks 1-8 which have been shown not to boil, the 1 in 4 policy is still applied as a matter of prudence. NII's analysis of failures up to February 2000, showed it to be of limited concern for tanks 12-21. However, for tanks 9 -11 it was shown to be important that the arrangements for actions upon coil failures should be clarified and strengthened and that appropriate methods for monitoring failure trends should be developed to give early warning of the onset of any possible coil wear out phase. BNFL has therefore submitted a formalised contingency plan for coil failures including an enhanced 'spare coils' policy implemented through the operating instructions which has clarified and strengthened the position. Trend monitoring methods are also now being developed by BNFL.

43. In anticipation of the future possibility of HAL from higher burn-up fuels, BNFL has established an operating regime which defines the cooling capacity of each tank and matches the heat load of the HAL to be stored to this level (with due allowance for the enhanced spare coils policies). Any future business involving higher burn-up fuels than currently planned will be evaluated, using the modelling capability developed for assessing emptying strategies, for compatibility with this storage capability.

44. Finally, for the longer term, BNFL had developed a procedure for use of corrosion inhibitors but has not presented the case for this, as it was decided not to proceed with the approach because of technical uncertainties. In the light of the recent coil failures and adverse trend potential, (and the continuing absence of NDT techniques for tank walls - see recommendation 7), it is considered appropriate that development of the understanding of the corrosion regime and the effects of inhibitors should be continued for possible future

application. This work is now being progressed and a feasibility study on the use of inhibitors is expected in the Summer of 2001. The data from weld corrosion laboratory studies, which is also well under way, will follow in the Autumn.

Recommendation 5:

BNFL should address the issue of passive safety within the new (1999) safety case, to show what modern standards would be, then justify why modification towards this standard is or is not reasonably practicable.

45. Design studies are being taken forward by BNFL to examine the use of alternative, passively safe, tank designs with passive cooling for the reduced plant stocks after buffer levels are achieved. Initial design studies are complete and further progress will be reviewed within the stock reduction programme milestones. We consider that the most practicable course is to pursue this option for the longer term solution.

46. The existing HASTs employ forced circulation of cooling water through an open circuit incorporating cooling towers. These therefore present the potential of breakthrough of radioactive liquor to the environment in the event of coil or tank wall failure. This is not as inherently safe as would be expected of a modern plant design. NII's judgement of modern standards for cooling systems for these tanks would either require a totally passively safe system as a first preference and whenever this is not practicable to provide a robustly engineered active cooling system (which may for instance include intermediate heat exchangers (IHXs) which provide the benefit of an additional barrier). In the February 2000 report, NII required BNFL to show in its new safety case what options modern design would provide for such a plant and consider the practicability of upgrading to this standard.

47. BNFL has examined the use of IHXs in the CW circuits for the cooling coils to give the necessary defence in depth against breakthrough faults. However its analysis identifies that the relevant liquor-side and water-side pressures lead to the conclusion that an IHX need not be considered further. BNFL justified not incorporating IHX's on the jacket cooling systems on a similar basis. The justification in relation to the jacket CW system however was lacking with regard to vessel wall to jacket leaks. BNFL has therefore embarked upon a feasibility study of the application of IHXs to provide a secondary containment barrier within the tanks and evaporators jacket cooling systems. The work is now included in BNFL's engineering programme and NII is progressing this as part of its normal regulatory interactions with the Company.

Recommendation 6:

BNFL should justify the adequacy of the cooling water ring mains and implement improvements as far as reasonably practicable to make the individual ring mains (Normal, Guaranteed, Emergency) truly independent.

48. BNFL's safety case submission for HAST cooling is dependent upon high reliability and integrity for the cooling water supply system. Cooling water is normally supplied via one of two ring mains; the Normal and Guaranteed mains respectively. On failure of both of these an Emergency ring main is brought into use supplied from the cooling tower basin, the River Calder or the site Wastwater ring main. There are many cross connections between the

three systems which do improve the flexibility. However, there is potential for common mode failure at cross-over sections. Also common pipe sections, such as the return leg, render the systems open to the potential for single failure. In the COSR and the follow-up responses BNFL has reviewed the independence of the ring mains and found the systems to be satisfactory. This is on the basis of a refurbishment programme carried out on the pipework and valves, the extensive flexibility available within the supply routes, and a forward programme of seismic upgrade work.

49. NII recognises that, as would be expected with existing, older plant, some areas cannot be upgraded to modern standards. NII therefore welcomes the considerable engineering work undertaken by BNFL to upgrade the CW systems, but was not fully persuaded that when assessed against modern standards all that is reasonably practicable had been achieved. In particular, the flexibility provided in the systems can only be realised if the appropriate isolations and bypasses are initiated after faults have occurred. Although there is a reasonable margin of time to do this before overheating would occur, it was not evident that the necessary actions would be achieved in the absence of documented procedures, instructions and training, especially under circumstances such as seismic events or other extreme emergencies which might require those actions to be taken.

50. Additionally, the common CW return leg renders the entire system open to single failure which would necessitate an alternative return route being improvised or guarantees that continuous make-up for the system to operate on a once through basis is possible. (This in turn would require confidence in the supply route). There is a multiplicity of supply routes available, some elements of which are the subject of enhancement in the engineering work programmes. However, there also remained some uncertainty of the post-event accessibility and operability of the relevant isolation valves and hose connections in the absence of hazard protection.

51. The BNFL justification relied on the numerous and diverse plant provisions to enable something to be improvised if the need arises in an emergency situation. The system was therefore still not as close to achieving the modern standard as might be expected and required to be robustly supported by the necessary instructions and training. NII therefore expects the relevant seismic upgrade work to be taken forward to ensure continued operability post-fault, instructions/ procedures for isolations and recovery to be formalised, and training to be introduced. In addition NII expects the refurbishment programme to be completed, and the single failure issue of the return leg to be addressed.

52. As part of the ongoing regulatory activity BNFL has recently given NII a presentation of its Engineering Work Programme and the ALARP justifications supporting it in order to provide the necessary reassurance that everything practicable is being done to bring the plant provisions (including the cooling systems) as near as possible to modern standards. The elements identified above are addressed within the programme and BNFL has now also developed a set of instructions to facilitate the actions needed for isolations and bypasses for the CW systems.

53. NII has requested an updated justification of the CW systems reliability

to be provided within the first annual review of the safety case taking account of all the above measures.

Recommendation 7:

The remote inspections of the HASTs carried out by BNFL to establish component corrosion rates have not been conclusive and as such have not made a significant input to confirm the assumptions in this area in the safety case. BNFL should continue to commit resources to the ongoing development of alternative remote inspection techniques to underpin the HAST structural integrity safety case.

54. Corrosion in relation to the HASTs could arise from the liquor side or the water side of cooling coils/jackets and is important from a number of viewpoints:

- long term structural integrity of the older tanks to ensure containment of the liquors;
- integrity of CW coils to ensure no activity ingress to CW circuits & towers; and
- integrity of the HAST shell to ensure containment of liquors and prevent activity breakthrough to jacket CW.

55. Liquor leakage to cells has the potential to give rise to a release of radioactivity via the cell vent system, and breakthrough of active liquor into CW circuits has the potential for a release of radioactivity to atmosphere via the CW towers.

56. For liquor side corrosion, a case has been constructed drawing upon very limited direct inspection data, corrosion coupons of parent metal in simulates & actual HAL, and wall thickness comparisons between cooling coils and tank walls. This provides some confidence in the tank shell condition. However, there is an absence of data for welds & other discontinuities and potential hot-spots where solids may build up, and there is no conclusive inspection data. For this reason BNFL was asked to continue to develop remote inspection techniques & equipment to provide a more robust support for this safety case.

57. This work is still ongoing and has not yet produced a viable technique (although a remote ultrasonic inspection tractor device is now in the early stages of development for possible use for deployment within the base jacket of the tanks). BNFL has therefore given further commitments in this area, to press on with the programme of NDT development, and to establish weld corrosion data using HAL simulants. It is anticipated that tank wall inspections on HASTs 1-8 should be relatively straightforward using a manipulator deployed from the cell roof and that it may be possible to extend this for inspection of welds. No programme has been given for this work but it is likely to depend upon the B215 tank emptying programme whereby a pair of tanks in a cell can be emptied to facilitate the inspection work. For the weld corrosion data, a HAL simulant has been developed on target by BNFL. Its use for generating weld corrosion data has already started and the results are expected this Autumn.

58. The case for waterside corrosion has been comprehensively reviewed previously and is attributed as the cause for the cooling coil and jacket pinhole failures to date, largely associated with emptied or stagnant spare cooling components. The case is made by BNFL that coil failures are manageable without risk to safety. Tank wall corrosion from within the water jackets by this route is also unlikely, and then

only at potential large pit sites. BNFL's submission in this area has also incorporated an argument that the pressure of cooling water in the coils exceeds that in the tank and makes reference to an assessment of "water hammer" (very rapid surges of pressure) which justifies that even if a coil fails it would not lead to large leakages of activity into the CW. This satisfies NII's concern with regard to plant operability should such large leakages occur.

59. BNFL's case does however recognise the deficiencies in the waterside corrosion case in the area of large pits. Acknowledging the absence of inspection techniques which are likely to be capable of inspecting for such sites, BNFL concludes that managing waterside corrosion to prevent excessive coil failures and to support the tank wall case requires an alteration to the corrosion regime. This can be achieved by the use of corrosion inhibitors and/or draining and drying spare coils & jackets. It is accepted that there are technical issues that need to be properly resolved before implementing such changes, and these need to be progressed through normal regulatory arrangements.

60. BNFL is now progressing a programme for the inhibitor proposals and jacket drying tests respectively. The initial choice of inhibitor appeared satisfactory technically but was not a practicable proposition. Alternative inhibitors are being evaluated and feasibility/ effectiveness of these will be advised as results of model pit monitoring test runs become available (6-9 months each run). An alternative regime using demineralised water is also being evaluated over the next 6 months. A programme for evaluating the cooling jacket drying uses a redundant delay tank. Drying and inspection should be complete by April 2002 with monitoring results of pitting sites following by April 2003. Given the spare cooling capacity available, this programme has been accepted. Additional priority may need to be applied in the light of the persistent hot spot in one of the tanks (see para. 31 above).

Recommendation 8:

NII has concerns that the inspections carried out by BNFL on the evaporators may not be adequate to predict the early failure of key components. BNFL should continue to develop remote inspection techniques and apply these to assess evaporator operating life. Additionally, BNFL should carry out further work to establish a clear position with respect to the possible requirement for additional evaporator(s) and the impact of premature loss of capacity on the HAL strategy and HAST emptying policy.

61. The evaporators operate at reduced pressure with a normal liquor temperature of only 50 - 60^{o}c, which ensures that the stainless steel remains in a passive corrosion regime. There are two main concerns with regard to evaporator integrity. Firstly accelerated liquor side corrosion in the vapour space by vapour films condensing as concentrated corrosive species on forged parts (which are likely to be especially vulnerable), and secondly, accelerated liquor side corrosion (below liquor level) of the steam coils and the stainless steel base section (which are subject to high temperatures and hot-spots within the sludge layer). Both of these could significantly reduce evaporator life.

62. NII was concerned that the limited remote inspections done by BNFL of the remnant thickness of the steam coils were inconclusive and that no data was

obtained on welds or forgings or evaporator walls. Hence evaporator life predictions remain uncertain. The implications of this for HAL stock reductions were also unclear.

63. In its response to this issue, BNFL has reported on problems with the evaporator used for oxide HAL (Evaporator C). Increasing operating temperatures were being recorded with temperatures in excess of 90°c. Although the problem is now resolved (see below) and temperatures are back to normal it did reinforce the need to understand corrosion at higher temperatures. With the uncertainty of weld and forging corrosion data at elevated temperatures BNFL recognises the need to provide some actual inspection data, corrosion rate data from simulant tests, and temperature profile modelling, in order to get an improved picture of overall evaporator performance and remnant life. A programme to address these areas has therefore been provided with initial temperature modelling results due imminently, corrosion data laboratory work due by September 2001 and development of an inspection device by December 2002. At the time of writing the inspection method options have just recently been finalised and agreement has been reached on some form of crawler as the particular inspection device to be developed for the evaporators.

64. The Evaporator C operational problems were due to solids build-up during 2000. BNFL took the evaporator out of service in order to investigate the problem. This has been successfully resolved through a programme of acid washes, and an evaporator wash regime is now being formalised to prevent this solids build up in future. Together, these measures provide for detection & elimination of conditions which could lead to trans-passive corrosion and will now be progressed through normal regulatory business.

65. BNFL's claim to date has been that the effect of evaporator failure is essentially only commercial since there is spare capacity and in the worst case it would be addressed by stopping THORP and B205 receipts. However, accelerated corrosion leading to vessel or coil failure would be seen as having safety implications. Magnox holdings, if not processed in a timely manner, can give rise to radiological problems in storage ponds due to corrosion of the fuel. Also, with the need to process magnox arisings, evaporator life limitations could jeopardise the 2015 target for reaching a buffer stock volume. The development programme in support of evaporator life is therefore welcomed and will no doubt be given further impetus by the recent (but now resolved) problems with Evaporator C.

66. BNFLs submissions have justified why it is unlikely that evaporators will fail. NII also welcomes BNFL's development of a strategy for the plant as a whole if such an eventuality did arise and the contingency provisions for this. It will keep this strategy under review.

Recommendation 9:

BNFL should complete, within its periodic review of the safety case, a more detailed definition of the B215 structure safety functions and then categorise the structures systems and components with respect to their importance to safety. The effects of ageing and general degradation of the structures should be predicted for an operational life up to the predicted date for completion of decommissioning and any appropriate remedial work put in hand.

67. BNFL has supplied a detailed definition of B215 safety functions in its COSR. The substantiation of these safety functions is provided in the supporting design assessment and justification reports. The engineering provisions for meeting these functions have been identified in a categorised schedule taking account of potential failure consequences. Improvements to the provisions for meeting these safety functions are being implemented through the work programme arising from the COSR and prioritised on the basis of ALARP judgements. (See also recommendation 2 above).

68. Procedures are in place for managing long term ageing and degradation processes largely through routine inspections/surveys and maintenance schedule programmes, and for implementing the findings of these via an action plan in accordance with ALARP considerations.

69. It is therefore recognised that the issue has been systematically addressed within the COSR submissions and that methodologies have been provided for managing important remedial work.

Recommendations 10

BNFL should provide a complete justification of the ventilation systems against modern standards within the reviewed and revised safety case and implement any reasonably practicable improvements.

[Note: The assessment described here was carried out with that for Recommendation 13 (see below) and, in part, addresses it.]

70. The vessel ventilation system for the HASTs performs three main functions; maintaining a depression in vessels relative to the cells, providing a clean up system for air discharged to atmosphere, and preventing build up of hydrogen within the HASTs.

71. BNFL's safety case relies mainly on redundancy claims for prime movers and associated equipment, and on instrumentation to allow operators to change over equipment when necessary. NII requested comparison of this with modern standards and justification of the position.

72. A ventilation upgrade project has been undertaken for the HALES plants involving provision of a Caustic Scrubber to further reduce aerial discharges. This has brought part of the plant up to modern standards so far as is reasonably practicable as well as providing, by means of a total system reconfiguration, a dedicated discharge route from the vessel ventilation system for HALES.

73. From assessment of BNFL's submissions on ventilation and services, it is recognised that BNFL has an adequate case even though the cell and vessel vent systems fall short of full modern standards (which is not unexpected for an existing plant of this age). The ventilation system does not provide fully engineered protection for the hydrogen hazard for example and relies on operator actions. Nevertheless the ventilation upgrade has enabled BNFL to have a satisfactory multi-legged case.

74. A large number of recommendations for improvements are also noted within BNFL's submissions, many of these being associated with the Caustic Scrubber and system reconfiguration work referred to above and which has only recently been completed. Further improvements are being taken forward through the

ongoing engineering work programme arising from the COSR.

75. In respect of the cell ventilation systems a programme of improvements has been prepared but the safety case did not address the claim that small leaks in the cell would be detected by the cell extract monitoring system. BNFL has now prepared a paper demonstrating the ability to detect small leaks (5 litres/hr) to a HAL cell within one minute via the installed cell vent beta-in-duct monitoring between filter banks.

Recommendation 11:

BNFL should improve the B215 safety case to make it clear which instrumentation the operator needs to have available to make plant control and protection decisions.

76. The revised safety case and its associated documentation has addressed the matter of clarity in the provision of information to the operator from plant instrumentation. Two main issues have been considered: firstly the independence between the equipment provided to fulfil the functions of protection and control was unclear; secondly the differentiation to the operator of instrumentation and alarms for routine plant control and for emergencies needed clarification.

77. Independence of protection and control equipment was examined in some detail enabling a satisfactory conclusion to be drawn to the assessment.

78. Differentiation of routine and emergency information was also examined. This has been addressed through reviews of: i) the plant's safety related equipment which is listed in the Safety Case in what is known as the "Engineering Schedule"; and ii) the clarification in the new Clearance Certificate (CC) of all the safety mechanisms required to support safety functions for the plant. In addition, the Operating Instructions (OIs) have been updated in support of the new CC and a programme of updates of Emergency Operating Instructions (EOIs) is underway. A site wide programme of labelling improvements has also been undertaken.

79. Together these measures enhance the clarity of emergency and normal operating instrumentation. NII considers that BNFL has met the requirements of this recommendation and taken the results of the revised case further. Also NII is looking at related aspects such as plant/operator interfaces.

80. Subsequent to the January 2001 incident, which occurred during the reconfiguration of the ventilation system, a concern was identified over the poor use and response by operators to alarm systems. Although this was not in fact a significant contributor to the incident, BNFL has taken it up on a site wide basis. NII's ongoing assessment will be broadened to cover this wider issue and will consider the adequacy of BNFL's own findings and recommendations.

81. Some additional detailed issues have also been raised regarding the outage times and substitutions permitted for equipment designated as "safety mechanisms". These will be progressed following COSR implementation and will be addressed in the next update of the CC.

Recommendation 12:

BNFL is encouraged to use the B215 safety case revision as an opportunity to *develop the use of seismic PSA on chemical plants.*

82. Within safety cases for all new plants, NII requires a Probabilistic Safety Assessment (PSA). At the front edge of PSA development, seismic faults are being examined by this technique. NII also encourages this to be carried out for existing older plants even though such designs did not generally provide for seismic tolerance.

83. BNFL has a Seismic Methodology Working Group which is developing the methodology for generic application to its plants and has applied the initial approach on a trial basis to B215.

84. BNFL's report on the results of this trial has been submitted to NII. No reasonably practicable in-cell improvements have been identified. However, potential improvements relating to the CW system have been identified using the methodology and although CW tower replacement would not significantly improve the risk figures in the PSA, upgrade work in this area is to be undertaken as part of the Engineering Work Programme projects.

85. Overall BNFL has met the challenge of using the B215 COSR as an opportunity for development of the generic seismic PSA methodology and intends to continue its development taking account of the B215 pilot study results.

Recommendation 13:

BNFL should fully justify all assumptions made in the ventilation system safety case that are used to provide assurance that hydrogen concentrations do not build up to unacceptable levels in the HASTs.

86. Radiolysis of stored HAL generates hydrogen in the HASTs (and in the evaporators after prolonged shutdown). The safety case therefore draws upon a number of features including dilution through air sparging, sufficient ullage volumes and an adequate ventilation flow to prevent hydrogen building up to flammable threshold limits. In the event of a loss of forced ventilation, dilution must be assured through natural ventilation routes. NII's February 2000 report stated that assumptions supporting this case needed to be reviewed and updated.

87. Additional analysis was required for example using a lower threshold limit to bring the case into line with general industry practice, using a higher hydrogen generation rate (G value) to provide additional conservatism, and using revised reliability modelling to take account of the ventilation system upgrade work and the new Caustic Scrubber installation. BNFL has reviewed currently available information on G values and has recently adopted justifiably conservative figures. Additional plant improvement reviews have been undertaken to identify worthwhile improvements to the compressed air and electrical services to further enhance the reliability of these systems.

88. BNFL has drafted an addendum to the Hydrogen case HAZAN to take account of the findings from these reviews, and the engineering improvements identified from the reviews have been incorporated into the HALES Engineering Work Programme.

89. BNFL has therefore met the requirement of justifying the assumptions in the ventilation safety case with respect to the issue of hydrogen build-up subject to completion

of the associated elements of the HALES Engineering Work Programme.

90. All of these additional elements of the case will be drawn together for presentation in an integrated format in the next annual review of the safety case.

(See also recommendation 10 above).

Recommendations 14 & 15:

BNFL should consider processes and controls in buildings such as THORP or B205 that could impact on the safety case for B215, and ensure that an integrated and transparent approach to safety case production is achieved. A specific example of this requirement is the control of the organic content of the HAL in the reprocessing plants prior to transfer to B215.

BNFL should further develop the 'Red Oil' hazard assessment within the safety case to complete and include the results of the current research work on the topic.

91. Under certain circumstances it is possible for organic solvent to react exothermically with aqueous nitric acid in a potentially runaway reaction. This is prevented by controlling the amount of material, the temperature, heat removal and gas/vapour removal. Similarly, organic solvent /nitrate reactions can produce reaction products such as 'red oil', gases and hydrocarbon vapours with the potential for explosion. In addition, organic phosphates, which might be carried over from the solvent in the reprocessing plant, can cause foaming to occur in the tanks. Carry-over of organic solvent from the upstream reprocessing plants to the nitric acid solutions in B215 must therefore be minimised. Similarly, any washings from plants either upstream or downstream which could carry over organics to B215 must be adequately controlled. The PSA for B215 did not address the faults which would permit such carry-over since these are faults in other plants and which are addressed in the specific safety case for those plants. It was therefore essential that BNFL extended its safety case in some other way to address all possible interactions with other plants, in order to ensure that the significance of such interactions to safety were clearly analysed and made visible.

92. BNFL in its submissions has now addressed specific interactions such as red-oil, ammonium nitrate, and criticality. Additionally, BNFL has developed a schedule showing that all interactions have been systematically addressed, confirming that this provides comprehensive coverage of them, and identifying the relevant safety mechanisms in the related plants. The safety provisions for these interactions are then being addressed in the safety cases of the related plants.

93. NII assessment to date has not identified any flaws in the approach being adopted to address the full range of possible interactions.

94. In the rare event of a fault giving rise to the carry-over of organic solvent in significant quantities, despite the above provisions, the potential hazard in B215 is related to either the HASTs or the evaporators. The most likely of these is the evaporators which receive liquors first. The very small likelihood of reactions occurring is justified because the evaporators operate at low temperature and under partial vacuum and incorporate a free route to the ventilation system, which would prevent pressurisation. (The HASTs anyway operate at lower temperatures than the evaporators, provide a heat loss greater

than a reaction would generate, and incorporate a free route to the ventilation system, which would prevent pressurisation). In addition, experimental research work is ongoing in relation to these reactions and their driving parameters, including effects of catalysis. The work to date supports the safety case conclusions. Scale-up work, to confirm the applicability of the results of the laboratory work to the plant, is progressing well and is due for completion and incorporation into the analysis by the end of 2001.

95. An updated case was submitted in response to the original recommendation. Assessment to date shows this to be sound. Further assessment will be undertaken following receipt of the revised analysis in December 2001.

Recommendation 16:

BNFL should take account of the latest predictions from the UK climate change programme within its revision of the B215 safety case.

96. In relation to extreme winds and other meteorological phenomena, BNFL has demonstrated cases for 1 in 10,000 year return events. In 1997 NII also requested all licensees to take account of global climate change effects on their safety cases. Accordingly, BNFL has taken account of the latest predictions from the UK climate change programme in its COSR for B215, over and above the 10,000 year estimates. The safety case methodology includes a review of this position with new data as it becomes available to be substituted at future periodic reviews.

Recommendation 17:

BNFL should provide a complete analysis of severe accidents and in particular those with a potential for a large release of radioactivity. BNFL should also provide additional analysis and safety case documentation to strengthen the definition of actions required to prevent accident escalation and to implement recovery procedures.

97. BNFL's original safety case showed the consequences of a large release of radioactivity from the HALES plant to be within the BNFL standards, which equate to limits of tolerability. Its approach relied on the main pathway to exposure being through ingestion, and on successful mitigation of the effects by defined countermeasures (such as food bans which restrict intake by ingestion). The approach does not however address the consequences of the unmitigated case, nor does it justify the assumptions of the mitigated case such as effectiveness of countermeasures.

98. BNFL has therefore responded to recommendation 17 by presenting an updated submission confirming the fault scenarios for large releases, identifying the bounding case, and listing the safety case documents in which the emergency provisions for this case are identified to meet the necessary safety functions.

99. The submission noted that BNFL had already addressed this comprehensively through the HAZANs and supporting documentation and that no additional equipment or measures were required beyond those identified in these and the Emergency Operating Instructions.

100. BNFL acknowledged however, that the emergency provisions were not immediately evident because of the disparate nature of the analysis and agreed to draw together a route map document leading from the analyses to

the engineered emergency provisions on plant and the updated emergency instructions. NII also requested the analysis of emergency provisions to be extended to the next most significant release scenario which BNFL deemed incredible and whose effects to the public would be mitigated by countermeasures. These elements will be developed and incorporated into the first annual review of the safety case.

101. As part of recommendation 17, NII also required BNFL to justify the emergency response equipment available for protracted severe accidents (>24 hours) to ensure that safety functions would still be met and identify any worthwhile enhancements to equipment or procedures.

102. BNFL's updated submission therefore confirmed the only two severe accident scenarios (prolonged loss of cooling and catastrophic HAST failure), noted their incredibility, and identified the structures, systems and components available to meet the safety functions associated with these.

103. However, because BNFL's methodology defines these scenarios as incredible, the use of these provisions is not built into emergency instructions. NII has therefore requested BNFL to consider, as part of the ongoing development of the safety case formal operator guidelines for severe accidents and large releases for a limited number of bounding fault scenarios, even though these would include some scenarios which are not deemed credible.

HIGHLY ACTIVE LIQUOR STOCK REDUCTION PROPOSALS

(Recommendations 18 - 22 - see Appendix 1)

Overview

104. As indicated in the background section of this report, there has been general acknowledgement that the most appropriate strategy for long term storage of wastes is provided by vitrification associated with minimised levels of feed liquor stocks. To develop this strategy, BNFL produced a wide ranging framework paper describing all of the work areas which required to be addressed in order to inform an acceptable long term feed strategy for B215. These areas included fuel inputs and business strategies, plant outputs and vitrification strategies, process optioneering and plant optioneering, stocks management modelling, and some measurement of harm potential associated with alternative strategies.

105. This framework paper was then developed by BNFL into a formalised 'Highly Active Liquor Stock Reduction Strategy' which drew together the work in each of these areas to provide overall reassurance that BNFL would achieve HAL stock reductions to a buffer level by around 2015.

106. The HAL Feed Strategy paper indicates the volumes of HAL likely to be in storage at any given time using BNFL's assumptions for realistic reprocessing and vitrification scenarios. It has been updated and revised as the process of developing the stock reduction strategy has progressed, following dialogue with ourselves. It addressed the range of agreed monitoring parameters referred to in our February 2000 report and used extensive modelling work to simulate

plant operations over the period to 2015 in order to produce revised HAL storage profiles.

107. Because of the importance of the understanding of the modelling to the HAL strategy, we commissioned independent modelling through the HSE's Health and Safety Laboratory which showed close agreement with the work done by BNFL.

108. The work in this area has provided confidence that reductions to an appropriate buffer stock of about 200 m^3 are achievable by 2015. It has also identified a number of areas where developments can be progressed that may permit even further reductions in the final level of the buffer stock. These developments and the programme of improvements which ensure the annual vitrification throughput is achieved will be associated with milestones in the reduction programme.

109. In its responses to recommendations 18 - 22 BNFL defines the reduction in stock in terms of total volume. However, this does not provide the best representation of hazard potential. For example, recent problems with solids in evaporators have led to a programme of acid washes which adds to the total volume stored but creates a more dilute HAL with no effective increase in radioactive inventory. Also, the use of total volume does not allow for the different types of HAL, so that as total HAL volume reduces over time the proportion of high heat load HAL from oxide waste could increase if arisings of low heat liquor volumes fall. To account for this, provisions have been made for introducing controls on the proportional volumes of HAL types, and for 'normalisation' of the HAL volumes to a standard concentration which will take account of inactive acid additions.

110. Demonstration of the effect of these controls on hazard potential will require a suitable measure to be developed. This will largely be dependent upon the mix of HAL from different sources and the timings of their arising from the reprocessing schedule. (Underpinning any reduction in hazard potential is also the requirement for the specified ramp up of WVP production which then requires to be sustained at the assumed higher level, and the contribution of increasing sparage of tanks and cooling capacity with time).

111. To properly inform the reduction in hazard potential and thus benchmark any future changes to BNFL's business plans, further work is required for the development of a 'safety index' for comparative evaluation of the various options.

112. The dialogue in the areas of standardisation of volumes and safety indices is ongoing and has been captured in the significant milestones programme associated with the stock reduction specification.

Liquid HLW Stock Reductions

113. This section addresses recommendations 18 - 22 as a whole (see Appendix 1).

Initial Proposals

114. Figure 1 shows the BNFL proposed limits for the reduction of HAL stocks as submitted at 31 July 2000. Beneath this limiting curve, stocks build up initially whilst vitrification capacity is built up and as business continues in accordance with the business plan for the baseload of 7000te (ending around 2006/7). Post-baseload business has a number of uncertainties after the currently contracted THORP business is completed around 2010.

115. BNFL simulated several scenarios using its stocks management model based on the options considered in the framework document. This showed that eventual operation of the plant via 2 HASTs is feasible at a buffer stock level of around $200m^3$.

116. Additional studies have been identified which have the potential to reduce the final buffer stock level even further but these require development work with associated lead times for implementation of the engineering. (They include development of arrangements to minimise heel volumes, design of small passively or inherently-safe tanks for use with a 'just-in-time' approach to vitrification using a much reduced buffer stock, and process development through a review of water balances to minimise volume arisings). Milestones have been identified for review of these ongoing studies and development work which will form part of the implementation arrangements.

117. Realistic reductions in stocks in the interim can only be achieved if there is successful operation of all 3 vitrification lines with their target throughputs achieved. A significant programme of improvements is being undertaken on vitrification lines 1 & 2 to address historical problems and line 3 is being commissioned to an improved design which takes on board the lessons learned from lines 1 & 2. The active commissioning start date for Line 3 is programmed for around September 2001.

118. NII's views on the assumptions to be made for future throughputs in WVP was set out in some detail in Ref.1. In its latest strategy BNFL has now assumed a less optimistic ramp up of throughput for the combined output of the 3 vitrification lines. Nonetheless, for BNFL to achieve the stock reduction required to achieve a buffer stock by 2015, it is essential that a reliable vitrification performance is achieved and sustained over a period of at least a decade. With the recent decision for cessation of Magnox reprocessing around 2012, more rapid reduction of stocks can then be achieved by maintaining the high level of output from the 3 vitrification lines. In practice problems associated with the performance of all 3 lines will represent a serious challenge to this target.

Improvements to Initial Proposals.

119. NII assessment of the proposals submitted at 31 July 2000 and depicted in Figure 1 revealed several areas for improvement:

a) They did not reflect a realistic starting datum for stocks measured in volume terms because, during 2000, it had been necessary to accept significant quantities of HAL at reduced concentrations. This resulted from operational problems with in-tank evaporation and arisings of additional inactive wash liquors due to problems of solids in the evaporators. At January 2001 the realistic start point would therefore have to be higher than shown in the July proposals in terms of volume even though neither activity content nor heat loading had been increased. Further plant simulation modelling runs were therefore agreed which reflected initial conditions projected to pertain on plant at January 2001.

b) The 31 July 2000 proposals did not drive towards any reduction in total volume limits over the early years to 2006 during baseload business. NII therefore required BNFL to explore alternative scheduling of fuels, which might achieve reductions in volume, and to examine the comparative effects on safety of the various scenarios. It was found that only minor rescheduling was realistic on an ALARP basis (taking account of the very significant business implications of the more radical options such as extending THORP operation by spreading out the baseload over a longer period). However, two areas of improvement were identified which did result in projections of lower volumes whilst maintaining the same end date for achieving a buffer stock. These were the reduction of Gadolinium (neutron poison) additions in THORP by April 2002 (giving improved incorporation of waste oxide in glass, equivalent to HAL reductions of around 20m^3 per yr), and rescheduling of liquor transfers from the "old side" (Tanks 1-8) to enable blending to be optimised but necessitating a relaxation in the final decommissioning timescales for these older tanks. This is justifiable because of the relatively benign conditions in those tanks and their good condition as shown by remote inspection. The modelling runs were also arranged to incorporate the effects of the recovery of optimal in-tank evaporation rates in the plant. Based on all of these runs, a number of improvements were identified in the total stock reduction proposals and these are reflected diagrammatically in the upper line of the revised stock reduction graph shown in Figure 2.

c) The 31 July proposals were defined in terms of total volume only and compliance would be fundamentally dependent on achievement of the vitrification plant throughputs. Concerns were that if WVP performance fell short, THORP could continue to feed forward oxide derived liquors to the HALES plant in preference to a feed of Magnox liquors from the Magnox reprocessing plant. (This would be even more likely if problems were experienced on the B205 Magnox reprocessing plant). This would be detrimental in terms of hazard potential and it was accordingly decided to ask BNFL to establish a control over oxide bearing HAL stocks which would link THORP operation to WVP performance.

<u>Oxide derived HAL Controls</u>

120. An intensive period of modelling ensued examining the various options for limiting the oxide bearing liquors. As of January 2001 the stocks of these were in excess of 700m^3. This necessitated evaluating scheduling options for high heat loading liquors for blending so as to ensure maximum incorporation in the vitrified product containers and optimise in tank evaporation.

121. Although first thoughts would suggest that the high heat load liquors should be vitrified first, it is necessary to retain sufficient of them to optimise WVP incorporation throughout the reduction period and to provide the heat load to aid in-tank evaporation. The volume necessary to sustain this was the subject of a detailed modelling analysis which showed a requirement of around 450m^3 for these liquors.

122. Allowing for an operational margin, a control level of 500m^3 was therefore agreed, with a linear reduction to this level from current stocks essentially over the baseload period. This control is shown diagrammatically by the lower line in Figure 2.

123. The actual stock projection for these liquors overruns the control levels on around 4 occasions during the baseload period. Rather than apply a higher ceiling which would give larger margins on oxide bearing stockholdings, it was agreed to retain the tighter levels as a controlling 'curve' with constraints to ensure that any deviations are

brought back on track in a timely manner. (Non-compliance would also result at one point towards the end of the baseload period if the Gadolinium reduction proposal was not implemented by April 2002).

124. Reporting arrangements for this control were built into the implementation requirements. These provided for the development of monitoring and reporting levels in terms of normalised volumes which would discount inactive acid additions which might be needed from time to time to accommodate operational requirements. A proposal for a methodology for the "normalisation" of volumes and development of operational controls has now been put forward and will run in parallel with the existing volume reporting measures in a pilot scheme from end of July 2001 to April 2002 before being formally adopted.

Formalisation of Limits and Controls.

125. From all of the foregoing, a legal 'Specification' (Ref 5) was drawn up effective from 1 Jan 2001 to ensure the reduction of HAL stocks to the buffer level of 200m^3 by July 2015 in accordance with total volume limitations and with controls on levels of oxide bearing liquors. The basis of this specification was drawn up in tabular form and reflects the reductions shown diagrammatically in Figure 2. The implementation arrangements also provide for regular reviews and for development of even tighter operational restrictions based on normalised volume controls.

126. Throughout all of the above however, it can be seen that the use of total volume is not the best indicator of safety. Also there is a large number of options for scheduling and management of stocks within the confines of the envelopes, each of which will reflect a different margin for compliance and this in itself will vary throughout the stocks reduction period. The baseload period and post-baseload contracted work period is now well defined and results in projections which show a general systematic reduction in radiological inventory and hazard potential once optimal concentrations of liquors are regained. Beyond that however, uncertainties in the business assumptions mean that there could be occasional increases in radiological inventory, albeit contained within the proposed envelopes.

127. It is therefore considered essential that some form of numerical index of safety is developed for application to the business options to ensure that in the post-baseload period in particular the hazard potential is minimised commensurate with the strategy adopted. The purpose of such an indicator would be for comparative rather than absolute use. To this end, a milestone has been incorporated into the implementation arrangements for development of such an index on a timescale which reflects the complexity of the issue.

Monitoring Milestones

128. Monitoring milestones will be associated with:

- the decision on the provision of a vitrification test rig to study the feasibility of proposed developments;
- a review of the water balance associated with evaporation conditioning and vitrification;
- a review of feed liquor sampling and analysis arrangements;

- a formal evaluation of passive HASTs;
- a review of the WVP process constraints;
- confirmation and amendments to the post operational clean-out strategy for old-side HASTs;
- review of, and subsequent improvement to, in-tank evaporation rates;
- the development of a safety index;
- commencement of plant improvements to remove constraints;
- the demonstration of progressive improvement in vitrification capacity;
- achievement of target flowsheet concentrations of liquors;
- a review of the constraints which limit the specified buffer stock to 200 m^3, and
- the development of operational controls and a monitoring system based on 'normalised volume'.

129. BNFL is being required to provide an annual report to NII on its progress against the specified limits and its committed programme of improvements. In addition, to take account of technological advances and the changing circumstances of BNFL's own business plans, NII intends to carry out a critical review of the strategy and overall programme every two years in order to identify any further reasonably practicable stock reductions.

CONCLUSIONS

130. In February 2000, NII reported on the safety of HAL storage at Sellafield, concluding that the arrangements were safe but identifying a number of areas in which improvements could be made. In respect of these areas, 22 recommendations were made, 17 relating to the safety case and 5 to HAL stock reductions.

131. Responses to all 17 of these safety case recommendations have now been received and incorporated as far as possible into the new COSR. Nothing has been identified which should prevent operation of the plant until the next periodic review. The updated safety case (COSR) which has now been completed was therefore cleared for implementation with effect from 31 January 2001 subject to a programme of further work and commitments to further submissions in support of the safety case. Unfortunately, implementation of the new case was delayed by problems with the ventilation upgrade work, but implementation has now been completed.

132. Responses to all five of the HAL stock reduction recommendations have been completed. Stock reduction proposals are now firmly defined which will achieve reduction of the stored liquid HLW in B215 to a buffer level of 200m^3 by July 2015.

133. To ensure that these are met, a legal ‘Specification’ has been issued for these stock reductions with effect from 1 January 2001.

134. A substantive programme of ongoing enhancements to plant safety has been identified through the safety case review process and this is being progressed through routine regulatory business.

135. A programme of ongoing developments has also been identified

in relation to stock reductions. These include a new operational control using standardised volumes and a safety index and these are to be progressed through monitoring milestones.

136. BNFL is required to report to BNFL annually on its progress against the specified limits and committed programme of improvements. NII also intends to carry out a critical review of the strategy and overall programme every two years.

FUTURE REPORTING INTENTIONS

137. We will provide reports to the Sellafield & Drigg sites Local Liaison Committee (LLC) through our normal process. These reports are available on HSE's Internet web site. Our site inspector attends the regular LLC meetings and responds to matters arising as part of his normal business activity.

HM NUCLEAR INSTALLATIONS INSPECTORATE
July 2001

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3. Safety of the Storage of Liquid High Level Waste at BNFL Sellafield. Report by HMNII. HSE Books. ISBS 07176 1045 5.1995.

4. Article, "BNFL Safety Case Improvement" in Nuclear Safety Newsletter, HSE, February 1999.

5. Specification Issued under Licence Condition 32(4) for the limitation of the Accumulation or Storage of Liquid High Level Radioactive Waste in B215. Licence Instrument 343. January 2001.

PUBLIC ENQUIRIES:

NSD Information Centre, St. Peters House, Balliol Road, Bootle, Merseyside L20 3L2. Tel: 0151-951-4103 Fax: 0151-951-4004.

Fig 1.   Total HAL Stocks Limiting Envelope - Proposal at 31 July 2000

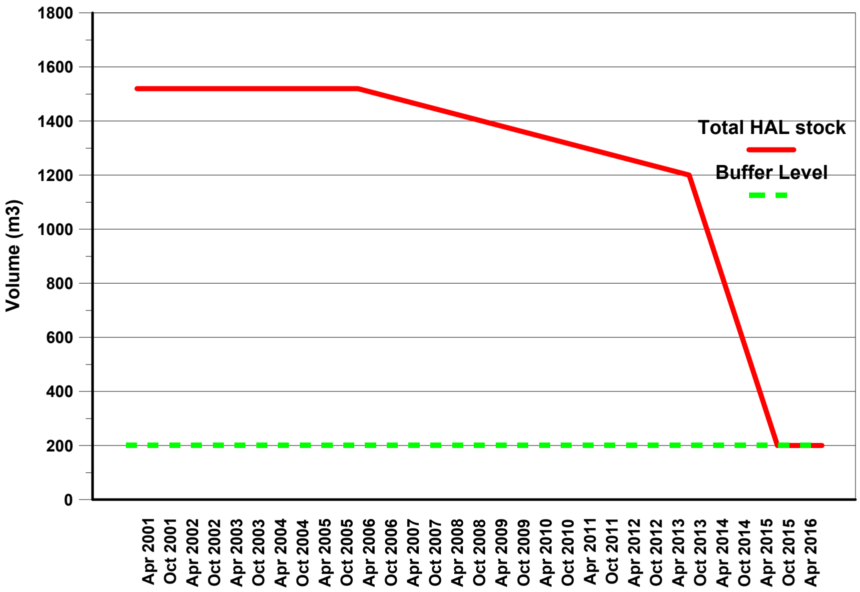
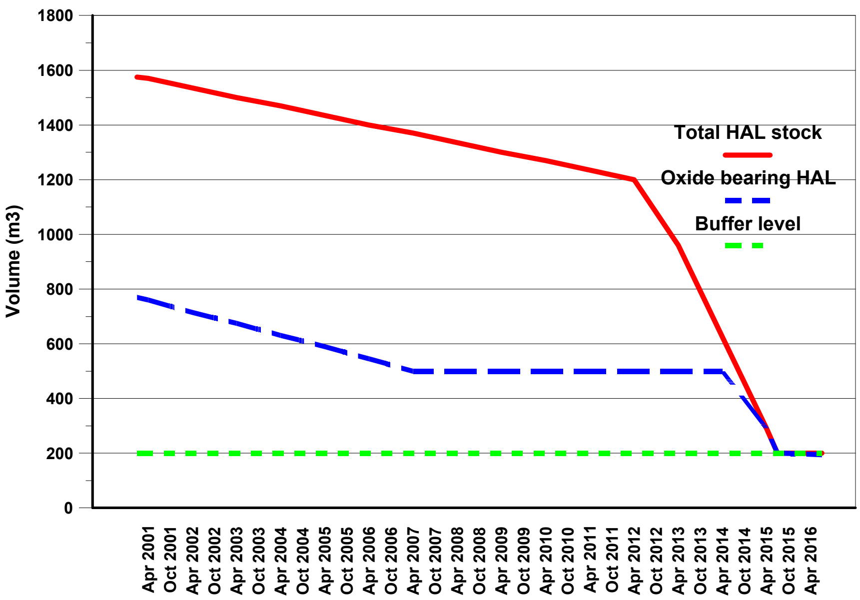


Fig 2. Total HAL Stocks Limiting Envelope & Oxide/Blended HAL Tracking Envelope



APPENDIX 1

Recommendations 18-22 from NII's February 2000 Report on Storage of Liquid HLW at Sellafield.

Recommendation 18: BNFL should provide an updated HAL feed strategy and estimate of the HAST emptying timescales for future fuel reprocessing business scenarios. The submission should include historical and predicted values of all HAL monitoring parameters agreed with NII in order that NII can assess BNFL's predictions for achieving the aim to empty the HAST's to a buffer stock by 2015 and the associated reductions in potential hazard.

Recommendation 19: BNFL should review the vitrified product container production rates assumed for WVP and use adequately cautious figures in the estimating of HAST emptying timescales resulting from recommendation 18.

Recommendation 20: BNFL should complete the work to assess the impact of HAL feed pipework blockages within the WVP processes on the declared HAST emptying policy and develop a permanent solution to the problem.

Recommendation 21: In determining the final HAL buffer stock BNFL should undertake a comprehensive study of options to achieve the aims of minimising the potential for harm and controlling the storage and feed regimes so as to make operations inherently safer.

Recommendation 22: BNFL should develop HAL stock reduction curves with suitable milestones for agreement with NII against the agreed HAL monitoring parameters, such that progress towards emptying the HASTs by about 2015, to the buffer stock resulting from the options study of R21 can be readily assessed and if necessary regulated by NII.

APPENDIX 2

Description of B215 Ventilation Incident

During the afternoon shift of 26 January 2001, planned work to modify the configuration to the duct supplying the ventilation systems to the B215 HAL vessels was being undertaken. The modification work was associated with the installation of a Caustic Scrubber to enable reduced environmental discharges from the B215 plant. When fully operational the Caustic Scrubber system would also provide a more robust ventilation plant and hence had additional safety benefit.

The work involved the fitting of inflatable "balloons" in a number of locations inside the ducting to enable sections of the duct to be isolated and others to be connected. Prior to this, a bypass duct had been fitted to ensure that ventilation to the vessels was maintained during the course of the modification work. This necessitated some adjustments to be made to the various ventilation systems to enable the vessel ventilation flows to remain within acceptable parameters. During this period alarms associated with the ventilation systems were occurring on a frequent basis reflecting the changing situation.

At around 19:30 hrs on 26 January, the planned work to make the first isolation was initiated. This was completed without significantly affecting the vessel ventilation systems around 20:00 hrs.

The modification required a second isolation to be made on the duct in an area between the main duct and the bypass duct. This second isolation was close to the first and was undertaken by the same team following the completion of the first isolation. Some difficulties were experienced during the fitting of the isolation balloon and it was necessary to reposition it to ensure an effective seal. The work was completed at approximately 20:30 hrs.

Around this time a number of hard wired alarms associated with the B215 vessel ventilation systems were annunciated in the B215 Control Room. These identified that the vessel ventilation systems had failed and that the jet ballast systems within each of the HAL storage tanks had tripped out of service. In addition a number of alarms were displayed on the plant surveillance computer system which confirmed that the vessel ventilation system was ineffective.

At approximately 21:00 hrs the Shift Team Leader was informed that the engineering work on the duct had been completed. A shift change the took place at approximately 22:00 hrs.

At approximately 22:45 hrs the new Shift Team Leader identified that the ventilation system to the HAL storage tanks was ineffective. This resulted in the implementation of the appropriate building emergency instruction to ensure that the radioactive materials held within the storage vessels were adequately controlled. At approximately 23:15 hrs the emergency situation was terminated with the vessel and cell ventilation systems being restored to acceptable levels.

The completion of the second isolation to the duct coincided with the loss of ventilation to the B215 HA storage vessels. Investigation suggests that the inflated balloon blocked both the main and bypass duct and hence isolated the vessel ventilation systems.

Following the incident BNFL initiated their own investigation, notified NII, and imposed a restriction on all non-essential operations. It was also agreed within NSD management that transparent action in line with HSC/E Enforcement Policy was required. Two Directions were issued by NII under the Licence Conditions attached to the Sellafield Nuclear Site Licence. These had the effect of preventing the implementation of further modifications to the vessel ventilation systems and limiting all non-essential operations until a review of safety had been completed.

Site management and safety representatives were briefed on the findings of the investigation and the nature of the enforcement action.

The requirements of both Directions have now been satisfied and normal operations have resumed within the plant. The caustic scrubber has now been satisfactorily connected to the ventilation system.

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