



**Investigation into the Product Purification 1 (PP1) Cycle Event in the Thermal Oxide  
Reprocessing Plant (THORP)**

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## EXECUTIVE SUMMARY

### Title

Investigation into the Product Purification 1 (PP1) Cycle Event in the Thermal Oxide Reprocessing Plant (THORP).

### Background

On 16<sup>th</sup> August 2014 incompletely conditioned process liquor was wrongly transferred to tanks and pipework within Sellafield Ltd's (SL) Thermal Oxide Reprocessing Plant (THORP) causing safety mechanisms installed to protect the plant and its staff to initiate.

The transfer of this liquor led to fissile material being carried over into a "non-geometrically safe" effluent route and so presented a potential criticality hazard. If a criticality had occurred, personnel at the plant could have received high (and possibly fatal) doses of radiation. Such erroneous transfers are however foreseen in the plant's design and safety mechanisms are installed to provide protection. These activated as expected and initiated an automatic trip of the product purification cycle limiting the carryover of fissile material to safe levels and ensuring that the plant remained within the limits of its safety case. There was therefore no harm from radiation to either workers or members of the public from this event.

Nevertheless, the event highlights shortfalls in compliance against Licence Condition 24 (Operating Instructions) and potentially against LC26 (Control and Supervision of Operations).

### Basis for Enforcement Decision

Following the completion of my investigation, I concluded that SL staff did not adequately follow written instructions. If SL's procedures had been followed in-line with SL's own expectations, it is highly unlikely that the event would have occurred. Thus I consider the event demonstrated a significant shortfall in compliance with LC24(1) operating instructions – which requires that "The licensee shall ensure that all operations which may affect safety are carried out in accordance with written instructions hereinafter referred to operating instructions".

Applying the principles of ONR's Enforcement Policy Statement via our Enforcement Management Model, gave an initial enforcement expectation that an Improvement Notice be served against LC24, but no action to be taken in regard to LC26 in view of a lack of clear evidence.

However following consideration of the relevant EMM strategic factors I consider that a regulatory letter should be served instead. This is primarily due to SL's positive response to the event and its commitment to implement the THORP Procedural Use and Adherence Improvement plan. In addition I considered THORP's plant management is fully committed to implementing improvements to Conduct of Operations more generally, which I consider will address the wider contributory factors associated with this event.

### Conclusions and Recommendations

I recommend that ONR should send a regulatory letter to SL to summarise the findings of this investigation. The letter should also set out ONR's expectations regarding SL's actions so that the THORP plant management define and implement necessary improvements which ensure all operations which may affect safety are carried out in compliance with written instructions.

## LIST OF ABBREVIATIONS

ACI	Apparent Cause Investigation
ALARP	As Low As Reasonably Practicable
DAP	Duly Authorised Person
EMM	Enforcement Management Model
EPS	Enforcement Policy Statement
HSE	Health and Safety Executive
IN	Improvement Notice
LC	Licence Condition
NO <sub>x</sub>	Nitrous Oxide
OI	Operating Instruction
ONR	Office for Nuclear Regulation
PP	Product Purification
SL	Sellafield Limited
STM	Shift Team Manager
THORP	Thermal Oxide Reprocessing Plant

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## 1 INTRODUCTION

1. On 16 August 2014 a transfer of incompletely conditioned process liquor occurred at Sellafield Ltd's (SLs) Thermal Oxide Reprocessing Plant (THORP) challenging the installed safety mechanisms.
2. The feed forward of unconditioned process liquor led to fissile material being carried over into a non-geometrically safe effluent route which presented a potential criticality hazard. During the event the installed safety mechanisms activated as expected and initiated an automatic trip of the product purification cycle; this ensured that the plant remained within the limits of the safety case by limiting the carryover of fissile material to safe levels. There were no consequences to workers or members of the public.

### 1.1 PURPOSE

3. This report has been produced to record the findings of the Office for Nuclear Regulation's (ONR's) investigation of the incident. The report also details the enforcement decisions taken by ONR in accordance with the ONR's Enforcement Policy Statement, guided by application of the Enforcement Management Model (EMM).

### 1.2 BACKGROUND

4. The THORP plant reprocesses spent uranium oxide fuel, producing plutonium, uranium and waste. Process liquor is treated using Nitrous Oxide (NOx) to ensure the plutonium is in the correct chemical state to ensure it remains in the product stream while it passes through the product purification cycle (PP cycle) (the part of the plant involved in this event).
5. On the evening of Friday 15<sup>th</sup> August 2014, SL experienced problems with its NOx plant resulting in incomplete conditioning of the process feed liquor. As per SL's procedures this liquor was diverted to the online and offline buffer tanks pending reconditioning once the fault affecting the NOx plant had been repaired. This state of plant was recorded in the appropriate plant log for the PP console.
6. On Saturday 16<sup>th</sup> August 2014 the fault on the NOx system was repaired and the Shift Team Manager (STM) (who was also the Duly Authorised Person (DAP)) initiated a discussion with the two operators staffing the PP console regarding the requirement to rework the out of specification process liquor in compliance with operation 4 of the continuous use Operating Instruction OI/05/0601 Issue 12 (Ref. 1) – Flushing of the online buffer tank to offline buffer tank... and then offline buffer... reworked into the NOx system.
7. The STM and operators then held a pre-job brief, however SL's investigation concluded this was ineffective at correctly communicating the operational requirements. There were clear failings in the performance of the pre-job brief which fell short of accepted standards with one of the operators continuing to carry out routine computer tasks rather than engaging fully in the pre-job brief.
8. For reasons which are unclear (noting that both operators post-event could clearly articulate the dangers of feeding forward unconditioned feed), the more experienced operator wrongly understood the required task to be to feed forward the online buffer tank and rework the offline buffer tank. This clearly demonstrated a lack of plant status awareness even though the plant state was accurately logged. Their understanding was challenged by the less experienced operator; however the less experienced operator eventually deferred to the position of the more experienced operator. The operators then proceeded to set up to rework the offline buffer tank and feed forward from the online buffer tank. It is unclear which procedure was used to perform this feed forward, as the approved continuous use procedure for PP1 restart in OI/05/0410 (Ref 2.) requires confirmation from the HA/PP STM that a restart can occur and advice on restart rates from the HA/PP STM.

9. The experienced operator then began the feed forward of unconditioned feed and this resulted in unconditioned fissile material be carried over into a non criticality safe effluent route. This eventually resulted in the activation of alpha and absolute neutron alarms, followed shortly by the operation of the safety mechanism PP1AR ANM trip ZX3617 which isolated all feeds into and out of the PP1 column.

## **2 LICENSEE'S RESPONSE TO THE INCIDENT**

10. Following the event SL quickly identified that an inadvertent feed forward of process liquor had occurred and then took appropriate recovery actions to ensure that the out of specification process liquor was correctly reworked before restarting the process.
11. SL initiated an Apparent Cause Investigation (ACI) (Ref. 3) to determine the cause of this event and identify lessons learnt. The findings from SL's investigation were:
- The apparent cause of the event was attributed to the operators misunderstanding the required task due to an inadequate pre-job brief and the failure of the STM to clearly communicate to operators 1 and 2 the operational intent of the task.
  - Contributory causes of the event were:
    - Shortfalls in procedural use and adherence, namely the failure to apply continuous use procedures in-line with site expectations.
    - Ambiguities in operating instruction OI/05/0601 (Ref 1.).
12. SL also concluded that plant protection systems operated as per design and this ensured the plant remained safe and within the operating envelope of the safety case.

## **3 ONR'S ASSESSMENT OF THE INCIDENT**

13. I reviewed SL's investigation into the incident and held a meeting with members of SL's staff who had completed the investigation (Ref 4).
14. I note that this event did not result in any radiation exposure to SL personnel or any significant increase in risk to the public due to the fact that the plant's safety systems operated as designed to maintain the plant within the bounds of the safety case.
15. SL's investigation concluded that miscommunication caused by an inadequate pre-job brief caused the event. My review of the event however identified several other contributory factors, some of which I consider were potentially more significant.
16. SL's investigation stated that "It was also found that in incorrectly initiating feed forward to PP1, some of the required steps in OI 05/0601 Operation 4 were not followed by operator 2". However SL later clarified that this part of the procedure was not followed at all as the operators incorrectly believed that there was no requirement to carry out flushing of the online buffer tank (Ref. 5).
17. Furthermore SL stated that if the restart had been carried out as per OI/05/0601 Operation 4, then the event would have been prevented. In addition it was asserted that the start-up checks did not appear to be duplicated in any other Operating Instructions associated with PP1 column start up and hence were therefore not carried out.
18. I reviewed SL's procedures relating to PP1 cycle restart and I identified that OI/05/0410 - PP Cycle active restart - Issue 8 - May 2014 (Ref. 2) was in my opinion the correct procedure for normal restart of the PP1 column and hence feed forward of this process liquor. Within this document I conclude, are sufficient steps which, if implemented as per SL's requirements for procedural use and adherence, would have prevented the event.
19. Thus I consider that suitable Operating Instructions were available; however they were not in use/being effectively used at the time of the event. As such I consider this to

represent a non-compliance with LC24 which requires that “The licensee shall ensure that all operations which may affect safety are carried out in accordance with written instructions hereinafter referred to operating instructions”.

20. I further consider that SL’s internal investigation placed insufficient focus on the importance of deficiencies in supervisory oversight. SL’s investigation makes a single reference to Supervisory Oversight/Management oversight stating that:
  - “Continuous supervision by the DAP of both operators during the set-up of the plant, would have provided an extra layer of protection against the mal-operation”.
21. Effective supervision would have ensured that the continuous use procedures were followed correctly and in this case I judge would have prevented the occurrence of this event. Although continuous supervision of trained personnel undertaking non-complex routine operations would not be appropriate, given the complexity, relevant infrequency and potential consequences of this operation I consider the DAP should have ensured that control and supervision enacted via operating instructions was supplemented by enhanced “appropriate direct contact and observation”.
22. I judge that this and related events (see para 34ff) suggest cultural issues relating to deficient standards of procedural use and adherence within THORP. To resolve this will require leaders at all levels on the plant, such as DAPs and the THORP management team, to set high standards for disciplined operations and then robustly and consistently reinforce them.
23. No potential security concerns or considerations were identified as a result of this event.

#### **4 IDENTIFICATION OF BREACHES**

24. It is my judgement that SL failed to comply with Licence Condition (LC) 24 – Operation instructions – in that it did not ensure that:
  - “... all operations which may affect safety are carried out in accordance with written instructions hereinafter referred to as operating instructions”.
25. This is due to that fact that suitable procedures were in place to prevent this event but these were not followed.
26. Furthermore I consider that SL may have failed to comply with its requirements under LC 26 – Control and supervision of operations:
  - “The licensee shall ensure that no operations are carried out which may affect safety except under the control and supervision of suitably qualified and experience persons appointed for that purpose by the licensee.”
27. However, in view of the lack of clear evidence for a breach of LC26, this will not be considered further in this report.

#### **5 REGULATORY ENFORCEMENT DECISIONS**

28. In evaluating what regulatory enforcement action should be taken as a result of the above potential breaches consideration has been given to the principles set out in the HSE Enforcement Policy Statement Ref HSE41 (Rev1), ONR guidance on the use of the EMM and EMM Operational Version 3.1. The resultant Enforcement Assessment Record (EMM1) can be found at (Ref. 6).
29. I consider that the event posed a potential risk to personnel within the THORP facility in that a feed forward of unconditioned process liquor increased the risk of a criticality in the facility, placing unnecessary reliance on other protective measures.
30. Considering the EMM I judge that the multiple casualty risk gap table is appropriate in this case due to the fact that a criticality has the potential to expose multiple individuals.

31. I consider that in this case the benchmark risk from a criticality is serious personnel injury (doses in excess of 10mSv above ALARP). Due to the fact that these risks can nearly be fully mitigated I consider that the benchmark likelihood should be Nil/negligible.
32. I consider that the actual risk of a criticality was however “remote” in view of the automatic protective measures in place.
33. These judgements result in a risk gap of SUBSTANTIAL and an EMM initial enforcement expectation, prior to taking other factors in account, that an Improvement Notice be issued. These other factors are considered in the following paragraphs.

#### Duty Holder Factors

34. ONR has previously identified shortfalls in THORP’s compliance with regards to procedural use and adherence (LC24). These observations were as a result of routine compliance inspections and previous lower significance events in THORP in which ONR considered that shortfalls in procedural use and adherence were a contributory factor. These led to ONR raising a formal Regulatory Issue 2382 in May 2014, requiring SL to improve procedural use and adherence standards in THORP.
35. In addition ONR formally wrote to SL in October 2014 (Ref. 7) regarding an event which occurred in May 2013 where ONR investigations identified that shortfalls in procedural use and adherence were a significant contributory factor. In this event, an incorrect chemical (formalin) was delivered to the Sellafield site and a series omissions/failures to properly implement SL’s own processes led to this chemical being delivered to an operational area in THORP. However in this instance no significant safety impact occurred due to local operators identifying the incorrect chemical prior to it being fed into process systems.
36. Although consideration of duty holder factors would potentially deem these to be relevant to the present enforcement action, I note that the formalin enforcement letter was sent to SL after the PP1 event and so I consider should not be a reason for more stringent enforcement action here.
37. Similarly, I do not consider the events cited in para 34 that led to Regulatory Issue 2832 are significant enough to be used as a compounding factor in the present assessment. The THORP management team, in response to Regulatory Issue 2382, has put in place an impressive and comprehensive improvement programme which I consider is starting to achieve real improvements at the plant. Related to this, ONR held a holding to account meeting earlier this year to ensure that the THORP Senior Management Team acknowledged ONR’s concerns regarding the standard of disciplined operations and procedural use and adherence within THORP (Ref. 8). Based on this, I have confidence that SL is now actively addressing ONR’s concerns and that taking additional enforcement action based on the PP1 event would not be of any particular benefit.
38. Finally, it should be noted that ONR has recently taken relevant formal enforcement action elsewhere on the Sellafield site, issuing an Improvement Notice at Magnox Reprocessing against LC24 (Operating Instructions) in June 2015. The failings that led to the Magnox Reprocessing Notice being served were however considerably more significant than those in the event being considered here to an extent that would make serving a further Notice here disproportionate on consistency grounds. Equally, the Magnox Reprocessing Notice should not be considered as relevant formal enforcement compounding the seriousness of the THORP event in view of the relative independence of the line management chains at THORP and Magnox Reprocessing (which only come together at a very senior level in SL’s organisation).
39. In conclusion, although there are relevant Duty Holder factors, I do not consider these should change the enforcement expectation away from the EMM initial enforcement expectation of an Improvement Notice.

### Strategic Factors

40. Following consideration of the Strategic Factors listed in the EMM, I consider that the following two strategic factors are relevant:
- Does the Indicated Action Coincide With Public Interest?
    - i. ONR's Regulatory Strategy for the Sellafield site is to focus the SL Senior Management on the key strategic matters which are required to deliver key safety improvements, e.g. the national priority to accelerate risk and hazard reduction at the legacy plants. Serving a Notice based on the present event would raise the importance of this matter beyond the level the event merits and potentially distract SL from its main strategic aim. Hence I consider that issuing an improvement Notice would not coincide with the public interest
  - Have the principles and expectations of the Enforcement Policy been met?
    - i. I consider that issuing an Improvement Notice would not be a targeted use of ONR's limited resources. ONR has already engaged with SL and particularly with THORP, to ensure improvements in its overall conduct of operations. A key focus of this is to ensure that THORP achieves significant improvements to its standards of procedural use and adherence (Regulatory Issue 2832). ONR is continuing to intervene here to ensure that THORP achieves sustained improvements with regards to procedural use and adherence across the THORP operating unit. (Ref. 8). Issuing a Notice would yield very little net benefit, but would consume a significant amount of licensee and ONR effort.
41. As such I consider that it is appropriate to reduce the initial enforcement expectation and instead issue a formal regulatory letter reiterating ONR's concerns. This letter should reinforce ONR's expectation that in line with the existing Regulatory Issue 2832 and commitments made at the above-mentioned holding to account meeting, SL puts in place such improvements as are necessary to ensure that in future all operations which may affect safety are carried out in compliance with written instructions.
42. I have liaised with the Environment Agency and they have confirmed they have no objection to this proposed course of action (Ref. 9).

## **6 CONCLUSIONS**

43. I note that this event did not result in any radiation exposure to SL personnel or any significant increase in risk to the public due to the fact that the plant safety systems designed to protect against such occurrences operated as expected to maintain the plant within the bounds of its safety case.
44. SL concluded that the event was primarily due to miscommunication caused by an inadequate pre-job brief. Although I agree this was important, both SL's and my investigation identified several other contributory factors, some of which I consider were potentially more significant.
45. I conclude that the prime cause of this event was that SL staff did not adequately follow written instructions. If SL's procedures had been followed in-line with SL's own expectations, I consider it is highly unlikely that the event would have occurred. Thus I consider the event demonstrated a significant shortfall in compliance with LC24(1) operating instructions – which requires that “The licensee shall ensure that all operations which may affect safety are carried out in accordance with written instructions hereinafter referred to operating instructions”.

46. The event may also represent a shortfall in compliance with LC26 – Control and Supervision of Operations. However, in view of a lack of firm evidence, formal enforcement of this has not been considered in any detail.
47. Though the EMM initial enforcement expectation is that an Improvement Notice should be served against LC24, consideration of EMM strategic factors have reduced this to a issuing a regulatory letter.

## **7 RECOMMENDATIONS**

48. Based on the conclusions of my investigation and consideration of the EMM I recommend that ONR should send a regulatory letter to SL. The letter should summarise the findings of my investigation, and set out ONR's expectations regarding SL's actions to ensure that, in-line with the existing ONR Regulatory Issue 2832, THORP plant management define and implement necessary improvements which ensure all operations which may affect safety are carried out in compliance with written instructions.

## 8 REFERENCES

1. Sellafield - Document - PP1 Event - OI/05/0601 - Operating Instruction - Transfers from the offline buffer tank V3441 via diverter V3790 and online/offline tank flushing operations - Issue 23 - June 2013 TRIM 2015/0254692
2. Sellafield - Document - PP1 Event - OI/05/0410 - Operating Instruction - PP Cycle active restart - Issue 8 - May 2014 TRIM 2015/0254900
3. Sellafield Limited Management Investigation – BN 1408A2050, Investigation into the Product Purification 1 (PP1) cycle event in the Thermal Oxide Reprocessing Plant (THORP), 2014/0415039
4. Sellafield - THORP - Intervention Record - ONR-SEL-IR-14-133 - Reagents and Chemical Safety Systems Inspection LC22 PP1 Update - December 2014 - TRIM 2014/465989
5. Sellafield - THORP - PP1 Event Investigation Clarification Letter - 17 December 2014 - 2014/464472
6. Sellafield - THORP - PP1 Event - PP1 EMM1 July 2015 - TRIM 2015/0255585
7. Signed Copy of Letter SEL77465R Findings from ONR Investigation into the Incorrect Import of Formalin into the THORP Facility - 30 Oct 2014 - 2014/400873
8. Routine ONR THORP Lead Team Meeting, and Discussion of Response to Incidents - ONR-SEL-CR-14-516 - 24 February 2015 - 2015/0090887
9. Sellafield - THORP - Email - Environment Agency PP1 Event No Objection Letter - 01 July 2015 TRIM 2015/243024