

Proposal for the removal of discharge limits from SIXEP stack

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1. Introduction

Sellafield is currently undertaking a major (Environmental Permitting Regulations (EPR) (2016) Radioactive Substances Regulations (RSR)) permit review encompassing all discharge outlets across the site. This paper covers the review and proposed sampling rationalisation of the Site Ion Exchange Effluent Plants' (SIXEPs) aerial outlet, as defined by the EPR-RSR permit.

2. Background

In support of its ongoing operations, Sellafield Ltd has permission to discharge prescribed radioactive substances to the environment. Those substances (and their defined discharge routes) are determined by the ERP-RSR permit KP3690SX [1].

Within this permit, the Site Ion Exchange Effluent Plant (SIXEP) stack outlet is an 'Individually Limited Stack', (disposal outlet ref. A7), which has annual limits for alpha and beta radionuclides.

In order to prove compliance with the above permit, the SIXEP undertakes a regime of sampling for limited radionuclides, as defined in the techniques document [2]. Stack discharges for alpha and beta are derived from the results of this sampling, which in turn is reported to the Environment Agency (EA) on a monthly basis.

Table 1: Annual limits of reportable nuclides for SIXEP stack (A7)

Nuclide	Annual Limit (MBq)
Total particulate alpha	5.3E-01
Total particulate beta	2.9E+02

As part of the permit review an assessment has been carried out in order to identify whether SIXEP stack discharges are of a suitably low impact in order to justify the removal of discharge limits, prompting a change in classification to that of 'Other Outlet'. This would remove the SIXEP stack from the EPR-RSR permit and it would instead appear in to the Compilation of Environment Agency Requirements (CEAR) [3].

There is no formal requirement for the individual sampling of stacks designated as 'Other Outlets' – any sampling that takes place is agreed upon at a plant level. Instead, these discharges contribute to the 'Open Fuel Storage Ponds & Other approved outlets' section of the permit, which is measured by the site-wide High Volume Air Sampler (HVAS) system. Monitoring of the stack discharges (with Harwell 3230's in SIXEP) would continue as per current arrangements.

This paper seeks to assess discharges from the SIXEP stack in order to consider the possibility of downgrading it from a 'Limited Stack' to that of an 'Other Outlet'.

Facility vent description

There are 4 main parts to the SIXEP ventilation system which combine to discharge up the SIXEP stack (effective stack height 50m);

- Building and Cell ventilation
- Vessel Ventilation
- Laboratory Extract
- Cabinet extract

Of these only the Building and Cell vent (B&CV) and the Vessel vent (VV) are sampled and reported to the Environment Agency. The other extracts having already been downgraded to 'Other Outlet' status. The Laboratory Extract and the Cabinet Extract are not discussed further in this paper.

The B&CV extracts air from the general operating areas into the active cells facilities (including the active cells, valve modules, trace active workshops and stores, pump and valve decontamination and flask decontamination facilities, and the active extract fan room). Air is discharged from the cell vent via primary and secondary HEPA filter banks as abatement. This discharge stream is sampled by a Bird and Tole Sampler (BS652) and monitored by a Harwell 3230 (BS631).

The Vessel ventilation maintains a depression in the vessels and storage tanks relative to the cells. This exhausts via a two stage HEPA filtration system to the stack. This discharge stream is sampled by a plastic style Maypack (BS650) and monitored by a Harwell 3230 (BS633).

Current stack sampling arrangements

The Analytical Schedule for reportable SIXEP stack discharges is outlined in Table 2.

Table 2: SIXEP accountancy analytical schedule

Discharge flue	Equipment	Sample Point	Sample medium	Bulk Frequency	Reported nuclides
SIXEP Building/ cell ventilation	Bird and Tole	SP 996 (BS652)	Filter paper	Monthly	α, β
SIXEP Vessel Ventilation	Maypack	SP 997 (BS650)	Filter paper	Monthly	α, β

3. Stack discharges

SIXEP stack has annual limits for particulate alpha and beta discharges. These discharges are measured using a filter paper from within the Maypack sampler / Bird & Tole Sampler – with the filter papers being changed weekly on a Monday. The filter papers are bulked for the monthly analysis.

These monthly discharge values are reported to the EA via SL’s discharge records team in order to prove compliance against permitted limits.

Table 3 illustrates average particulate discharges from SIXEP and compares them with the annual plant and site limits.

Table 3 – Comparison of SIXEP particulate discharges against plant and site limits.

	Alpha	Beta
SIXEP Mean annual discharge (MBq) ¹	1.25E-01	7.10E-01
SIXEP Plant Limit (MBq) ²	5.3E-01	2.9E+02
SIXEP mean annual discharge as % of plant limit (%)	23.6 %	0.24 %
Site Limit (MBq) ^{3 4}	8.80E+02	4.20E+04
SIXEP mean annual discharge as % of site limit (%)	0.014 %	0.001 %

4. Removal of plant limits

SL has worked closely with the EA to achieve agreement on the principles regarding removal of plant limits. These take a risk-based approach, aiming to ensure that both the public and the environment are protected appropriately, whilst minimising the burden of regulation on the business.

The method that has been defined and agreed with the Environment Agency for the purpose of assessing plant discharges to determine whether the monitoring, analysis and reporting requirements implemented are proportionate, is referred to as ‘standardised reporting’. This methodology is based in the Environment Agency’s *Radiological Monitoring - Technical Guidance Note (TGN) 1* [4] and was agreed with the EA in a recent permit variation [1]. The principal

¹ SIXEP average annual discharge based upon actual reported discharges Jan-12 to Dec-17.

² Plant limits from EPR (2016) RSR permit KP3690SX (effective December 2017)

³ Site limits from EPR (2016) RSR permit KP3690SX (effective December 2017)

⁴ Including all Outlets, Ponds, and Other approved Outlets

justification used behind this variation utilised a standardised reporting assessment based on past reported discharges and their resulting dose impacts.

Assessment Methodology

In order to undertake the assessment the following must be calculated:

1. A detection limit, this is an annual discharge which would result in radiological impact (dose) to the worst case critical group, that would therefore require enhanced monitoring, analysis and reporting requirements;

- The detection limit is based on a maximum annual dose of 1 μSv to the critical group resulting from the total site aerial discharges per individual radionuclides.
- For discharges from individual stacks the dose criteria is 0.01 $\mu\text{Sv}/\text{yr}$ per stack and per nuclide. This is determined by dividing 1 μSv by 100 (100 pessimistically representing the amount of aerial stacks across site).
- The detection limit is calculated using the following;

$$\text{Dose } (\mu\text{Sv}) = \text{Discharge (Bq)} \times \text{Dose Factor } (\mu\text{Sv} / \text{Bq})$$

Therefore;

$$\text{Detection limit (or annual discharge in Bq)} = \text{Dose } (\mu\text{Sv}) / \text{Dose Factor } (\mu\text{Sv} / \text{Bq})$$

The dose factors for each radionuclide originate from SLF 2.11.109.01. The 'Sellafield Industry LADRR's' (Long-term Aerial Dose Release Ratio) [6] dose factors have been selected, taking into account the worst case critical group (i.e. Adult, Child or Infant), and effective stack height (50m) for the SIXEP stack.

2. The annual decision threshold is half the detection limit i.e. discharge which would result in a 0.005 μSv dose to the critical group.
3. The monthly decision threshold is the annual decision threshold divided by twelve. This gives a maximum monthly value which would result in a 0.005 μSv dose if continually discharged for twelve months.

Once the above has been calculated, the monthly reported discharges (typically for a twelve month & five year period) are compared to the monthly decision threshold, in order to determine if the below criteria are met:

- 100% of monthly discharges in the most recent twelve months is less than the monthly decision threshold;
- 95% of the monthly data is less than the monthly decision threshold over a five year period;

and

- Operational reasoning can be provided to underpin the assumption that discharges are not expected to increase in the future.

Though it is not part of the limit removal criteria, the assessment should evaluate the proportion of sampling results that are routinely reported at Limit of Detection (LoD). Historically if more than 90% of results were reported as LoD, then this would have been grounds to remove the limit (if the dose criteria were also met).

Table 4 illustrates the detection limits and decision thresholds calculated.

Table 4 – SIXEP detection limits and decision threshold

Nuclide	Dose Criteria (µSv) ⁵	LADDR ⁶ (Sv y ⁻¹ per TBq y ⁻¹)	Detection Limit (MBq) ⁷	Annual decision threshold (MBq) ⁸	Monthly decision Threshold (MBq)
Alpha	0.01	3.98E-03	2.51E+00	1.26E+00	1.05E-01
Beta	0.01	5.18E-05	1.93E+02	9.65E+01	8.04E+00

Table 5 illustrates the results of the assessment of SIXEPs aerial discharges over a five year period against the criteria outlined above.

Table 5 – SIXEP standardisation proposal

Nuclide	Monthly decision Threshold (MBq)	% of monthly results below decision threshold (5 year) ⁹	Criteria met (>95%)	% of monthly results below decision threshold (last 12 months) ¹⁰	Criteria met (100%)	% of monthly results ≤ LoD ¹¹
Alpha	1.05E-01	100%	Yes	100%	Yes	95%
Beta	8.04E+00	100%	Yes	100%	Yes	34%

The assessment table (above) confirm that the discharges of aerial particulate from the SIXEP stack over the past 5 years (and 12 months) meet the criteria for limit removal. In addition to this the alpha results are routinely reported as LoD.

It can therefore be reasoned using the standardised reporting methodology, that the limits that are currently applied to the stack for alpha and beta should be removed. This would prompt a downgrade to an ‘Other Outlet’.

5. Future discharges

It should be noted that throughput in SIXEP changes depending on operations occurring around site. As site moves towards POCO and ongoing decommissioning, it is likely that the liquid discharges that are processed through SIXEP will change, and some of these are likely to be more challenging than others.

⁵ 0.01 microsievert is based on 1 µSv being pessimistically divided by 100 outlets on site.

⁶ Assumed as the worst factor (from Adult, Child and Infant) for a 50m height stack. Per guidance, alpha uses Pu-239, whilst Beta uses Cs-137.

⁷ Calculated from the Dose criteria (µSv) and the LADDR

⁸ Half of the detection limit

⁹ Based upon discharges between Jan-12 and Dec-17

¹⁰ Based upon discharges between Apr-17 and Mar-18

¹¹ Based upon discharges between July-15 and Feb-18

SIXEP has already started to process new feeds including liquid discharges from sludge retrievals from FGMSF. During this period of time no notable increase in SIXEP aerial discharges was noted – see Graphs 1 & 2 in Appendix 1 for recent aerial discharge trends.

The impact of future liquid discharge streams through SIXEP and the associated impact on the aerial discharges have been considered. Given the feeds that have already been processed and the aerial discharges measured during that time, it can be concluded that it is unlikely that future feeds will increase the aerial stack discharges to levels significantly higher than present. It should also be noted that analysis of the flowsheets for SCP, as part of detailed design, has meant that the SCP outlet will be designated as an 'Other Outlet' [7].

6. SIXEP temporary sampling campaign

Temporary Sampling Campaign

The temporary sampling campaign in SIXEP does not influence the outcomes of this sampling rationalisation proposal, as the analytes sampled during the campaign are not limited at SIXEP stack. A summary of the campaign is included in this paper for completeness.

Between December 2017 and May 2018 a temporary sampling campaign was commissioned in SIXEP. This was to enable the results of the campaign to feed into the design of the SIXEP Contingency Plant (SCP) stack system.

The temporary sampling system was added to the Vessel Vent and consisted of:

- A 2 bubbler system – sampling for Carbon 14, and
- A single Maypack – sampling for Iodine 129.

During the sampling period SIXEP had a variety of throughputs, including sludge processing operations in FGMSF and FHP – reflecting the potential discharges that SCP will eventually be challenged with.

The conclusion from the sampling campaign was that discharges of C-14 and I-129 are *Trivial* and that it is reasonable to assume that this would reflect future SCP discharges, as it is unlikely that discharges will increase significantly based on these results [8].

7. Summary

Following on from the above calculations it is clear that SIXEP meets the criteria to be downgraded to an 'Other Outlet'. If the stack is downgraded then there is the option to remove sampling/analysis on the B&CV and the VV, as the sampling of the SIXEP stack would be counted with the other 'Other Outlets' across site as part of the site wide HVAS system.

To summarise, SIXEP should be downgraded and sampling cease for the following reasons:

- There is low impact from aerial discharges coming from SIXEP.
- All of the reported discharges are below the decision threshold.
- Substantial lifetime cost and time saving would be available following the removal of sampling and reporting of discharges from SIXEP, and

- Monitoring of stack discharges will still be available from BS631 (Building & Cell vent) and BS633 (Vessel Vent). The option remains to send the filter cards from these units for analysis if required.

Owing to their low impact, the cessation of particulate sampling for alpha and beta species from the SIXEP stack represents BAT.

8. Implementation

Due to the timescales involved in a permit variation, sampling and monitoring in SIXEP would be required to continue under current arrangements until the permit is reissued. Once SIXEP has been removed from the permit (and the permit reissued), a decision can be made over the future of stack sampling in SIXEP. If sampling ceases and the equipment is isolated then this should be done via a PMP. SIXEP stack monitoring systems would remain in place with the option to send the filter cards for analysis as required.

9. Proposal

From the assessments undertaken and arguments made in this paper, the following recommendation has been made:

- Removal of the alpha and beta limits from the SIXEP stack and subsequent downgrade to 'Other Outlet' status.
- After being downgraded it is recommended that sampling and analysis cease from BS652 (SP995) and BS650 (SP997). Sampling will take place instead from the site wide HVAS network. Further analysis is available from BS631 and BS633 if desired. The cessation of sampling should be completed separately via a PMP.

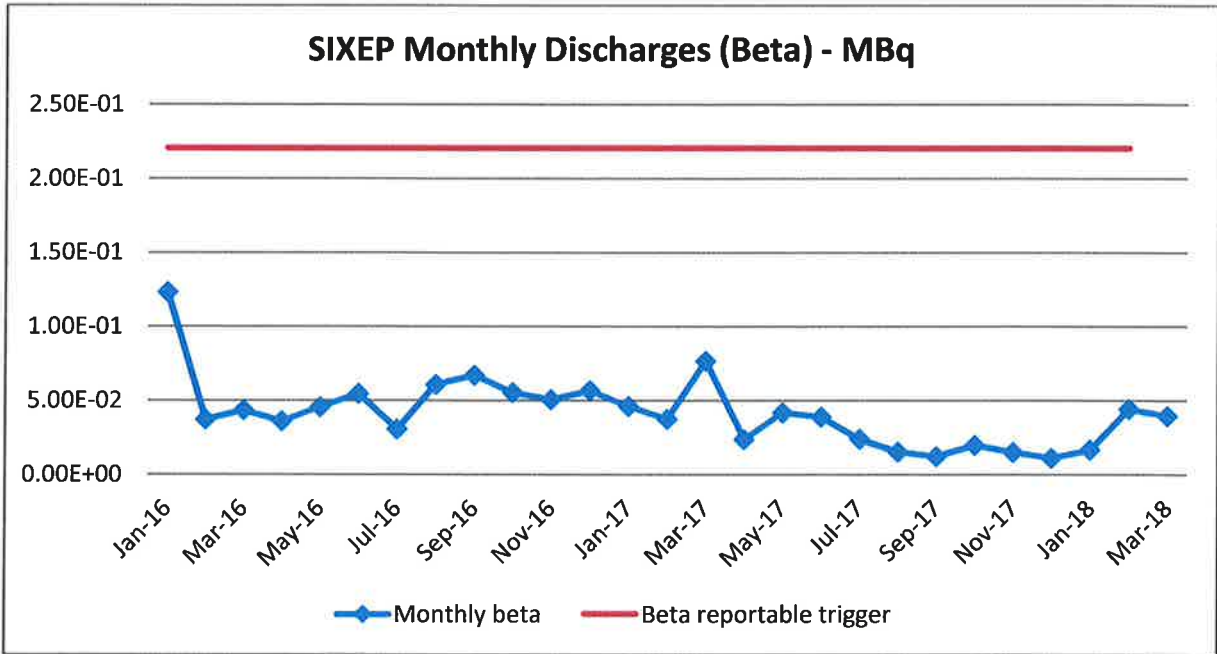
It is therefore recommended that these proposals are taken forward in the permit review process in order to gain EA agreement.

10. References

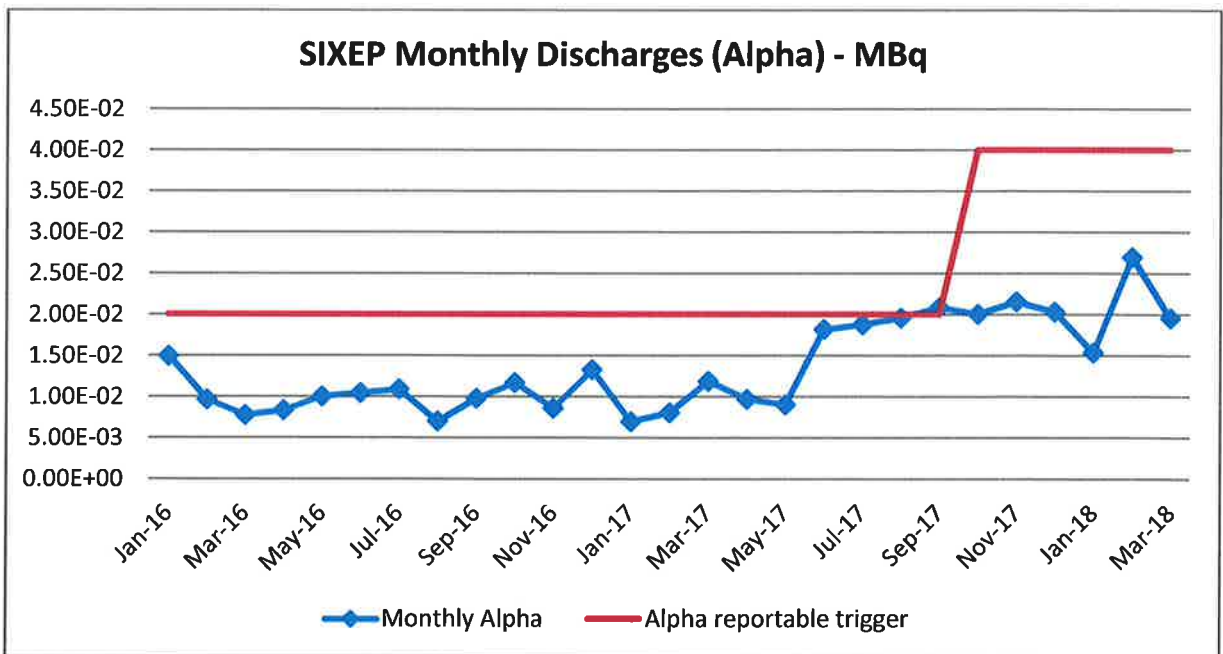
- [1] Environment Agency, "Environmental Permitting Regulations (2016)," Radioactive Substance Regulations Permit KP3690SX, December 2017.
- [2] SLSP 2.11.100, "Techniques for determining the activity of waste disposals made under the environmental permit for radioactive substances," 04/2018.
- [3] Environment Agency, "Compilation of Environment Agency Requirements, approvals and specifications made under permit KP3690SX," December 2017.
- [4] Environment Agency, "Radiological Monitoring Technical Guidance Note 1. Standardised Reporting of Radioactive Discharges from Nuclear Sites.," Version 1, May 2010.
- [5] Environment Agency, "Environmental Permitting Regulations (2016)," Radioactive Substance Regulations Permit KP3690SX, December 2017.
- [6] Sellafield Ltd., "SLF 2.11.109.01 Public Dose Factor Tables," March 2013, Issue 2.
- [7] ██████████, "SIXEP Contingency Plant Environment Case for detailed design," Issue: Draft, RP/████████/SAFE/00045, 2018.
- [8] ██████████, "SIXEP/SCP Position Statement on I-129 and C-14," MRTC/2018/06, 03/2018.

11. Appendix 1

Graph 1 – Monthly discharge of beta from SIXEP between Jan-16 to Mar-18 in comparison with the current trigger level



Graph 2 – Monthly discharge of alpha from SIXEP between Jan-16 to Mar-18 in comparison with the current trigger level¹²



¹² Alpha reportable trigger increased in September 2017 as part of the Annual trigger review.