HALES Operating Rule 26

Project Assessment of Sellafield Limited's Proposal to Modify HALES' Spare Volume Capacity Operating Rule

Project Assessment Report ONR-SDFW-PAR-16-012
Revision 1
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EXECUTIVE SUMMARY

Modification of Existing Plant: Highly Active Liquid Evaporation and Storage (HALES) Operating Rule (OR) 26

Permission Requested
In accordance with its arrangements under Licence Condition 22(1), "Modification or experiment on existing plant", of schedule 2 of site licence 31G, Sellafield Limited (SL), the licensee, has requested the Office for Nuclear Regulation's (ONR) "agreement" to modify the Highly Active Liquid Evaporation and Storage (HALES) plant's Operating Rule (OR) 26, in accordance with a Category B Plant Modification Proposal (PMP).

Background
The HALES facility supports both the Thermal Oxide Reprocessing Plant (THORP) and Magnox reprocessing operations at Sellafield by receiving Highly Active Aqueous Raffinate (HAAR) into buffer storage and then concentrating the HAAR through evaporation. The result is a concentrated liquor known as Highly Active Liquor (HAL). The HAL is held in interim storage within HALES in Highly Active Storage Tanks (HASTs) prior to it being transferred to another facility, the Waste Vitrification Plant (WVP), where it is processed into glass blocks, suitable for long term storage.

In 2013, SL introduced the HALES performance plan in order to prolong the life of critical assets within HALES (notably Evaporator C and the cooling coils within the HASTs). The implementation of the performance plan has seen a steady increase in the volume of HAL stored in HALES, as a result of the storage of more dilute HAL. This has been caused by a number of factors (detailed below) which, taken together, mean that the HAL currently being stored is now only approximately 40% of the concentration of that stored five years ago. Since any liquor stored within a HAST is designated as HAL irrespective of its concentration or hazard potential, even though the hazard posed by HALES has been falling steadily since 2001, SL is now at a point where it is predicting that it will likely breach (the current) OR26 in late 2016. To prevent this breach, and in view of the lack of other reasonably practicable options, SL has produced a safety case to justify modifying the OR.

Assessment and inspection work carried out by ONR in consideration of this request
In accordance with an agreed regulatory strategy and scope, I engaged a Fault Studies specialist inspector to carry out an assessment of SL's safety case. I also undertook a Chemical Engineering assessment myself. In these activities we:

- Performed sampled assessments of SL's suite of safety case documents supporting the modification
- Reviewed a number of the reports produced by SL's Independent Nuclear Safety Assessment (INSA) team and Internal Regulators
- Held meetings and discussions to feed back our assessment findings and allow SL to present revised proposals.

Matters arising from ONR's work
The ONR Fault Studies assessment sought to determine the adequacy of the safe case, examining whether the reduced spare capacity would still be sufficient to accommodate all stored HAL in the event of HAST failures and that adequate recovery measures would be in place should a situation arise where there is more HAL than immediately available safe storage. The specialist drew two key conclusions: only a failure of a HAST base would result in the need for prompt emptying of a HAST, and the likelihood of two HAST failures within a short space of time (i.e. a few months) such that recovery operations are impacted is very low. These conclusions are supported by an ONR Structural Integrity inspector. The Fault Studies inspector also concluded that SL has taken appropriate credit for its ability to recover sufficient

capacity from other vessels in the facility to mitigate the consequences of having greater volumes of HAL than immediately available HAST storage. The Fault Studies specialist recommends the issue of the requested Licence Instrument (LI), as well as oversight of future HAL volumes. This latter recommendation is already covered by existing regulatory activities. Nevertheless, the relevant site inspector has been informed of the recommendation so as to ensure continued appropriate oversight.

The ONR Chemical Engineering assessment reviewed the claims, arguments and evidence supporting the justification for the modification. This included an assessment of the licensee's option review process, which concluded that modification to OR26 was the most appropriate course of action. The assessor concludes that the proposed change in the OR should be supported since the Waste Vitrification Plant provides an export route for HAL, there are a number of alternative vessels available for short-term HAL storage, some stored liquor could be evaporated quickly to regain significant storage space, and the likelihood of HAST failures is low with no significant common cause failure mechanisms identified. The Chemical Engineering Specialist therefore recommends that ONR issues an LI to enable SL to implement the modification to its OR.

The overarching assessment taken by the ONR project inspector concludes that the licensee's arrangements for implementing the modification are adequate and suitably underpinned. The project inspector also concludes that the proposed modification is in line with the Sellafield Lifetime plan and whilst the modification will result in a small increase in plant risk, this is balanced out by the reductions in hazard and risk on site that are avoided (i.e. cessation of Oxide & Magnox reprocessing operations) should the current OR not be changed.

Conclusions

Based on ONR's specialist assessments and my own interactions with SL during this work, I am satisfied with the claims, arguments and evidence laid down within the safety case and supporting documents. Whilst this modification results in a small increase in total plant risk as a result of a reduction in plant contingencies, the risk nevertheless remains low and at a level where ONR's SAPs suggest it would not be proportionate to pursue any improvements. Since the modification also safeguards hazard and risk reduction activities elsewhere on site, I judge that it reduces overall site risks to ALARP.

Recommendation

I recommend that ONR should issue Licence Instrument 904 as an agreement to implement the proposed modifications to the Highly Active Liquid Evaporation and Storage plant's operating rule 26.

LIST OF ABBREVIATIONS

AGR	Advanced Gas-Cooled Reactor
ALARP	As Low As Reasonably Practicable
BSL	Basic Safety Level
BSO	Basic Safety Objective
CCOI	Clearance Certificate Operating Instruction
FHP	Fuel Handling Plant
GDF	Geological Disposal Facility
HAAR	Highly Active Aqueous Raffinate
HAL	Highly Active Liquor
HALES	Highly Active Liquor/Liquid Evaporation and Storage
HAST	Highly Active Storage Tank
HOW2	(Office for Nuclear Regulation) Business Management System
INSA	Independent Nuclear Safety Assessment
ITE	In-Tank Evaporation
LI	Licence Instrument
MSC	Management Safety Committee
NDA	Nuclear Decommissioning Authority
ODM	Operational Decision Making
ONR	Office for Nuclear Regulation
OR	Operating Rule
PAR	Project Assessment Report
PMP	Plant Modification Proposal
POCO	Post Operations Clean Out
SAP	Safety Assessment Principle(s)
SL	Sellafield Limited
THORP	Thermal Oxide Reprocessing Plant
WVP	Waste Vitrification Plant

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Table 1: Relevant Safety Assessment Principles Considered During the Assessment

1 PERMISSION REQUESTED

1. In accordance with its arrangements under Licence Condition 22(1), "Modification or experiment on existing plant", of schedule 2 of site licence 31G, Sellafield Limited (SL), the licensee, has requested (Ref 1) the Office for Nuclear Regulation's (ONR) "agreement" to modify the Highly Active Liquid[1] Evaporation and Storage (HALES) plant's Operating Rule (OR) 26, in accordance with a Category B Plant Modification Proposal (PMP). The following safety case documentation was submitted for consideration by ONR:

   - Plant Modification Proposal HALES/B***/1458, HALES MSC P(16) 075 "Implementation of changes to the HALES Safety Case, including Operating Rule 26, CCOI 467, CCOI 520, and ALARP Justification, Cult 18003" (Ref 2)
   - Cult 18003, HALES MSC P(16)073, "ALARP Justification to Revise HALES Operating Rule OR26" (Ref 3)
   - WEDTC/16/288, HALES MSC P(16) 076, " Predictions for Future HAST Liquor Volume and Capacity under a 1 in 6 Spare Volume Operating Regime" (Ref 4)
   - HALES MSC 216, "Management Safety Committee minutes of meeting" (Ref 5)

2. No existing licence instruments have been identified for amendment or revocation as a result of this agreement.

3. An "agreement" is the use of a derived power offered to ONR through the wording of licensee's own arrangements. Derived powers enable ONR to permission licensee activities without use of the primary powers ONR is granted by the licence conditions. Under its arrangements, SL needs "agreement" from ONR to implement this modification to its OR.

4. This Project Assessment Report (PAR) has been written to present the basis for the permissioning decision made by ONR. The rationale for regulating this permission through a PAR and Licence Instrument (LI) is described in a Decision Record (Ref 27).

5. This report has been prepared in accordance with the requirements of HOW2 (Ref 6).

[1] The acronym HALES normally stands for Highly Active Liquor Evaporation and Storage. However, SL's requesting letter refers to this plant as Highly Active Liquid Evaporation and Storage. As the intended meaning of SL's request is not in doubt (e.g. there is only one plant at SL performing the activities referred to in the submission), ONR has not asked for this request to be resubmitted and both expansions of the acronym appear in this report consistent with the context used.

2 BACKGROUND

2.1 FACILITY INFORMATION

6. The HALES facility broadly consists of two areas: Storage and Evaporation. The Storage element comprises of a number of High Activity Storage Tanks (HAST) divided into 'old side' (essentially quiescent) and 'new side' (in active operations). The Evaporation element consists of three evaporators A, B and C (with a fourth evaporator, D, currently under construction). Parts of the HALES facility were constructed in the 1950's and have since been extended and modified over the subsequent years and so comprise different generations of HASTs and evaporators.

7. HALES supports both the Thermal Oxide Reprocessing Plant (THORP) and Magnox reprocessing operations by receiving Highly Active Aqueous Raffinate (HAAR) into buffer storage. The volume of HAAR is reduced through evaporation[2] (low temperature boiling at sub-atmospheric pressure), resulting in a concentrated liquor known as Highly Active Liquor (HAL). The HAL is held in interim storage within the HASTs prior to it being transferred to the Waste Vitrification Plant (WVP) where it is processed into glass blocks, suitable for long term storage.

8. The safe interim storage of HAL within the HASTs is of key nuclear safety importance to the public and workforce. Due to the very high radioactivity of HAL, it is self-heating and generally requires active cooling to remove the excess heat.

2.2 REGULATORY BACKGROUND

9. SL currently has two ORs to control the amount of HAL stored within the HASTs. The first (OR20) acts as a strategic, high level control to ensure ongoing reductions in HAL stocks each year. OR20 was introduced in 2015 as the prime mechanism for the control of HAL stocks at Sellafield (a role previously performed through ONR's HAL stocks Specification (LI793)). The second (OR26) limits the volume of HAL that can be stored within the HASTs to ensure that there is always sufficient spare capacity such that should the integrity of a HAST be challenged, its contents can be safely and promptly stored elsewhere within the facility. Neither OR is subject to an "Approval" under ONR's Licence Condition 23 powers; i.e. changes to these ORs do not require a primary power "Approval" Licence Instrument.

10. OR20 states: "*Over a one year period, the total HAL input to Highly Active Liquor Evaporation and Storage (HALES) facility resulting from reprocessing operations must be less than the total HAL output from HALES as a result of Vitrification Operations*." The OR is intended to deliver year-on-year reductions in the HAL stocks at Sellafield and utilises the key principles within the HAL stocks specification. OR20 is measured in teU (tonnes of spent fuel equivalent) as this reflects the hazard potential of the HAL better than a straightforward volume measurement.

11. There is a significant regulatory history around the rationale for the development and implementation of OR20, which is detailed in an ONR PAR (Ref 7). However, as OR20 is not directly affected by SL's proposed modification to OR26, this will not be discussed further within this report.

[2] Evaporators A and B can only process liquors from the Magnox reprocessing stream, whilst Evaporators C and D can process both Magnox liquors and liquors from the THORP reprocessing stream ('Oxide' liquors)

12. OR26 currently states: *"The total volume of liquor within the new side HASTs must not exceed the limit based upon 75% of the total safe storage volume…'* [3] and is colloquially known as the '1 in 4' limit. The '1 in 4' limit is a long-standing policy that has been in place since at least the 1970's and was formalised as an OR in 2001 as part of HALES' continued operations safety case. This policy (and latterly OR) has not attracted significant regulatory attention since its inception largely due to the volumetric margin to safety maintained over that time and the high degree of redundancy in cooling provided to each HAST. Both of these aspects are related to the high concentration of the liquors being stored hitherto.

13. In 2011, following a number of HAST cooling component failures (thereby reducing the degree of redundancy in cooling), ONR raised concerns about the integrity of the existing HAST fleet to support SL's reprocessing and vitrification operations through to completion. In response, SL initiated the 'Replacement HASTs' project, to provide additional contingency for the storage of HAL.

14. In November 2011, the Nuclear Decommissioning Authority (NDA) outlined its preferred strategy to close THORP in 2018, and to place any un-reprocessed Advanced Gas-Cooled Reactor (AGR) spent fuel into interim storage pending conditioning and disposal to a Geological Disposal Facility (GDF) (Ref 8). The NDA's strategic position enabled SL to clarify and bound its reprocessing commitments and to predict with more accuracy the quantities of HAL to be stored over the remaining lifetime of the plant.

15. In parallel, SL continued to progress the Replacement HASTs project to a sufficient level of detail to estimate the required costs, resources and timescales. According to SL's own estimates, the additional HASTs would come on stream in around 2019, i.e. towards the end of the Magnox Operating Plan and after the intended 2018 closure of THORP. Capital costs were projected to be of the order of £500m.

16. In February 2012, SL concluded that the Replacement HASTs project would not deliver the safety benefits that were the original drivers of the project (Ref 9). General project performance at that time suggested that the project was likely to suffer delays in delivery, which would reduce even further the project's contribution to safety. More significant safety benefits could instead be gained by targeting available funds to the decommissioning of other high hazard installations. ONR acknowledged SL's conclusions (Refs 10 & 11).

17. In order to provide confidence that the existing HASTs have sufficient capacity to support reprocessing and vitrification safely through to completion, SL developed the 'HALES performance plan' which would maximise remaining asset lifespans; ONR permissioned the plan's implementation in 2015 (Ref 12). The key modifications associated with the performance plan were the development of corrosion and cooling models to predict HAST safe operating life going forwards and the increase of cooling water flow rates to prevent stagnant water corroding the inside of HAST cooling components ('water-side corrosion'). The latter modification had the additional impact of reducing the temperature at which the HAL is stored, giving a larger margin of safety for loss of cooling events and further reducing process-side corrosion.

[3] Volume limits are explicitly described in the OR but are not shown here to allow this paper to be published on ONR's website.

2.3 LICENSEE'S PROPOSAL

18. In 2013, SL introduced the HALES performance plan in order to prolong the life of critical assets (notably Evaporator C and the cooling coils used in the HASTs). The implementation of the performance plan has seen a steady increase in the volume of HAL stored in the HASTs as a result of the storage of more dilute HAL. The elements of the performance plan that contribute to this are:

- The endpoint of the evaporative process is now controlled to prevent solids formation on the base of Evaporator C. Since solids production is more likely with increasing concentration, the final concentration of the batch is reduced.
- Evaporator C is subject to a washout after each batch to prevent a build-up of any solids that may have accumulated on the base despite the endpoint control. This wash liquor is sent forward to the HASTs and is counted as HAL despite its very low hazard potential.
- The cooling flow has been increased to the HAST coils and jackets, which has had two key effects:
  - It has reduced the HAL storage temperature thereby reducing corrosion rates (a benefit), and
  - It has eliminated the In-Tank Evaporation (ITE) process (a detriment); ITE was previously used to help reduce the volume of HAL stored over time by concentrating the liquor.

19. Taken together, these factors mean that the HAL currently being stored is now only approximately 40% of the concentration of that stored five years ago. This situation is further compounded by the recent downturn in performance at WVP and the continued good throughput performance of Sellafield's reprocessing facilities.

20. Since any liquor stored within a HAST is designated as HAL irrespective of its concentration or hazard potential, even though the hazard posed by HALES has been falling steadily since 2001, SL is now at a point where it is predicting that it will likely breach (the current) OR26 in late 2016. In order to prevent this from happening, SL is proposing to modify OR26 from the current '1 in 4' (25% ullage) spare capacity to a '1 in 6' (16.6%) spare capacity.

21. In support of this modification SL has submitted the following documentation to ONR:

- Covering Letter (Ref 1)
- Plant Modification Proposal (Ref 2)
- ALARP Justification Paper (Ref 3)
- Future Volume Projection Paper (Ref 4)

22. The PMP (Ref 2) identifies this as a category 'B' modification within SL's arrangements, because it significantly modifies an extant OR. The PMP also details the extent of the modification, the updates to documentation required and how this will be implemented on plant.

23. The ALARP justification paper (Ref 3) reviews the current situation and details the potential options (e.g. reduce reprocessing operations, re-introduce in-tank evaporation, concentrate dilute wash liquors in Evaporator C and relaxation of the '1 in 4' limit). It concludes that the best overall solution is to relax the existing '1 in 4' limit in favour of a limit that is more appropriate to HALES' current operational circumstances. The paper then proceeds to demonstrate that the increase in risk from this modification is tolerable and that risks are reduced to As Low As Reasonably Practicable (ALARP).

24. The Future Volume Projection paper (Ref 4) reviews the anticipated future inputs to HALES and outgoings to WVP across a range of scenarios to demonstrate that the new proposed limit is not likely to constrain future operations.

3 ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST

3.1 ONR SPECIALIST ASSESSMENT

25. In accordance with the regulatory strategy and scope laid out in the Decision Record (Ref 27) related to this project, which was agreed by the Superintending Inspector, I engaged a Fault Studies specialist inspector to carry out an assessment of SL's safety case. I also undertook a Chemical Engineering assessment myself. In these activities we:

- Performed sampled assessments of SL's suite of safety case documents supporting the modification
- Reviewed a number of the reports produced by SL's Independent Nuclear Safety Assessment (INSA) team and Internal Regulators
- Held meetings and discussions to feed back our assessment findings and allow SL to present revised proposals.

26. In line with ONR's normal process, further supporting documentation was requested by ONR, which is referred to where appropriate within the specialist assessments.

27. I note that SL has subjected the suite of documents submitted to a prescribed checking and approval process. I have taken due note of comments from its INSA (Ref 13) and I note that SL due process has been followed in that the safety case documentation submitted for acknowledgement was approved at the relevant Management Safety Committee (MSC) and Technical committee (Ref 5).

3.2 CONSULTATION WITH OTHER DEPARTMENTS

28. I have consulted with the Environment Agency, which has confirmed that it has no objection to the issuing of a licence instrument in this matter (Ref 14).

29. I have liaised with ONR civil nuclear security, which has confirmed that it has no objection to the issuing of a licence instrument in this matter (Ref 15).

30. The nature of this proposal does not relate to the transport or safeguarding of nuclear material, therefore I have not liaised with ONR's inspectors within these areas.

4 MATTERS ARISING FROM ONR'S WORK

4.1 FAULT STUDIES ASSESSMENT

31. In the fault studies assessment (Ref 16), the specialist inspector sought to determine the adequacy of the safety case, examining whether the reduced spare capacity would still be sufficient to accommodate stored HAL in the event of HAST failures and that adequate recovery measures will be in place should a situation arise where there is more HAL than immediately available safe storage.

32. Following assessment of the submitted documentation and engagement with the licensee, the specialist inspector arrived at two key conclusions. The first is that only a basal failure (i.e. a failure of a tank base) would necessitate the prompt emptying of a HAST (and the likelihood of such a failure is low). The second is that the likelihood of two basal failures occurring in timescales short enough (i.e. a few months) to impact upon recovery operations is very low. The inspector considered both independent failures as well as common cause failures. In addition, an ONR structural integrity specialist has also been involved for a confirmatory opinion and has agreed that SL has provided adequate evidence to underpin the low frequency of multiple HAST failures (Ref 30).

33. In addition, the Fault Studies inspector also concluded that SL has taken appropriate credit for its ability to recover sufficient capacity from other vessels in the facility to mitigate the consequences of having greater volumes of HAL than available HAST storage.

34. As a result, the inspector recommends that ONR should issue a licence instrument to permit the modification of OR26. The inspector also recommended that ONR should maintain close oversight of the HAL volumes within the new side HASTs to ensure that SL undertakes appropriate consideration of further options should the safety case limits be challenged in future years.

35. ONR has a number of site inspectors for the Sellafield site, one of whom is allocated to HALES (and WVP) as part of their remit. That inspector already receives regular updates and has regular interactions with the licensee monitoring the level of HAL stocks. Therefore, I am content that this latter recommendation can be (and is already) met through normal day-to-day regulatory business. Nevertheless, I have informed (Ref 31) the relevant ONR site inspector of the Fault Studies specialist's recommendations to ensure continued appropriate oversight.

4.2 CHEMICAL ENGINEERING ASSESSMENT

36. As well as being a project inspector for this modification, I am also a chemical engineering specialist; hence I have undertaken the specialist assessment work for this project. For simplicity, clarity and timeliness, my assessment has been detailed in the following sections rather than in a separate report. These sections have been reviewed and accepted through ONR's normal due process for specialist assessment advice.

4.2.1 CHEMICAL ENGINEERING ASSESSMENT SCOPE

37. The scope of this assessment is limited to the adequacy of engineered aspects of the proposed modification. The fault studies assessment has assessed the adequacy of the safety case.

4.2.2 LICENSEE'S SAFETY CASE

38. The licensee claims that the issue with OR26 has arisen due to recent poor throughput from WVP, the introduction of wash batches on Evaporator C (to prolong asset life) and as a result of more dilute HAL being stored following the cessation of ITE (a consequence of implementation of the HALES performance plan). Once SL identified the potential for the OR to be challenged, it reviewed the available options to prevent a breach. These options (and SL's view on them) are described over the following few paragraphs.

39. SL considered re-introducing ITE on a subset of HASTs to decrease the volume stored within them; however SL concluded that since ITE is a relatively slow process (<0.5% of the volume of a HAST per day) and can significantly shorten the lifespan of the selected HASTs, this is not practicable since the HASTs will be required to support reprocessing and decommissioning operations for the next 10-15 years.

40. SL also considered taking the washout liquors stored in some of the HASTs and concentrating them in Evaporator C to reduce the stored volume significantly and quickly. However as Evaporator C was not designed to process high-solids content liquors such as the wash liquors, there is a risk that the feed lines may become blocked which would then compromise reprocessing operations. SL claims that this option becomes more viable when Evaporator D becomes available (currently scheduled for mid-2017) as the plant has been designed with the capability to handle solids-bearing liquors.

41. SL states that using Evaporator C in this manner would also prevent it from supporting oxide reprocessing operations. SL states that it does not want to stop reprocessing operations as this would threaten the site lifetime plan and delivery of the 'single pond' solution for the long-term storage of AGR fuels (i.e. it would leave a greater amount of un-reprocessed AGR fuel post-2018 than SL is currently planning to store).

42. SL is progressing the re-introduction of a currently out-of-use HAST. However as this is likely to take several months and is not guaranteed to be successful, a different course of action is necessary to prevent either a breach of the OR or the immediate cessation of reprocessing activities. Therefore SL concludes that at the present time, since all other options to prevent a breach of the current OR cannot be delivered quickly enough (reintroduction of a HAST, ITE), or without unacceptable plant or site-wide risks (ITE, evaporation of wash-liquors, ceasing reprocessing), its best option is to explore relaxing the OR.

43. To this end, SL has developed a safety case for a 16.6% spare capacity (1 in 6) OR in place of the current '1 in 4' OR. SL states that the original '1 in 4' policy, which has been in place since at least the 1970's, was developed at a time when there was no mechanism to reduce HAL stocks (WVP had yet to be built). So upon a HAST failure, its only option would have been to build more HASTs. This situation changed in the early 1990's when WVP came online to provide immobilisation and interim storage of the vitrified wastes prior to disposal. SL states that the '1 in 4' policy was retained as it was not constraining at that stage and was well-embedded. In 2001, as part of the development of the continued operations safety case, SL formalised the '1 in 4' policy as an OR.

44. SL considers that the OR in its current form is overly-conservative, given the changes in circumstance since it was adopted as an OR in 2001 and proposes that a '1 in 6' limit is now more appropriate. SL has undertaken a simple numerical analysis to support this (Ref 3). The numerical analysis shows that in the '1 in 4' spare capacity scenario, the risk of running out of capacity as a result of HAST failure is several orders of magnitude smaller than the relevant Basic Safety Objective (BSO) from Target 8 of our Safety Assessment Principles (SAPs) (Ref 26). Under the proposed '1 in 6' capacity scenario, although the risk is increased, it is broadly at the level of the BSO.

45. SL has also reviewed the engineering impact of the modification and states that at worst, the '1 in 6' policy halves the number of HAST failures that would be needed before there could be insufficient capacity to store HAL safely in the remaining HASTs. I note however, that SL has not accounted for ejector dilution in these calculations (ejector dilution is the increase in volume of transferred liquor that arises from the condensation of the ejector motive steam; it is generally taken to be 10% of the volume being transferred).

46. SL argues that in the event of a HAST base failure, HAL would be transferred to spare storage and reprocessing operations would stop until the required spare capacity has been returned. SL states that in the past, the only way this would have happened was through the construction of new HASTs, which would take several years. However, volume reduction equivalent to a full HAST can be now be vitrified in a much quicker time when compared to building new HASTs, so the time at risk is reduced significantly. SL adds that it would also review the options considered above to determine if the balance of risk then supported utilising one of the alternatives rejected in its current considerations. For example, use of Evaporator C (or D, when available) to concentrate washout liquors could free a volume equivalent to nearly a full HAST in three weeks; however the decision to do this would have to be subject to an Operational Decision Making (ODM) process at the time.

47. SL has also undertaken an assessment of the likely volumes to be stored in the HASTs between now and the completion of HALES Post Operational Clean Out (POCO) in around 2028. This indicates that '1 in 6' provides adequate capacity to support HAST operations through to POCO and no further modifications to the OR should be required. On the basis of the above, the '1 in 6' capacity OR is intended to be a permanent change and SL will not revert back to a '1 in 4' capacity once HAL stocks have been reduced.

4.2.3 ONR'S CHEMICAL ENGINEERING ASSESSMENT

48. I have reviewed SL's options assessment process and agree with the licensee's assessment that re-introducing ITE is not an appropriate solution. Whilst ITE operated successfully in HALES for many years, and resulted in significant volume reductions when operating on all HASTs simultaneously, I agree with SL that the higher HAL temperatures required played a direct role in the failure of a number of cooling components within the HASTs; around a quarter of the total having failed before ITE was halted (Refs 3 & 12). However, since the introduction of HAST chilling approximately three years ago, there have been no further failures of cooling components.

49. An ONR Structural Integrity specialist inspector has considered (Ref 33) the potential for radiolytic-induced corrosion effects on the water-side of the cooling components and has determined that, given the absence of any such effects in the Evaporator C coils (which face a similar environment and where measurements have been taken), there is a low likelihood of such effects in the HAST cooling components themselves and the downstream components. Thus, I consider that the risk of common cause failure of the HAST cooling system via this mechanism can be considered ALARP.

50. Each time a cooling component fails, it places a challenge on the Automatic Isolation System, a safety system in place to prevent a potentially significant radiological release. Therefore I agree with SL that it is best to minimise the likelihood of failure so far as is reasonably practicable. Since HAST chilling has proven to be an effective measure to prevent cooling component failure, I agree that it would be inappropriate for SL to return to routine ITE.

51. I am also satisfied that the licensee's argument for not using Evaporator C to concentrate washout liquors currently stored in the HASTs is reasonable owing to the potential for the evaporator feed lines to become blocked as a result of the higher solids content of the liquors it would need to process. Whilst these blockages might be recoverable, the potential delay to reprocessing operations would be unacceptable from a hazard reduction standpoint (directly in the case of Magnox reprocessing[4] and indirectly in the case of THORP reprocessing[5]). ONR has reviewed and accepted the argument around prevention of unnecessary delays to reprocessing operations several times over the past few years, for example as part of the Evaporator C continued operations assessment in 2015 (Ref 17). I have reviewed the arguments submitted as part of the Evaporator C continued operations assessment and I am satisfied that they are similarly applicable to this case. I support SL's view that when Evaporator D enters active commissioning these liquors should be considered for the early Evaporator D operations as this would provide a benefit to HALES whilst providing less radiologically challenging liquors to prove the Evaporator D design. Although not directly mentioned in SL's case, I am also satisfied that SL is unable to use Evaporators A or B to process these wash liquors. This is because the wash liquors are from Evaporator C and so are Oxide-based, whereas Evaporators A and B were only designed to process Magnox-based liquors. Evaporators A and B would also be prone to blockages in the same manner as Evaporator C.

[4] Magnox fuel is not suitable for long term wet storage and so completion of the Magnox reprocessing programme will see all the UK's wet-stored Magnox fuel reprocessed. Delays to this programme increase the likelihood of the ageing Magnox Reprocessing facility failing to meet that aim.

[5] Both Magnox and AGR fuels are received into the Fuel Handling Plant (FHP), which has little free space. If AGR fuel is not moved out of FHP (as a result of cessation of THORP reprocessing) then fuel receipt from the legacy ponds would be impacted as FHP's primary mission is completion of the Magnox and THORP reprocessing programmes (Ref 32).

52. I am pleased to note that SL is proposing to return a disused HAST to service, in line with ONR recommendations made in 2013 (Ref 18). Clearly, if this had been done earlier it may have prevented the necessity for the present OR modification proposal. Regardless, given that the re-assurance testing being undertaken will not be completed until Autumn 2016 (i.e. after the pinch point necessitating consideration of relaxing OR26) and even then SL may not be able to substantiate the HAST for further use, I agree with the licensee that investigating a modification to the OR is the appropriate course of action.

53. I have reviewed SL's evidence and arguments and accept its claim that OR26 was not derived from the safety case and hence that it may be overly-conservative. SL has now remedied this and included the '1 in 6' policy in the safety case prepared in support of the present proposals. Specifically, with the OR amended to '1 in 6', its numerical assessment shows the risk from failures of HASTs to be significantly better than the Basic Safety Level (BSL) and broadly at the level of the relevant BSO[6] in Target 8 of ONR's SAPs. These aspects have not been assessed in detail in my assessment however, as they have been considered specifically by the Fault Studies specialist inspector in Section 4.1.

54. I have reviewed the licensee's claims that under the new '1 in 6' arrangements two concurrent HAST basal failures can be accommodated and still have sufficient capacity to store all the HAL. I have reviewed both the 'worst case' and 'realistic' scenarios considered by SL and I am satisfied that these are somewhat pessimistic but possible scenarios. For the worst case scenario, where SL is operating at the '1 in 6' limit at the point of a HAST failure, SL's assessment shows that it can tolerate 1.6 HAST failures. However, if the (lower) subordinate Clearance Certificate Operating Instruction (CCOI) limit is assumed, (i.e. the limit the plant would work to in practice) this increases to 1.8.

55. I also note that SL does not account for ejector dilution within its case. In the event of basal failure of two nominally full HASTs (the worst case), this would mean that an additional 0.2 of a HAST (i.e. 2 x 0.1) would be needed. SL has responded (Ref 34) that the exclusion of ejector dilution from its ALARP justification was a conscious decision and was shared with (and accepted by) its INSA team. I do not agree with SL's assertion that the exclusion of ejector dilution was necessary to keep the case simple. However, when including ejector dilution, one (full) HAST basal failure still results in enough contingency capacity (1.6 available versus 1.1 needed) while two (full) HAST basal failures still results in a capacity shortfall (2.2 needed versus 1.6 available). Whilst I agree with SL that as a result of operational benefits, the HASTs are rarely run at their full capacity, the safety case permits them to be so. Therefore, I have to assume that, at the time of a double basal failure, the failed tanks are at full capacity and that specific element of SL's argument should be ignored here.

56. SL notes however that there is further safe storage available for HAL beyond the 'new-side' HASTs (e.g. WVP Feed Tanks, Evaporator Stock Tanks, 'old-side' HASTs, and a currently out-of-service HAST) which have all been specifically designed to handle and store HAL on an interim basis and can account for the residual volume required, although prior justification would be required for some elements of this capacity to be realised (e.g. the 'old-side' HASTs). I am nevertheless satisfied that these additional tanks are likely to be suitable for storing HAL in an emergency recovery situation as they are located within the HALES biological shielding, and have cooling components and activity breakthrough detection systems installed equivalent to those on a HAST.

[6] i.e. the risks are at levels where it would not be proportionate for ONR to pursue any improvements.

57. Furthermore, SL also argues that in the worst case of two full HASTs failing, additional space could be made available through emergency recovery. Specifically, there is additional space above the nominal full HAST capacity, reserved by the current safety case (and ensured via Operating Rules). Whilst this reserved space would have to be justified prior to use, I believe that in the event of two (near) simultaneous basal failures of full HASTs (which I expect to be very unlikely), if non-HAST storage was not sufficient, use of some of this reserved capacity might still be acceptable. This reserved space amounts (when summed) to an equivalent volume of around 80% of a nominal HAST. In other words, through justification of non-HAST storage and by applying the emergency recovery measures described above, SL would be able to secure sufficient capacity to deal with two basal failures even for the 'worst case' scenario considered in the safety case.

58. However, since these non-HAST tanks are already in use for transient transfers of HAL (so may be full at the time of a HAST failure), I sought assurance from SL on how likely it would be that the volume of stored HAL would be at or near the proposed OR/CCOI limits, so as to understand the 'time at risk' element of this claim. SL responded that it is unlikely that the facility would maintain HAL stocks at or near the OR limits for long durations as a result of general good operational practice and the predicted HAL imports/exports as presented in its volume paper (Ref 4). In further support of this claim, HALES has a local management volume limit designed to prompt senior management action, as described below.

59. I have reviewed the licensee's paper assessing the projected volumes to be stored in HALES going forward. I agree with SL that the assumptions made in the paper are conservative when compared against the actual performance at WVP over the past few years (Ref 19) and the actual cooling component failure rates when compared to the rates assumed. Generally the paper demonstrates that in all scenarios there is adequate volume capacity in HALES to support safe reprocessing, POCO and vitrification operations through to completion.

60. Given the declining HAL stocks projected in this paper (post 2017), I am content with SL's proposal that the change to '1 in 6' should be permanent (and by inference, that the '1 in 4' OR will not be readopted in the future). Many factors contribute to allow me to form this view, the main ones being;

- Evaporator D coming on line in 2017 (so allowing SL to deal promptly with its wash-liquor arisings),
- The cessation of THORP and Magnox reprocessing in the next few years (resulting in reduced HAAR feed to HALES),
- Generally improved performance has been seen at WVP in recent years (albeit with intermittent downturns, such as those being experienced at present) which will result in reduced HAL stocks holdings.

61. That said, SL predictions show its CCOI will be exceeded in mid-2017 when volumetric HAL stocks are predicted to peak. Though noting that exceeding an OI limit is not a regulatory matter (see ONR's Operating Rule Technical Assessment Guidance, Ref 25), I challenged SL as to whether this was appropriate. SL responded (Ref 29) that there are actually three volume limits in place: one defined by OR26, another defined by the CCOI (set below OR26), and below the CCOI limit, there is also a local management limit. If reaching the local management limit is anticipated, HALES management is informed and SL's Operational Decision Making process would be invoked before committing HAL to the HAST fleet. In consequence, a prediction that the CCOI might be exceeded will not, in all likelihood, mean the limit being exceeded in reality.

62. In addition, prior to the start of any new evaporator batch, a specialist team within HALES produces a report that, amongst other things, predicts the volume of HAL from the completed batch. With this information, HALES plant management have early indication of HAL volumes approaching the local management limit, the CCOI limit and, ultimately the OR limit.

63. Overall, I am therefore satisfied with SL's claims that it can manage with two HAST failures and still have adequate safe storage capacity for all stored HAL. However, this argument is only valid provided that the likelihood of failure is low and that there are no significant common cause failure mechanisms. I note however that the ONR Fault Studies assessment (Ref 16) has provided reassurance on both these points (see Section 4.1).

64. Finally, I note that if a base failure were to occur, SL advises that it would stop reprocessing operations and review the situation to determine the most appropriate way forward. This would include formally re-assessing the arguments discussed earlier around ITE, use of Evaporators C (or D, if available) to process wash liquors, and halting reprocessing operations. I am satisfied that SL's plans to do this through its MSC and ODM processes (with the final decision made by the head of facility) are appropriate and in line with ONR SAP MS.3 and that suitable technical analysis would take place to inform SL's final decision-making.

4.2.4 CHEMICAL ENGINEERING ASSESSMENT CONCLUSIONS

65. Overall, I am satisfied that the licensee has adequately considered all relevant options available to it to prevent a breach of OR26 and I agree that modifying the OR to a '1 in 6' approach is the most appropriate action in this instance. I agree with the licensee that, from an engineering perspective, the '1 in 4' capacity limit is conservative and that permanent relaxation to '1 in 6' still delivers adequate contingency in retaining sufficient capacity for up to two HAST failures. I am reassured that in the event of a HAST failure, the licensee has adequate arrangements in place and can recover to a compliant state reasonably quickly by evaporating the washout liquors (with minimal asset risk once Evaporator D comes online in mid-2017), reducing the risk of running out of storage space following any subsequent failures. Therefore I support the licensee's proposal to modify OR26 to a '1 in 6' approach on a permanent basis.

4.3 OVERARCHING ASSESSMENT

66. As project inspector for this permission decision I have also reviewed the modification as a whole to assure myself that SL has considered the modification in totality and that it has appropriate arrangements in place to implement the modification on plant.

67. I have reviewed the licensee's safety case documentation and I note that the HALES facility is in this situation as a result of series of actions and events which are largely beyond its immediate control (although they remain within SL's overall control at a site level). I have undertaken a high level review of the licensee's reasons for introducing wash batches and HAST chilling and I agree that these are essential for safe and secure long term operations, as demonstrated by the absence of any cooling component failures since their introduction in 2013. Therefore, I am satisfied that the HALES facility is being managed appropriately with regards to volume liquor management. I have also reviewed the anticipated master production schedules for WVP and the reprocessing facilities, as detailed by the site's long term plan and I note that if these had operated as expected this problem would not have arisen.

68. I have reviewed the PMP and I note that there is a significant quantity of documentation that requires updating to implement this modification on plant, raising the possibility that further regulatory attention on this project will be required. However, SL advises that the only modification will be to change the value of the OR and apart from this aspect, the documents will be staying the same (Ref 22). The quantity of documentation being changed reflects the importance of the OR which forms one of the key limits on HALES operations. Given that the modifications to the arrangements are minor (albeit numerous) and ONR has assessed these arrangements as part of the HALES Performance Plan permission in 2015 (Ref 12), I do not see the need for them to be reassessed as part of this permission.

69. As SL is proposing a modification to a key OR, I have discussed this modification with ONR's site inspector for HALES and reviewed recent inspection outcomes to gain confidence that the licensee has appropriate control of its ORs. The site inspector advises that he has no outstanding regulatory issues associated with ORs at HALES, and that he recently closed out Regulatory Issue 2783 following improvements to the approaches being adopted. He stated that in a recent System Based Inspection he rated OR compliance as 'Green – No formal action' (Ref 23). This aligns with an LC23 (Operating Rules) compliance inspection I undertook in 2015 using ONR guidance on the limits and conditions for nuclear safety (Ref 25), where I rated the licensee as '2 - Good' (Ref 24)[7]. Since there are no Regulatory Issues relating to ORs at HALES and recent inspection results show the management and control of ORs to be adequate I am satisfied that the licensee has suitable and sufficient controls of its ORs and no further assessment is necessary in support of this permission.

70. Since a HAST base failure would be a significant event that could lead to SL operating HALES for a prolonged period with reduced spare capacity, I have reviewed the length of time that SL could potentially be operating with decreased margins and what arrangements it has in place should this scenario occur. SL states that it could take as long as 9-12 months to return to compliance with its OR following a HAST failure (depending on the performance of WVP) or as little as three weeks if SL elects to use one of the evaporators to concentrate wash liquors. I have reviewed these timeframes and consider them reasonable, although in my opinion, the three-week period for using an evaporator is optimistic as, whilst the batch will take about this time to process,

[7] ONR's 6 point numerical inspection rating system (Ref 20) was revised in 2016 and replaced by a 3 point Red, Amber and Green system (Ref 21).

there will need to be a period of consideration prior to this. Consequently I believe the process would take around one or two months in reality, but still a significant reduction in comparison to just using WVP. I do agree however with SL that both of these options are significantly better than the 'build a new HAST' approach in place when the '1 in 4' policy was introduced.

71. It should be noted that SL's analysis does not predict any basal failures through process-side corrosion (Ref 29). This confidence arises from the original thickness of the base being approximately four times thicker than the estimated corrosion loss over a HAST's lifetime. However, if a basal failure were to occur, the current method used to determine HAST corrosion rates would undoubtedly be called into question and ONR's expectation would be that SL investigates the validity of the model used.

72. On a site-wide level, the main safety benefit from this proposal is the avoidance of delays to reprocessing, both for the Magnox Operating Plan (needed to avoid long-term wet storage of Magnox fuel) and the Oxide Operating Plan (so that enough AGR fuel is reprocessed to enable the remainder to be stored safely in a single pond prior to THORP's 2018 closure). Without this change, reprocessing operations would have to pause while HALES reduced its volume stocks, since further HAAR/HAL could not be stored in compliance with the current OR. This could lead, in the longer term, to there being more AGR fuel than can be stored in the THORP receipt & storage pond, resulting in AGR fuel having to be stored within the Fuel Handling Plant in the spaces currently allocated for legacy fuels. This would result in delays to retrieval operations from the legacy ponds. ONR has assessed and accepted this strategic argument on multiple occasions in recent years (e.g. Refs 7 & 17). I have reviewed these arguments and am satisfied they remain valid and that the proposal therefore reduces site-wide risks ALARP.

73. This risk balance is however dynamic, e.g. the safety benefits will reduce as more fuel is reprocessed and when Evaporator D enters full operations (scheduled for mid-2017). In consequence the most appropriate course of action should a HAST become unavailable for storage cannot necessarily be pre-determined. I therefore agree with the licensee that it would be inappropriate to have a pre-set course of action defined at this stage. Instead I have reviewed the process SL would follow when deciding on what to do. Here, SL is proposing that it would halt HALES operations and apply its Operational Decision Making (ODM) process, coupled with MSC oversight, to determine the best way forward. The ultimate decision on the course of action to be taken would then be made by the Head of the HALES (Ref 3) taking site-wide aspects into consideration.

74. I am satisfied that this is an appropriate structure as it has technical oversight from the MSC and the Head of HALES is a suitably senior and empowered role to make the final decision on the continued safe operation of the HALES facility. I am satisfied that these arrangements adequately capture the regulatory expectation that, following an event resulting in the need to promptly empty a HAST and/or the OR being breached, SL would return to compliance as soon as reasonably practicable.

5 CONCLUSIONS

75. This report presents the findings of ONR's assessment of the adequacy of SL's proposals to permanently modify its HALES OR26 (which controls the volume of HAL stored in the new side HASTs) from a '1 in 4' (25%) spare volume capacity to a '1 in 6' (16.7%) spare volume capacity. ONR's targeted assessment of SL's supporting documentation indicates that SL has carried out an appropriate assessment of the associated hazards and risks.

76. Whilst this modification results in a small increase in total plant risk as a result of a reduction in plant contingencies, the risk nevertheless remains low and at a level where ONR's SAPs suggest it would not be proportionate to pursue any improvements. Since the modification also safeguards hazard and risk reduction activities elsewhere on site, I judge that it reduces overall site risks to ALARP.

6 RECOMMENDATIONS

77. I recommend that ONR should:

- Issue Licence Instrument 904 (Ref 28), under SL's approved arrangements for site licence condition 22(1), as an agreement to implement the proposed modifications to the Highly Active Liquid Evaporation and Storage plant's Operating Rule 26.

7 REFERENCES

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15. *'RE: CNS Involvement in HALES permission',*
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18. *'Continuing Use of Existing HASTs',*
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8 REVIEW, LEARN, IMPROVE

In line with the Review, Learn, Improve (RLI) guidance on HOW2, it is not considered necessary to conduct an RLI event. The prompts given in the HOW2 guidance are shown, along with a comment to its relevance, in the table below.

Prompt	Comment
The task was complex and multi-disciplinary.	The task was not complex and only involved two main specialist disciplines.
The task significantly exceeded the estimated effort.	The task did not exceed the original estimated effort.
There were significant issues when interacting with the licensee.	The licensee was open and honest in all interactions; however the submission was at shorter notice than usually seen.
There were significant issues interacting internally.	There were no significant internal issues.
There were differences in professional opinion between inspectors and procedure INS/031 was invoked.	Not applicable.
The recommended routine decision process could not be used – an exception or novel approach had to be taken.	A routine decision has been made.
Issues have arisen which may have wider regulatory implications.	No issues have arisen.
There is a need to inform the corporate memory (Knowledge Management)	This is not likely to be the case.

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No	SAP Title	Description
MS.3	Leadership and Management for Safety – Decision Making	Decisions made at all levels in the organisation affecting safety should be informed, rational, objective, transparent and prudent.