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TECHNICAL PEER REVIEW - AIR POLLUTION CONTROL RESIDUE (APCr) IMMOBILISATION PLANT AND DISPOSAL SOLUTION AT RED HILL

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EASTERN METROPOLITAN REGIONAL COUNCIL
TECHNICAL PEER REVIEW - AIR POLLUTION CONTROL RESIDUE (APCr) IMMOBILISATION PLANT AND DISPOSAL SOLUTION AT RED HILL

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Description	**This report provides a peer review of the Eastern Metropolitan Regional Council (EMRC) proposed Air Pollution Control residue (APCr) Immobilisation Plant and Disposal Solution at Red Hill as detailed in the EMRC Environmental Protection Authority (EPA) Referral document .**

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1. Introduction

1.1 Introduction

Ramboll Australia Pty Ltd (hereafter "Ramboll") was retained by Eastern Metropolitan Regional Council (hereafter 'EMRC" or the "Client") to provide a high level review of the operational and engineering aspects of the proposed Air Pollution Control residue (APCr) Immobilisation Plant and Disposal Solution at Red Hill as detailed in the EMRC Environmental Protection Authority (EPA) Referral document (Talis, 2024) (the "Project").

1.2 Background

The EMRC is proposing to accept, treat and dispose of APCr at their Red Hill Waste Management Facility. The treated APCr will be disposed to an existing licensed Class IV landfill cell which will have an appropriate leachate collection and treatment (i.e., via evaporation) and will be capped with a low permeability cover to minimise potential for leachate generation. The treated APCr will not be co-disposed with other Class IV materials and will be managed in a designated portion of an existing Class IV cell and eventually into a dedicated Class IV cell when this is approved.

Ramboll understands that concurrently to the Western Australian EPA Referral (Talis, 2024), the EMRC has submitted a Works Approval application to the Department of Water and Environmental regulation (DWER) for the construction of the Immobilisation Plant. This peer review has been requested to support the EPA and DWER approval process .

1.3 Objectives

The overall project objective is to provide high level review of the operational and engineering aspects of the proposed APCr plant at Red Hill, the disposal of the immobilised APCr into an existing class IV cell, and eventually into a dedicated class IV cell when this is approved, as detailed in the EPA referral (Talis, 2024).

Specific objectives include:

- Gap assessment of the design and construction principles for the proposed Red Hill APCr immobilisation plant and disposal solution, against best practices in Europe, and other locations, where there is existing waste incineration and APCr disposal.
- Development of prioritised recommendations for mitigation of the identified gaps.

1.4 Scope

The scope of works completed to meet the project objective included:

- Project background and summary of local landfill requirements
- Desktop review of international APCr management and treatment methods
- Peer review of the of the operational and engineering aspects of the EMRC's EPA referral (Talis, 2024)

2. Limitations

This report has been prepared Ramboll Australia Pty Ltd (Ramboll) ('Ramboll') exclusively for the intended use by the client Eastern Metropolitan Regional Council ('EMRC') in accordance with the agreement in accordance with the scope of works detailed in the Proposal for Technical Review of

APCr Treatment Plant, reference no 231312, dated 6 June 2025 between Ramboll and the client defining, among others, the purpose, the scope and the terms and conditions for the services. No other warranty, expressed or implied, is made as to the professional advice included in this report or in respect of any matters outside the agreed scope of the services or the purpose for which the report and the associated agreed scope were intended or any other services provided by Ramboll.

In preparation of the report and performance of any other services, Ramboll has relied upon publicly available information, information provided by the client and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate, complete and available to Ramboll within the reporting schedule.

Ramboll's services are not intended as legal advice, nor an exhaustive review of site conditions and/or compliance. This report and accompanying documents are initial and intended solely for the use and benefit of the client for this purpose only and may not be used by or disclosed to, in whole or in part, any other person without the express written consent of Ramboll. Ramboll neither owes nor accepts any duty to any third party, unless formally agreed by Ramboll through that party entering into, at Ramboll's sole discretion, a written reliance agreement.

Unless otherwise stated in this report, the scope of services, assessment and conclusions made assume that the site will continue to be used for its current purpose and end-use without significant changes either on-site or off-site.

3. Project Background

3.1 Air Pollution Control Residues

Western Australia has two Energy from Waste (EfW) facilities. The Kwinana Energy Recovery (KER) project in Kwinana Beach, which is currently in startup and operations and the East Rockingham Waste to Energy project located in East Rockingham, which is currently in administration and receivership. These facilities are located approximately 40 km south of Perth in Western Australia and combined will produce approximately 40,000 tonnes per annum of raw APCr.

The APCr is a by-product that is generated from flue gas treatment in EfW Plants and is characterised by:

- Residue from treatment of flue gas from a Municipal Solid Waste (MSW) fired EfW facility using a semi-dry flue gas treatment process in which hydrated lime is injected for the purpose of capturing mainly HCl and SO_2. Activated carbon is injected for the purpose of capturing mercury and dioxins. The residue and fly ash are separated as one mixed product from the flue gas in a bag house filter.
- Boiler ash may be included for treatment (may be transferred to the same silo as the APCr)

Based on Ramboll's experience APCr is predicted to be classified as Class V waste in accordance with the DWER Landfill Waste Classification and Waste Definitions 1996 (as amended 2019) (DWER 2019).

3.2 Landfill Guidelines

Waste acceptance at landfill is regulated by the DWER in accordance with landfill guidelines (DWER, 2019). Classification of materials under these guidelines requires assessment of both leachable and solid concentrations to determine classification as one of the following categories:

- Uncontaminated Fill: Non-hazardous/non-biodegradable waste (excluding asphalt and biosolids), that meet the concentration and leachate requirements set out in the guidelines;
- Class I landfill: An unlined landfill designed to accept inert wastes for burial;
- Class II landfill: An unlined landfill designed to accept putrescible and inert wastes for burial;
- Class III landfill: A lined landfill, which may include a leachate collation system, designed to accept putrescible and inert wastes for burial, and
- Class IV landfill: A double-lined landfill with leachate collection, designed to accept contaminated soils and sludges (including encapsulated wastes) for burial.

There is only one facility in WA that is licensed to accept waste exceeding Class IV (i.e. Class V) which is Tellus Sandy Ridge Facility, located approximately 500 km northeast of Perth.

If wastes can't be classified in accordance with DWER guidelines (i.e. the waste exceeds the acceptance criteria), some form of immobilisation is required. Further leachate testing is then required to determine the appropriate waste classification. Only the leaching criteria is required for assessing the landfill category for the treated waste (DWER, 2019).

DWER guidelines (DWER, 2019) also require that treated/immobilised waste is reduced by only one 'level' of waste classification, for example:

- Immobilised or encapsulated Class V waste – to Class IV landfill;
- Immobilised or encapsulated Class IV waste – to Class III landfill, and
- Immobilised Class III waste – to Class II landfill.

Encapsulated waste need not be further tested, but approval of the encapsulation method must be obtained from the DWER (DWER, 2019). Ramboll understands that the Minister for Environment may be able to grant an exemption for the treated APCr to be classified more than one class lower after treatment, however this should be confirmed through discussion with the relevant agency.

4. Summary of Treatment Methods

International practices for management of APCr generally involve treatment, to reduce release of contaminants and then landfilling in either traditional landfills (i.e. at ground level, with leachate collection and top covers), or in geological stable, 'dry', subsurface disposal sites such as old salt mines.

The objective of treating the APCr prior to landfilling is to reduce the leachability of Chemicals of Potential Concern (COPC) (heavy metals and sometimes salts), which in turn enables compliance to relevant landfill acceptance criteria.

Treatment options adopted worldwide differ due to varying legislation and criteria required for disposal. The treatment options discussed below are based on enabling APCr disposal to Landfill in WA.

Treatment options can be categorised as:

- Extraction and separation
- Chemical stabilisation
- Solidification
- Thermal treatment

A brief background on the various treatment options, as well as dilution and subsurface disposal, is provided below.

4.1 Extraction and separation

4.1.1 Using Water

A possible and relatively easy treatment method to reduce leachability of metals is washing of the APCr prior to landfill disposal. Washing will result in a wastewater with a high content of salts and heavy metals. This wastewater will require some treatment such as precipitation of the metals and discharge of the metal-free but still salty wastewater.

The main disadvantage is the generation of metal and salt containing process wastewater. The main advantage of extraction and separation processes is the use of a relatively simple technique. This technology is currently in use.

4.1.2 Using acidic solutions

Heavy metals are generally much more soluble at lower pH and therefore extraction using an acidic solution will resulting in improved removal of these components compared to using water as an extraction medium. Acid solutions will also extract salts like when using water for washing.

Advantages are increased metals 'recovery' from APCr and improved 'quality' of APCr for landfill disposal. Also, the mass of treated APCr (or washed solid matter) requiring landfill disposal is reduced.

Acid washing would be preferred over water-only to reach leachate requirements reliably. Acid for washing could comprise an acidic 'waste' or would need to be purchased.

The technique is used in several commercially available technologies, particularly the FLUWA process, which is currently in operation at several plants, mostly located in Switzerland.

4.2 Chemical Stabilisation

The main advantage of chemical stabilisation processes is a significant improvement of the leaching properties of the residues and the use of relatively simple techniques.

For example, stabilisation with CO_2 and H_3PO_4 involves changes to the geochemical binding of heavy metals similar to stabilisation with $FeSO_4$, however in this case the metals (primary focus on Pb, Cd, and Zn) are bound as relatively insoluble carbonates or phosphates.

A variety of the above stabilisation processes also utilise phosphate as the stabilising agent and bind the heavy metals as phosphate minerals. Originating from USA, this process mixes reagents and residues more or less dry, often only with a little water to avoid dusting. As such, the process does not include water extraction of salts but on the other hand generates no process wastewater.

4.3 Solidification

Solidification is the most widespread technology for reducing leachability of organic and inorganic COPC and it can be combined/used after chemical stabilisation or washing.

Solidification involves mixing APCr, cement and other components to increase strength of the treated materials. It is the process of creating a physical change such as decreasing the surface area exposed to leaching. COPC can also be subjected to chemical stabilisation and immobilisation reactions with components in the binding material.

The main advantages of solidification techniques are a decrease of leaching and improvement of the mechanical properties. Solidification techniques often also make use of relatively simple technology. The main disadvantages are that the physical integrity of the product may deteriorate over time.

4.4 Thermal Treatment

Vitrification means heating the waste to a very high temperature and adding silicon dioxide to melt the waste into a glass-like product. This product can then be used in the construction industry replacing aggregate material.

Although this technology is widely used in Japan, it is considered unlikely that this technology is commercially viable for treatment of APCr from Western Australian WtE Plants due to associated high startup and operational costs.

4.5 Dilution

Mixing the APCr with IBA is a form of dilution, which is not considered best practice for waste management in WA. Dilution of APCr with IBA does not decrease the mass of contaminates with the potential to leach from the waste. Dilution will also increase the mass and associated costs of landfill disposal.

Dilution is not considered to be an acceptable treatment method for APCr.

4.6 Sub-surface Disposal

Disposal of residues in subsurface landfills or disposal sites is typically done in abandoned mines. An assessment of potential subsurface disposal options has not been carried out as a part of this report. For sub-surface disposal to be an option for APCr disposal there should not be the potential for hydraulic conductivity between the APCr and groundwater. Most below ground mines in WA require some sort of dewatering to lower groundwater levels (i.e. coal mines in Collie and gold mines in Kalgoorlie) and therefore would not be a suitable disposal option for the APCr.

5. Peer Review

This section of the report provides a peer review of the operational and engineering aspects of the proposed APCr Immobilisation Plant and Disposal Solution at Red Hill as detailed in the EMRC referral document (Talis, 2024). As a part of this review Ramboll has identified ‘gaps’ based on the Waste Treatment Best Available Techniques (WT BREF) reference document (Pinasseau, A et al, 2018) and Ramboll’s more than 50 years of experience within the waste incineration and energy recovery sector.

5.1 Identification of International Best Practices for APCr Treatment

The proposed treatment of APCr based on cement can be considered among best practice and should meet Class IV or III criteria and therefore enable landfill disposal at suitably licenced landfill sites. This concept is widely used worldwide except in Scandinavia and Germany. The reason being that Germany is using the APCr as material for stabilisation of old salt mines and backfilling, and that Norway is mixing the alkaline APCr with acidic waste prior to disposal in a dedicated old limestone quarry. In these cases, APCr is used without involving cement. As noted in Section 4.6 this option is not considered a suitable disposal method for APCr generated in Western Australia due to presence of groundwater at possible disposal sites.

Ramboll notes that there are three main concepts to dispose the treated APCr in the landfill practiced in the industry.

1. As per the proposed method using agitator truck and pouring of the mixture into smaller bunded areas (with max height of around 0.5 m) to allow controlled curing.
2. Production of large cubes (around 1 m^3) near the batching area. Transport of the cubes by truck to the landfill after curing.
3. Discharge of the mixed material into jumbo bags (around 1 m^3). Curing in shelter and then disposal of the bags into the landfill.

It is Ramboll's general experience that using an agitator truck, as proposed by the EMRC will result in the lowest dust emissions as compared to the other two mentioned methods detailed above.

Comprehensive Lifecycle Analysis (LCA) of these different disposal options can be found in literature. A comprehensive study from 2022 concluded that stabilisation of the APCr is the most attractive, if the options of old salt mines and the Norwegian concept is not available within a reasonable distance (Maresca. A., et al. 2022).

5.1.1 Best Available Techniques Reference Document for Waste Treatment

The BREF published in 2018 (Pinasseau, A et al, 2018) provides information on the best available techniques for minimising environmental impacts for the waste treatment sector activities, amongst which include the disposal of hazardous waste with a capacity exceeding 10 tonnes per day involving physico-chemical treatment (such as immobilisation treatment). The WT BREF (Pinasseau, A et al, 2018) was developed from the information exchange involving regulators, industry representatives, and environmental non-governmental organizations and will be periodically reviewed and updated.

It should be noted that WT BREF (Pinasseau, A et al, 2018) does not cover the aspects of incoming transportation of the waste to site nor of the landfill of (treated) waste and that the techniques listed in the WT BREF are neither prescriptive nor exhaustive.

In the following section, the concept design of the immobilisation facility will be reviewed against some of the best practises according to Ramboll's experience and considerations raised in the WT BREF document.

5.2 Data Gap Assessment

The report 'Environmental Assessment and Management Plan. Air Pollution Control Residue – Interim', provided as Appendix A to EPA Referral (Talis, 2024) provides a conceptual description of the immobilisation facility in Section 6. The review comments/recommendations or gaps based on the conceptual description are tabulated in **Table 5-1** below

Table 5-1: Data Gap Assessment

Section in report	Activity	Methodology Proposed	Best Practice	Comment/Recommendation/Gap
6.2	Raw APCr testing	Periodic laboratory testing on the raw APCr to verify continuing compliance with the ash characterisation plan at a specified interval prior to transport and acceptance at the facility	Yes	Ramboll assumes the frequency of periodic testing is adequate for detection of non-compliant incoming APCr qualities. It should be considered to perform regular test for hydrogen gas generation of incoming raw APCr (due to presence of aluminium in residue) to monitor and verify/understand the risk of hydrogen formation potential that may impact immobilisation or equipment safety design.
6.3	Transport of raw APCr	Powder tanker trailers (27 tonnes capacity) operated in with the dangerous Goods Safety Regulations 200.7	Yes	None
6.4	Weighbridge acceptance	CCTV + weighed in/out by computerized system + registration of waste type, volume, waste holder details + carrier details	Yes	Ramboll assumes a waste tracking and inventory system will be maintained as part of the environmental management system (EMS) implementation
6.5	Internal access route	Powder tanker will drive to reception area and connect to the silo reception pipeline. The treated material will be transported by agitator truck from plant to disposal area.	Not applicable	None
6.6	Design and construct contractor	Not applicable	Not applicable	None
6.7	Conceptual drawings	Not applicable	Not applicable	None
6.8	Plant infrastructure	Equipment located under cover to protect against elements (and to minimize volume of storm water from this area): -Unloading area -Loss of weight hoppers -Mixers	Yes	It is recommended to consider including storage silos for APCr and cement to be under roof as well to minimise potential of moisture ingress into the silo through leaking connection seals on top of silos and any open hatches.

Section in report	Activity	Methodology Proposed	Best Practice	Comment/Recommendation/Gap
		-Loading area		
6.8.1	Concrete hardstand (reinforced)	22 m x 23 m Area is bunded to prevent spill to surroundings	Yes	Ensure that bunded areas are designed and built to prevent seepage, e.g. by painting, coatings, concrete quality, sealing systems applied on the inside. There, it must be possible for the sealing system to be inspected at any time.
6.8.2	Administration and control room	Located nearby with clear line of sight to key activities	Yes	None
6.8.3	Unloading area	Roofed area. Bunded area with sump for any spill of contaminated water or spills.	Yes	None
6.8.4	Storage silos	4 x 130 m3 (chisel nose silos) 1 x 72 m3 cement storage silos Reverse jet pulse dust filter fitted on each silo. Dust emission from filter <10 milligram per normal cubic meter (mg/Nm3);	Yes	It should be considered to install dust monitoring at the outlet from dust filter. It is assumed that periodic monitoring of filter outlet emission as minimum is performed (assume implemented as part of EMS). The BAT associated dust emission level from filter-based technique in the WT BREF is 2-5 mg/Nm3.
6.8.5	Overfill controls	Audible alarm, strobe light, high level probe and air actuated butter valve at inlet end of the fill pipe.	Yes	It is recommended to consider including high level measurement of radar (assume installed) to automatically close inlet valve when triggered.
6.8.6	Discharge screws	Screw conveyor to transfer material to Loss of weight hopper from silo	Yes	It is noted that the discharge system is often an area causing issues for APCr handling e.g. bridging. It is important to minimise any moisture ingress (due to the hydroscopic nature of the APCr) in this area e.g. from compressed air for anti-bridging. It should be considered that hopper walls should be designed with minimum 60º slope and it is preferable with a slide frame concept above the discharge screws to reduce material discharge issues.

Section in report	Activity	Methodology Proposed	Best Practice	Comment/Recommendation/Gap
				It needs to be confirmed that gate valve between silo and discharge screw will be installed (for isolation during maintenance) for personnel safety and containment of material.
6.8.7	Loss of weight hoppers	Separate hoppers for cement and APCr. Enclosed system with reverse jet pulse dust filter fitted on each.	Yes	It should be considered to install dust monitoring at the outlet from dust filter.
6.8.8	Mixer and loading area	Mixing chamber and chrome 27 special grade replaceable paddles.	Yes	It is noted that the environment will be corrosive in and around this mixing chamber. It is recommended that all parts are stainless steel or above including bolts and nuts. The handling of the wash water from the daily washing should be carefully considered in the layout and design. Depending on the design of the mixer and its discharge, adequate dust suppression needs to be considered to avoid release of dust into the surrounding environment. If not integrated in mixer, separate dust extraction system involving wet scrubbing may be considered.
6.8.9	Washdown bay	Internal of agitator washed at the end of the day. The washdown water to main collection sump	Yes	It should be considered to include tyre washing for incoming and outgoing vehicles to prevent dispersion of APCr dust by vehicles to outer areas of immobilisation plant
6.8.10	Surface water management and supply water	1 in 100 year (72 hours storm event) + 46 m3 (to cater for rupture at one water tank) Design: Directed to main collection sump with silt trap. Water transferred surface water pond (HDPE lined). Water from pond is pumped to water tanks for usage.	Yes	None
6.9	Acceptance and treatment process	Fully enclosed process to mitigate any risks associated with release of APCr material into the surrounding environment.	Yes	No new comment, refer to above comments on dust emission related.

Section in report	Activity	Methodology Proposed	Best Practice	Comment/Recommendation/Gap
6.10	Operation and maintenance	Qualified technician	Yes	Ramboll assumes that appropriate training and safety risks awareness to the hazardous nature of materials handled in immobilisation plant is provided to all staff, operators and technicians as per mentioned also in section 8 of report.
6.11	Laboratory testing	Six-monthly basis at a NATA accredited laboratory to confirm compliance with Class IV acceptance criteria.	Yes	Frequency considered ok as disposal of treated APCr to landfill is controlled (i.e. tracked daily) and EMRC can manage non-compliant materials as required. However, more frequent testing should be considered in the initial phase of the operation to confirm that the required landfill criteria can be met with the immobilisation plant, cement type and quantity used etc.
6.12	Disposal into Stage Class IV East Cell.	See below	See below	See below
6.12.1	Groundwater separation distance	Separation distance of approximately 4.1 – 5.7 m to the groundwater table, higher than DWER's preference of minimum of 3m	Yes	None
6.12.2	Landfill lining system	Double composition basal and side wall lining system consistent with international standards for hazardous waste containment cells,	Yes	None
6.12.3	Stage 2 Class IV Lining system integrity assessment	Continue to monitor groundwater monitoring wells in accordance with the Licence L8889/2015/1 and Surface Water and Groundwater Environmental Management Plan; and conduct tracer testing within the Stage 2 Class IV landfill western cell leachate sump.	Yes	Ramboll assumes that the landfill is adequate for said disposal purpose and that relevant remedy and management plan be developed and approved to cater to scenario if the continuous monitoring revealed that leakage from landfill has occurred.
6.12.4	Phase Hydrogeological risk assessment	Not applicable	Not applicable	Not applicable

Section in report	Activity	Methodology Proposed	Best Practice	Comment/Recommendation/Gap
6.12.5	Filling method	Transferred with agitator truck. Filling areas of 3 m width and height of 500 mm by earthen bunds. 300 mm soils layer to protect lining.	Yes	None
6.12.6	Class IV Waste types disposed	Approximately 100,000 m3 of Class IV waste material has been disposed of into the Stage 2 Class IV cell	Not applicable	It should be confirmed that there is no waste disposed with acidic properties that may dissolve treated APCr if is in contact with leachate of acidic nature.
6.12.7	Capping of stage 2 East Cell	LLDPE geomembrane (protected by 1.2 m soil layer) to prevent ingress of rainwater.	Yes	None
Not included	Emergency eye wash/shower station	Not mentioned	Yes	It should be considered to have adequate installation of emergency eye wash and shower station in appropriate area of the plant as first aid measures for exposure in eyes or on skin to accidental release of APCr.

It is further noted that Section 8 of 'Environmental Risks and Management' in the EPA Referral (Talis, 2024) mentioned that EMRC has developed an Environmental Management System (EMS) that adopted the international standard ISO 14001:2015 in January 2019. Ramboll assumes that the EMS will be updated to include the considerations described in the section for the operation of the immobilisation plant with updated parts related to the plant such as:

- Handling and transfer procedures
- Accident management plan
- Management of non-compliant treated residue
- Monitoring plans for emissions to air (and water)

The EMRC EMS is not part of the scope of this review and it is assumed that the plan incorporates various best practices.

5.3 Risk assessment

The assessment performed in the previous **Section 5.2** can be grouped into "gaps" that should be closed with recommended implementation and "nice-to-have" recommendations that can improve operational aspect of the plant and reduce environmental impact based on Ramboll experience and best practices and optional to implement.

To assess the various potential environmental and health risks associated with the gaps identified, the potential hazards identified were classified according to the DWER's Guidance Statement, as used in the report 'Environmental Assessment and Management Plan. Air Pollution Control Residue – Interim' (prepared by Talis Consultants) as shown in **Table 5-2** below

Table 5-2: Risk Rating Matrix

		Consequence				
		Slight	Minor	Moderate	Major	Catastrophic
Probability	Almost Certain	Medium	High	High	Extreme	Extreme
	Likely	Medium	Medium	High	High	Extreme
	Possible	Low	Medium	Medium	High	Extreme
	Unlikely	Low	Medium	Medium	Medium	High
	Rare	Low	Low	Medium	Medium	High

The current risk rating and revised probability and consequence for each identified gap and engineering recommendation following the implementation of defined management measures are shown in **Table 5-3** and **Table 5-4** below. It should be noted that minor gaps and recommendation of low-risk rating have not been included in the table.

Table 5-3: Risk Assessment and Profile of Gaps identified

Gap identified	Hazard	Risk	Probability x Consequence	Risk Rating	Management Measures	Revised Probability x Consequence	Revised Risk Rating
Monitoring of hydrogen gas forming potential of incoming raw APCr to verify/understand its associated risk is not done.	Unaccounted hydrogen gas formation when raw APCr contacts moisture or during mixing with water in immobilisation process may result in explosive gas mixture formed in dead spaces of equipment or if ventilation is not adequate.	Explosion and rupture of equipment leading to personnel injury and loss of containment of APCr into the environment and affecting site personnel.	Unlikely x Major	Medium	Perform regular tests for hydrogen gas generation of incoming raw APCr to monitor the hydrogen formation potential. Frequency of testing may be reduced after stable operation and test results shows stable trend. Evaluate the design the equipment with consideration of potential hydrogen formation in mind to ensure suitability.	Rare x Major	Medium
Lack of continuous monitoring of dust at silo and equipment filter outlet	Increased emission of APCr dust from filter due to damaged filter bag that goes unnoticed for long period of time.	Increased risk to exposure to dust emissions of APCr at the Immobilisation Plant resulting in health impacts	Possible x Moderate	Medium	Include continuous dust measurement at outlet of filter. May not necessarily be a high accuracy monitor, but suitable one to detect a ruptured bag etc.	Unlikely x Moderate	Medium
Lack of emergency eye wash/shower station	Delayed first aid treatment to personnel exposed to hazardous APCr in the eyes or on body.	Not reducing severity to impact to personnel health	Possible x Moderate	Medium	Ensure adequate provision of emergency eye wash/shower station in the plant	Unlikely x Moderate	Medium

Table 5-4: Risk Assessment and Profile of "nice-to-have" identified

Gap identified	Hazard	Risk	Probability x Consequence	Risk Rating	Management Measures	Revised Probability x Consequence	Revised Risk Rating
No roofing over APCr and cement storage silo	No direct hazard, but risk of moisture ingress from top of silo may cause operational problem and clogging due to formation of lumps in the silo.	Possible loss of containment of APCr into the environment during maintenance when troubleshooting clogged equipment.	Unlikely x Minor	Medium	Include roofing for storage silo	Rare x Minor	Low
Insufficient consideration for storage silo discharge design to minimise discharge issue.	Frequent bridging and clogging in discharge system requiring increased maintenance and troubleshooting.	Possible loss of containment of APCr into the environment during maintenance when troubleshooting clogged equipment.	Unlikely x Minor	Medium	More detailed consideration in design such as designing hopper walls with minimum 60 º slope and ensuring low moisture introduction into system e.g. when selecting compressed air dryness used for bridge breaking/fluidisation.	Rare x Minor	Low

6. Conclusions

The use of immobilisation techniques for the treatment of APCr to reduce hazardous classification and enable disposal at a landfill facility, is a widely used concept in alignment with the available techniques from the WT BREF.

The concept design for the immobilisation plant has been reviewed for any operational and engineering gaps and referencing 'best practice' in the WT BREF and Ramboll's experience. While most of the proposed design concept incorporated best practice, Ramboll notes some engineering design consideration that have not been mentioned. The gaps include:

- Testing or monitoring of incoming raw APCr to understand/verify risk of hydrogen gas formation potential
- Continuous monitoring of dust emission of the hazardous APCr
- Lack of emergency safety eyewash/shower facility in the plant

The proposed filling method, of applying treated APCr using an agitator truck direct to landfill, is also considered best practice by Ramboll's experience.

Ramboll assumes that the Class IV landfill is adequately designed and constructed for the disposal of the treated APCr, and that contingency and response measures are in place if the continuous monitoring shows leakage of leachate from the landfill. We have also assumed that other Class IV hazardous waste that have already been landfilled and future waste, does not consist acidic property or generate acidic leachate that can impart the leaching and integrity of the treated APCr when they come in contact.

The Environmental Management System (EMS) which forms an essential component of operation of the plant was not reviewed as part of this report. Ramboll assumes that the plans and procedures in the EMS incorporates various best practices, including:

- Handling and transfer procedures
- Accident management plan
- Management of non-compliant treated residue
- Monitoring plans for emissions to air (and water)

Ramboll also provided recommendation on "nice to have" design consideration aimed to improve operational aspects and indirectly reducing environmental and health impacts. These can be considered by the EMRC for inclusion into the design, however, these are not considered to a 'best practice' requirement.

7. References

Maresca. A., et al. 2022. Life cycle assessment of air-pollution-control residues from waste incineration in Europe: Importance of composition, technology and long-term leaching, Waste Management Volume 144, 1 May 2022, Pages 336-348

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