Johnson Matthey

BAT Assessment in Support of Permit Variation V005

Johnson Matthey PLC

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		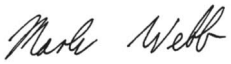	
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Revision	Revision date	Details	Authorized	Name	Position
1	18/03/2021	Final Report		Mark Webb	Technical Director

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1. Introduction

This document has been prepared in support of the application to vary Environmental Permit (EPR/KP3536UC).

The report presents a review of the changes proposed under Variation V005 to the permit against published guidance on Best Available Techniques (BAT).

The EU BAT Reference (BREF) documents applicable to the site operations are:

- Speciality Inorganic Chemicals BREF (SIC) – August 2007; and
- Additional Guidance for the Inorganic Chemicals Sector (EPR 4.03) – March 2009

The SIC guidance document however also makes reference to the Common Waste Water and Waste Gas Treatment / Management in the Chemical Sector BREF (published in May 2016) and where relevant reference has also been made to this BREF and associated BAT Conclusions.

This report has been developed from the previous BAT Review of all site operations undertaken in support of Permit Variation V003 and then updated to incorporate the changes proposed under Permit Variation V004 (blue text within Tables 1 – 3).

The changes to this assessment associated with permit variation V005 are presented in red text within Tables 1 – 3.

2. BAT Conclusions Assessment

The specific requirements of the applicable BREF Notes and BAT Conclusions are summarised in tabular form.

Table 1 covers the BAT requirements specified within the Speciality Inorganic Chemicals BREF (SIC) – August 2007.

Table 2 covers the BAT requirements specified within the Additional Guidance for the Inorganic Chemicals Sector (EPR 4.03) - March 2009.

Table 3 covers the BAT requirements specified within the Common Waste Water and Waste Gas Treatment / Management in the Chemical Sector BREF and associated BAT Conclusions – May 2016.

Table 1: Speciality Inorganic Chemicals BREF (SIC) – August 2007

BAT No.	BAT Justification	Operating to BAT	Operator Comments
Scope	‘‘Production within the meaning of the categories of activities contained in this section means the production on an industrial scale by chemical processing of substances or groups of substances listed in Sections… 4.2. Chemical installations for the production of basic inorganic chemicals, such as: (a) gases, such as ammonia, chlorine or hydrogen chloride, fluorine or hydrogen fluoride, carbon oxides, sulphur compounds, nitrogen oxides, hydrogen, sulphur dioxide, carbonyl chloride. (b) acids, such as chromic acid, hydrofluoric acid, phosphoric acid, nitric acid, hydrochloric acid, sulphuric acid, oleum, sulphurous acids. (c) bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide. (d) salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate (e) non-metals, metal oxides or other inorganic compounds such as calcium carbide, silicon, silicon carbide. 4.3. Chemical installations for the production of phosphorous-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers). 4.4. Chemical installations for the production of basic plant health products and of biocides. 4.5. Installations using a chemical or biological process for the production of basic pharmaceutical products. 4.6. Chemical installations for the production of explosives’’.	-	The BREF document applies as the permitted activities is defined under 4.2 Part A(1)(a)(v) of Schedule 1 to the Environmental Permitting Regulations 2016.
Other BREF	**Interface with other BREF** • Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector [8, European IPPC Bureau, 2003] • Emissions from Storage [31, European IPPC Bureau, 2000] • Industrial Cooling Systems [36, European IPPC Bureau, 2003] • Monitoring of Emissions [37, European IPPC Bureau, 2003] • Economics and Cross-Media Effects [32, European IPPC Bureau, 2004] • Large Combustion Plants [34, European IPPC Bureau, 2004] • Waste Incineration [35, European IPPC • Waste Treatments [29, Cefic, 2004].	-	CWW BREF also applies to the site.
Section 5.1	**Raw and auxiliary materials supply, storage, handling and preparation** BAT is to reduce the amount of packaging materials disposed of by, e.g. recycling ‘hard’ and ‘soft’ used packaging materials (see Sections 4.2.1 and 4.2.2), unless safety or hazard considerations prevent it. • Suppliers take back empty containers for recycling/reuse. • Use largest possible container.	Not Applicable	The majority of the existing processes within the MSC are small scale R&D operations. The new Pilot Plant process operations to be introduced are also small scale with production <10 tonnes of product generated per year. The raw materials therefore can vary widely, and materials are not ordered in bulk quantities that lends itself for the reuse of packaging. Due to the hazardous nature of some of the raw materials, the packaging is not readily reused or recycled. This requirement is therefore considered to be inapplicable to the permitted operations. No change associated with the introduction of activity AR4. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of raw materials, and the introduction of activity AR5 will lead to the use of bulk bags in the supply of raw materials. JM will seek to recycle packaging where possible through its existing site waste management procedures and application of the waste hierarchy.

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Section 5.2	**Synthesis / reaction / calcination** BAT is to reduce emissions and the amount of residues generated by implementing one or more of the following measures: a. using high purity feedstock (see Section 4.3.1). b. improving reactor efficiencies (see Section 4.3.2). c. improving catalyst systems (see Section 4.3.3).	Yes	MSC operations are generally small-scale R&D. The main purpose of the MSC and Pilot Plant is primarily to optimise process efficiencies prior to full scale operation at other JM locations. The vessels used are small and in the kg size / scale. That said, laboratory work is undertaken prior to being undertaken at the pilot scale. This allows the process to be optimised as far as practicable prior to going on to the pilot plant. Reaction efficiencies also tend to be very high with yields typically being in excess of 90%. Due to the high selectivity; by products and wastes do not tend to be generated in any great quantities. Activity AR4 is not expected to generate any significant solid waste stream, with the majority of solids being returned to the process where possible. High quality feedstocks are used to avoid the generation of by-products, and the processes applied are expected to achieve extremely high yield. There will be an aqueous waste stream, which will result from the process, however the generation of this waste stream is an inherent characteristic of the reaction processes and cannot be further minimised. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of materials, but will not alter the yields or efficiencies. New Activity AR5 will be designed to use high purity feedstocks where possible, and to optimise the leaching and separation / recovery processes during detailed design and initial commissioning to optimise yield and minimise waste.
Section 5.3	**Synthesis / reaction / calcination** For discontinuous processes, BAT is to optimise yields, lower emissions and reduce waste by sequencing the addition of reactants and reagents (see Section 4.3.4). (Process changes that optimise reactions and the use of raw materials reduce the generation and release of waste. Many SIC installations use computer controlled systems which analyse the process continuously and respond more quickly and accurately than manual control systems. These systems are often capable of automatic start-ups, shut downs, and product change-overs which can bring the process to a stable condition quickly, minimising the generation of off specification products. Other process optimisation measures include: • equalising the reactor and storage tank vent lines during batch filling to minimise vent gas losses. • sequencing the addition of reactants and reagents to optimise yields, lower emissions and reduce waste (for discontinuous processes). • optimising sequences to minimise cleaning operations and cross-contamination of subsequent batches (for discontinuous processes).	Not Applicable	See Section 5.2 above. Section 4.3.4 refers to computer-controlled systems which are not relevant to the small-scale R&D operations, which employ manually intensive operations. Storage tanks are not used for the storage of materials. The purpose of the pilot plant is to optimise the efficiencies of the processes prior to scale up. Activity AR4 is undertaken on a sequenced addition process which will control the rate of reaction / precipitation and hence the rate of product generation. A combination of automated control loops and manual control systems are applied to each of the stages of the process. These have been selected to optimise the operation of the plant, maximise yield and minimise waste generation. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of materials, but will not alter the yields or efficiencies. New Activity AR5 will be designed to optimise yield where possible and will be operated on a product campaign basis to minimise losses associated with cleaning, and hence reduce waste.
Section 5.4	**Synthesis / reaction / calcination** For discontinuous processes, BAT is to minimise cleaning operations by optimising the sequences for addition of raw and auxiliary materials (see Section 4.3.4).	Yes	The MSC operations are small scale R&D activities. Sections 4.3.4 refers to computer-controlled operations which are not applicable to R&D activities, which employ manually intensive operations. The vessels used are small scale and cleaning generates only trivial quantities of waste. For Activity AR4 recovery of raw materials and product will be prioritised to maximise yield. Cleaning activities will be planned and scheduled aligned with production campaign scheduling to minimise waste generation. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of materials, but will not alter the yields or efficiencies – These activities will continue to run on a pre-planned campaign basis. New Activity AR5 will be designed to optimise yield where possible and will be operated on a product campaign basis to minimise losses associated with cleaning, and hence reduce waste.
Section 5.5	**Product Handling and Storage** BAT is to reduce the amount of residues generated by, e.g. using returnable product transportation containers/drums (see Section 4.2.1).	Yes	Due to the small quantities of materials brought into the site, the suppliers will not allow the containers to be returned due to efficiencies of scale for recovery and recycling. IBC's are reused on site, but they cannot be returned for reuse. No change associated with the introduction of the Activity AR4.

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			The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of raw materials, and the introduction of activity AR5 will lead to the use of bulk bags in the supply of raw materials. JM will seek to recycle packaging where possible through its existing site waste management procedures and application of the waste hierarchy.
Section 5.6	**Dust in Off-gases** BAT is to minimise emissions of total dust in off-gases and achieve emission levels of 1 - 10 mg/Nm^3 by using one or more of the following techniques: a. cyclone (see Section 4.4.2.1.2). b. fabric or ceramic filter (see Section 4.4.2.1.5). c. wet dust scrubber (see Section 4.4.2.1.3). d. ESP (see Section 4.4.2.1.4). The lower end of the range may be achieved by using fabric filters in combination with other abatement techniques. However, the range may be higher, depending on the carrier gas and particle characteristics (see Section 4.4.2.1). Using fabric filters is not always possible, e.g. when other pollutants have to be abated (e.g. SOx) or when the off-gases present humid conditions (e.g. presence of liquid acid). The particulate matters recovered/removed are recycled back into production when this is feasible. The scrubbing medium is recycled when this is feasible.	Yes	Powder handling operations are generally undertaken within dust booths that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filter system and there are no releases via A1/A2/A3 or A9/A10/A11 The dust booth units are subject to regular maintenance programmes in conjunction with an approved supplier. Furthermore, differential pressure gauges on the HEPA filters on these systems provide an indication of any fouling and these filters can be removed from service for maintenance prior to further use. The design and frequency of the monitoring programmes are based upon COSHH assessments. Monitoring of emissions to atmosphere from the thermal processes has not been undertaken. The installation was previously regulated under a low impact permit which did not define emission limits for the vent stack, nor was routine monitoring required. For thermal processing operations, a programme of testing was completed in 2018 to assess the typical levels of entrainment of powder from a typical batch furnace. This assessment was completed in the new facility, using a furnace which includes gas injection, using a fine powder and using a tray with no lid. This is presumed to have presented a pessimistic operation. An impact assessment undertaken based on this programme of testing demonstrated that the emissions of dust to atmosphere are insignificant and therefore routine monitoring is not considered appropriate (emissions levels from all vents are expected to be <1 mg/m^3). Emission points A5, A6 and A8 from the existing process operations are fitted with HEPA filtrations systems. Similarly, the continuous furnace relating to the new process has a HEPA filter arrangement installed. These systems are considered to be representative of BAT. Activity AR4 will also undertake all powder handling operations in dust booth with recirculating extraction systems installed with double HEPA filter protection. There will be no emission to atmosphere from this source. There is the limited potential for dust generation during vessel charging which is extracted via an extraction hood (primarily for Operator protection) to a wet chemical scrubber. The powders used at this stage of the process do not contain fine particles, and laboratory testing has shown that the materials present at this stage do not have PM_{10} or $PM_{2.5}$ present, hence the potential for dust generation at this stage is limited. Any larger particulates transferred to the scrubber would either be captured or be dissolved into the scrubber liquor. Dusts can also be generated by the dryer activities, and the extracted air is treated using a bag filter followed by double HEPA filtration, the extracted air is then fed into the wet chemical scrubber prior to discharge to atmosphere. Hence the dust abatement measures applied at the site are all representative of BAT, and there are not expected to be any emission of dust via emission point A12. Hence the emissions of particulate dusts from A12 will be below the BAT-AEL range. The expansion of activity AR2 and increase in throughput of AR4 will continue to apply the same controls as stated above. Powder handling operations are generally undertaken within dust booths that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filter system and there are no releases via A13/A14/A15. The relocated ovens for AR1 (emission point A16) will perform at the same emission levels as discussed above. Activity AR5 will also apply appropriate controls to all dust handling activities through the use of dust booths / enclosures that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filtration system and there will be no releases of dusts to atmosphere
Section 5.7	**HCN Emissions** BAT is to reduce HCN emissions and achieve emission levels of <1 mg/m^3 by scrubbing with an alkaline solution. The scrubbing medium is recycled when this is feasible (see Section 4.4.2.2.5).	Not Applicable	Not applicable to the Installation - no HCN used in Installation processes. No Change.
Section 5.8	**Ammonia Emissions**	Yes	Emission point A8 was introduced in the permit variation that was granted in 2014. The equipment is again used mainly for R&D purposes but can produce material for commercial sale.

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	BAT is to reduce NH_3 emissions and achieve emission levels of <1.2 mg/m³ by scrubbing with an acidic solution. The scrubbing medium is recycled when this is feasible (see Section 4.4.2.2.5).		The process involves the uses of a formulation with a very small quantity of ammonia or acetic acid (either 3 ml of 28% ammonia or 10 ml of 99% acetic acid in a batch) which may result in a trivial amount of ammonia being released to atmosphere. The risk assessment undertaken at the time of the application demonstrated that the emissions were "insignificant "and abatement is not necessary to achieve the emission limit value. Activity AR4 can generate ammonia, and all potential sources are extracted to the wet chemical scrubber where a 15% solution of sulphuric acid is used as the scrubbing media. The scrubber is guaranteed to achieve emissions of NH_3 no higher than 1mg/m³. The scrubbing liquor is recirculated within the scrubber with an intermittent purge and acid dosing to maintain the scrubbing liquor efficacy. Due to the addition of ammonium salts to activity AR1, there is the potential for trace ammonia emissions from the thermal treatment ovens venting via emission points A1 – A3 and A16. No abatement of these emissions is proposed as they have been modelled and demonstrated to lead to no significant impacts. The plant will meet the existing guidance emission limits in the S4.03 guidance of 10 mg/Nm³.
Section 5.9	**HCl Emissions** BAT is to reduce HCl emissions, e.g. by wet gas scrubbing under alkaline conditions (see Section 4.4.2.2.4). If HCl is the main pollutant to be treated and alkali scrubbing is used, BAT is to achieve 3 – 10 mg/Nm³ HCl.	Not Applicable	Not Applicable - no HCl emissions from the MSC or Pilot Plant operations. No Change.
	Waste Water Management and Water Emission Abatement Waste water treatment in the SIC sector follows at least three different strategies: • pre-treatment within the premises of the SIC installation and final treatment(s) in a central WWTP within the premises of a larger site where the SIC installation is located. • pre-treatment and/or final treatment(s) in a WWTP within the premises of the SIC installation. • pre-treatment within the premises of the SIC installation and final treatment(s) in a municipal WWTP.	Not Applicable	The Installation does not discharge process effluent to trade sewer and does not have an effluent treatment plant. The effluent volumes are extremely small and do not warrant a discrete effluent treatment plant. The effluent (essentially process vessel wash down waters) can be discharged directly to the Billingham site drains within the current discharge consent limits applied to RT01 for the integrated site. This is not applicable as the site does not have effluent that goes to a waste water treatment plant. All aqueous wastes generated by activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence Activity AR4 does not discharge into either site or municipal drainage systems, and there is no onsite treatment of aqueous wastes. No Change – all process wastewater from AR4 and AR5 will be collected for appropriate offsite treatment / disposal.
Section 5.10	**Waste Water** BAT is to allocate contaminated waste water streams according to their pollutant load. Inorganic waste water without relevant organic components is segregated from organic waste water and routed to special treatment facilities (see Section 4.4.1 and Figure 4.1).	Yes	All liquids associated with processing are collected in IBC's and removed from the site by a licenced waste disposal contractor for offsite disposal. Consequently, process effluents are not discharged to controlled waters. The pilot-plant does however discharge some process washing (i.e. filter cake washings) to the effluent drain which is discharged to the Tees via RT01. This is a discharge point that is managed by CF Fertilisers and both JM and Fuji Films discharge through into this point which allows for significant dilution. Discharges to the chemical drain are undertaken in compliance with the CF Fertilisers discharge consent "Billingham Site Effluent Agreement: RT01/INTCON/3/C". The site has an internal limit that requires any effluent to meet the emission limit values at the discharge point and does not rely on any dilution taking place within the drainage system. Effluent from process washings and vessel cleaning operations is segregated into IBC's prior to analysis and discharge via RT01. It should be noted that due to the site operating R&D and small-scale production activities the volumes of effluent and process washings are extremely low. All aqueous wastes generated by Activity AR4 will be inorganic in nature and are transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence Activity AR4 does not discharge into either site or municipal drainage systems, there is no requirement to segregate organic from inorganic waste streams, and there is no onsite treatment of aqueous wastes. No Change – all process wastewater from AR4 and AR5 will be collected for appropriate offsite treatment / disposal.

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Section 5.11	**Rainwater** BAT is to minimise pollution to receiving watercourses by applying all of the following measures: a. minimising the contamination of rainwater from activities carried out at the installation in particular by applying measures for reducing fugitive and diffuse emissions (see BAT 5.12 and BAT 5.13 and BAT 5.17). b. ducting and storing rainwater (see Section 4.7.4) expected to be contaminated from activities carried out at the installation and treating it if necessary. Other rainwater may be directly discharged (see Section 4.7.4). c. monitoring the discharge of this other rainwater as outlined in Section 4.7.4. Rainwater found to be contaminated is treated as in b. above (see Section 4.7.4). In some cases, the use of rainwater as process water to reduce fresh water consumption may be environmentally beneficial.	Yes	a) The only potential for rainwater to be contaminated is from the storage areas. Rainwater emanating from the storage areas is collected and analysed / tested prior to being discharged to the Billingham site drains. If contamination was evident in quantities greater than the discharge consent; then the effluent would be removed by an offsite waste contractor. In the event of contamination entering the drains there is some capability to divert effluent from the drain network to two effluent storage tanks (for quarantine) prior to removal by road tanker for off-site disposal. Diversion to the effluent tanks is dependent on pre-established trip limits for pH, ammoniacal nitrogen, nitrate or TOC. The diversion can also be facilitated by a manual intervention by the CF Fertilisers Shift Manager. b) The drum park is isolated from the connection to the Billingham site drainage system and if rainwater was found to be contaminated then it could be isolated and pumped out for offsite disposal as waste. Spillage (or small quantities of equipment washings) inside the buildings would be collected in a bund - with no connection to the external drainage system. Material would be removed to IBC for offsite disposal. Activity AR4 introduces a number of new bunded areas (scrubber, effluent tank, liquid ring buffer tank, new materials storage area) as well as a new tanker loading area, which is sloped with a sleeping policemen arrangement to prevent a major spillage overtopping and has a 1 m³ blind sump to collect spillages. Rainwater collecting in all of these areas will be tested prior to discharge to the site chemical drain. Should contamination be identified then the liquid will be removed for offsite disposal. There are no process emissions direct to receiving watercourses, and all other process activities are undertaken within a building with no direct route to drains or groundwater. No change for activities AR1 – AR4. Activity AR5 will introduce additional materials storage areas and a tanker loading / unloading area. All storage and containment areas will be isolated from the storm water systems with rainwater only being pumped out from the containment areas if it is found to be uncontaminated.
Section 5.12	**Diffuse Dust Emissions** For diffuse emissions, BAT is to minimise diffuse dust emissions where dust may arise (in particular from the storage and handling of materials/products) by applying one or more of the following techniques: a. storing materials in closed systems (e.g. silos, see Section 6.3.4.1). b. using covered areas protected from rain and wind (see Section 6.3.4.1). c. having production equipment, e.g. conveyors, totally or partially enclosed (see Section 2.2). d. having equipment designed with hooding and ducting to capture diffuse dust emissions (e.g. during loading into storage) and abating it (e.g. using a fabric filter, see Section 6.3.4.1). e. carrying out housekeeping regularly, e.g. by vacuuming (see Section 4.7.6).	Yes	a) The preference for feedstocks, intermediates and products is to be stored within the installation buildings with some waste materials being stored outside in either covered or uncovered locations in suitable sealed containers. b) Materials are stored mainly within the building and/or within sealed containers. c) Production equipment is largely enclosed. Powder additions are undertaken within dust booths with a pre filter and followed by two HEPA filters to minimise diffuse dust emissions; or HEPA protected mobile exhaust systems. Should the extraction system fail then a local alarm sounds in the down flow booth to alert the operator. The operators will then cease transfer operations until the air flow can be re-established. The transfer of powdered material is within a building and therefore diffuse emissions are minimised. d) Dust booths are in operation during transfers of powdered materials. e) Extensive housekeeping procedures are in place to ensure any spilt powders are vacuumed immediately. Specialist vacuum cleaners fitted with HEPA filters are used. Activity AR4 will also undertake all powder handling operations in dust booth with recirculating extraction systems installed with double HEPA filter protection. There will be no emission to atmosphere from this source. There is the limited potential for dust generation during vessel charging which is extracted via an extraction hood (primarily for Operator protection) to a wet chemical scrubber. The powders used at this stage of the process do not contain fine particles, and laboratory testing has shown that the materials present at this stage do not have PM_{10} or $PM_{2.5}$ present; hence the potential for dust generation at this stage is limited. Any larger particulates transferred to the scrubber would either be captured or be dissolved into the scrubber liquor. Dusts can also be generated by the dryer activities, and the extracted air is treated using a bag filter followed by double HEPA filtration, the extracted air is then fed into the wet chemical scrubber prior to discharge to atmosphere. All of the process activities will be undertaken within enclosed equipment within the Installation buildings building, hence the controls implemented for diffuse dust emissions are all representative of BAT, and there are not expected to be any diffuse dust emissions from the process. The expansion of activity AR2 and increase in throughput of AR4 will continue to apply the same controls as stated above. Powder handling operations are generally undertaken within dust booths that use a double

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			HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filter system and there are no releases via A13/A14/A15. The relocated ovens for AR1 (emission point A16) will perform at the same emission levels as discussed above. Activity AR5 will also apply appropriate controls to all dust handling activities through the use of dust booths / enclosures that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filtration system and there will be no releases of dusts to atmosphere. All of the process activities will be undertaken within enclosed equipment within the AR5 building, hence the controls implemented for diffuse dust emissions are all representative of BAT, and there are not expected to be any diffuse dust emissions from the process.
Section 5.13	**Fugitive Emissions** For diffuse emissions, BAT is to minimise fugitive gaseous and liquid emissions by applying (according to the substances that may require controlling) one or more of the following techniques: a. having periodic leak detection and repair programmes (see Sections 4.7.1 and 2.6.6). b. operating equipment at slightly below atmospheric pressure (see Section 6.3.4.16). c. replacing flanges by welded connections (see Section 2.6). d. using seal-less pumps and bellow valves (see Section 2.6). e. using high performance sealing systems (e.g. effective gaskets and flanges, valves and pumps with high integrity packing, see Section 2.6). f. carrying out housekeeping regularly (see Section 4.7.6).	Yes	The majority of the processes undertaken at the MSC and Pilot Plant are small scale R&D operations. Due to the small-scale nature, there is limited potential for fugitive losses of materials. However, the Installation does have control measure in place. a) Permitted operations are contained within the installation buildings. There is no connection to the external drainage system and any leaks would be apparent. The building is occupied on a regular basis and therefore leaks would be detected quickly. b) The MSC building has an extract system than generates a slight negative pressure. Any fugitive losses of dust would be captured in the building hygiene extraction / filtration system. c) Only small bore pipelines are used in the MSC and Pilot Plant however, the nature of the processes requires flexibility in the use of the various pieces of equipment. d) Seal-less pumps are used when it is appropriate to the materials being pumped. f) The site has extensive housekeeping procedures in place. To the extent that spillages in the MSC or pilot plant would be considered to be a minor incident and would be recorded and investigated as such. There is a defined programme of basic housekeeping audits and a series of high level audits undertaken at the site. No change associated with the introduction of activity AR4. The expansion of activity AR2 and increase in throughput of AR4 will continue to apply the same controls as stated above. Activity AR5 will involve larger volumes of liquids, but these will be processed within appropriately designed process equipment within the AR5 building and will be subject to similar controls to those applied at the MSC and pilot plant– no significant potential for fugitive emissions of gas or liquid is anticipated.
Section 5.14	**Computerised Control** For new installations BAT is to use a computerised control system to operate the plant (see Section 4.5.2). However, this does not apply where safety issues do not permit automatic operations (e.g. in the production of SIC explosives).	Not Applicable	Not applicable - existing installation. Also not applicable to R&D and small scale operations, which employ manually intensive operations. No change associated with the introduction of activity AR4. No Change to AR1 to AR4. The AR5 process will be batch based and subject to procedure based batch controls. Detailed design may incorporate some computerised controls, but at this stage of the design process it has not been decided.
Section 5.15	**Cleaning Systems** For installations where solid hazardous compounds can build up in pipelines, machines and vessels, BAT is to have in place a closed cleaning and rinsing system (see Section 4.5.1).	Not Applicable	The equipment used in MSC operations is small scale, typically in the litres or kilogram range. Closed cleaning and cleaning in place routines would not be applicable to such small equipment. No change associated with the introduction of activity AR4. No Change to AR1 to AR4. Activity AR5 may incorporate a closed cleaning and rinsing system for process vessel cleaning between campaigns.
Section 5.16	**Energy** BAT is to reduce the consumption of energy by optimising plant design, construction and operation, e.g. by using pinch methodology, except if safety issues prevent it (see Section 4.6.1).	Yes	The nature of R&D operations is to optimise the process prior to scale up and thereby minimise the consumption of energy prior to scale up.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
			The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management and continuous improvement. The site also operates to the JM Group Sustainability programme. Activities at the site level are fed into the JM Group that monitors and publishes progress against each of the goals. The programme includes items such as waste minimisation, increasing recycling, water usage, energy minimisation, efficient use of raw materials etc. These systems, along with the JM Energy Policy, require energy to be managed and minimised as far as possible. The Johnson Matthey Group has a target of reducing greenhouse gas emissions per unit of production by 25% by 2025 for a 2016 to 2017 baseline. Equipment used in the MSC and pilot plant tends to be relatively new and replaced on a regular basis and thereby tends to be the most up to date and efficient as possible. No change associated with the introduction of activity AR4 process. Where possible, new equipment (e.g. the dryer) has been purchased to high energy efficiency standards. The new equipment proposed for Activities AR2 and AR5 will all be selected with due consideration of energy efficiency, and the detailed design process for activity AR5 will include consideration of energy use optimisation.
Section 5.17	**Cross Boundary Techniques** BAT is to minimise soil and groundwater pollution by designing, building, operating and maintaining facilities, where substances (usually liquids) which represent a potential risk of contamination of ground and groundwater are handled, in such a way that material escapes are minimised (see Section 4.7.1). This includes all of the following: a. having facilities sealed, stable and sufficiently resistant against possible mechanical, thermal or chemical stress. This is particularly important for highly toxic substances – e.g. cyanides, phosphorus compounds. b. providing sufficient retention volumes to safely retain spills and leaking substances in order to enable treatment or disposal. c. providing sufficient retention volume to safely retain firefighting water and contaminated surface water. d. carrying out loading and unloading only in designated areas protected against leakage run-off. e. storing and collecting materials awaiting disposal in designated areas protected against leakage run-off. f. fitting all pump sumps or other treatment plant chambers from which spillage might occur with high liquid level alarms or having pump sumps regularly inspected by personnel. g. establishing programmes for testing and inspecting tanks and pipelines including flanges and valves. h. providing spill control equipment, such as containment booms and suitable absorbent material. i. testing and demonstrating the integrity of bunds. j. equipping tanks with overfill prevention. k. storing materials/products in covered areas to keep rainfall out.	Yes	a) The majority of materials are stored within the Installation buildings in sealed containers. There are no connections to sewer from the buildings. The whole floor in the MSC and pilot plant is epoxy coated to prevent any ingress of materials to ground. No solvents are used on the site. Any spilled materials would be isolated and cleaned up within the building. Specialist vacuums are available for cleaning up powder spills. b) Materials that are stored outdoors are again stored in sealed containers and IBC's. The drum storage area is isolated from the drains and spillages would be retained and collected for disposal. Some materials are stored undercover and on portable bunds. c) Appropriate design and management actions should allow the early detection of and minimise the risk of fire spreading and thereby minimise the generation of fire water. d) Materials are transported and stored in sealed containers. Powders are transferred in dust booths with double HEPA filters to prevent diffuse emissions. The majority material transfers are undertaken within the MSC and pilot plant buildings that does not have a connection to the Billingham external drainage system (isolated hydraulically). e) Materials are stored indoors, in the drum park that has drainage isolation or on portable bunds. These measures provide adequate retention against material losses to ground. f) Not applicable, the volume of the building sumps is greater than the volume of an IBC which is the maximum storage volume onsite. Sumps are inspected and analysed prior to being pumped out. The sumps are isolated and require pumping to the Billingham site drains. Loading and unloading operations are fully attended. g) The site has an extensive planned preventative maintenance system. Some vessels (glass and pressure vessels) are tested on a routine basis. CCTV inspections of the drainage system are also undertaken. h) Spill kits are located at strategic locations on the site. Spillages of powdered material are retained within the building and vacuumed using specialist equipment. i) Sumps have a three year test involving hydraulic testing and visual checks. j) There are no bulk storage tanks on site and vessels are small scale. k) The majority of materials are stored indoors. Some IBCs are stored externally undercover. Only a limited amount of sealed containers are stored without cover. The AR4 process introduces a number of new potential areas where sources of contamination may be present (scrubber, effluent tank, liquid ring buffer tank, new covered materials storage area) as well as a new tanker loading area. All of these areas are appropriately bunded or provided with appropriate containment provisions to contain a loss and prevent contamination reaching soil, groundwater or surface watercourses. Rainwater collecting in all of these areas will be tested prior to discharge to the site chemical drain. Should contamination be identified then the liquid will be removed for offsite disposal. The same controls applied to the rest of the installation apply to Activity AR4.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
			All of the proposed changes under this variation will include the provision of suitable measures to contain potential losses of contamination, with scheduled maintenance and inspection being undertaken of all plant and containment infrastructure. The new plant areas will be operated in line with the BAT requirements.
Section 5.18	**Education and Training** BAT is to have a high level of education and continuous training of personnel (see Section 4.7.2). This includes all of the following: a. having personnel with sound basic education in chemical engineering and operations. b. continuously training plant personnel on the jobs. c. regularly evaluating and recording the performance of personnel. d. regularly training personnel on how to respond to emergency situations, health and safety at work, and on product and transportation safety regulations.	Yes	The workforce is highly skilled with qualified chemists, mechanical engineers, chemical engineers and experienced operational staff involved in the process designs. Due to the specialist nature of the equipment, training is provided prior to operators being able to use it. Personnel must demonstrate competence prior to being unsupervised. SHE procedures and training are provided. Operators are trained in spill control and clear up procedures. Designated personnel (on call) that can respond to all foreseeable incidents (Incident Controllers) are in place. Risk assessments are undertaken prior to any reactions being undertaken on site and to ensure safe operation. Emergency simulations are undertaken periodically. Mandatory training is provided for all site personnel. Personal development plans for current and future jobs are in place for site personnel. No change associated with the introduction of the AR4 activity. Additional workforce competence and training needs will be identified and applied prior to operation of Activity AR4. No Change
Section 5.19	**Industry Codes** BAT is to apply, if available, the principles of an Industry Code (see Section 4.7.3). This includes all of the following: a. applying very high standards for safety, environmental and quality aspects in the production of the SIC substances. b. carrying out activities such as auditing, certification, training of plant personnel (related to BAT number 5.18 and 5.22).	Yes	The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management. The Johnson Matthey Group has very high standards for safety, environmental and quality. These are published on the company website. JM Group EHS team undertake 3 yearly audits of Environment Health and Safety (EHS) operating systems and procedures on site. The site is ranked highly within the business. The site also has procedures for corrective actions to ensure all findings are addresses. No change associated with the introduction of activity AR4. No Change
Section 5.20	**Safety Assessments** BAT is to carry out a structured safety assessment for normal operation and to take into account effects due to deviations of the chemical process and deviations in the operation of the plant (see Section 4.7.5).	Yes	HAZOPs are undertaken for any new processes. Process Hazards Reviews (PHR) are undertaken every 5 years. This considers failure modes and abnormal operating conditions. Risk assessments are undertaken for any new processes or materials. Management of Change (MoC) processes are in place and reviewed prior to any new introductions. This takes into account process emissions and wastes. COSHH assessments are also undertaken. No change associated with the introduction of activity AR4. No Change
Section 5.21	**Process Control** In order to ensure that a process can be controlled adequately, BAT is to: apply one individual or a combination of the following techniques (without ranking, see Section 4.7.5): a. organisational measures. b. concepts involving control engineering techniques. c. reaction stoppers (e.g. neutralisation, quenching). d. emergency cooling. e. pressure resistant construction.	Yes	The small-scale nature of process operations and the nature of the materials does not result in runaway reactions. Reactions stoppers and emergency cooling are not required. The thermal processing equipment would simply be turned off and allowed to cool. Scale up documents are generated as a result of R&D operations and include assessments that cover the heat of reaction etc. TGA assessments (in the analytical laboratories and at small scale) are undertaken to assess the process and emissions. Risk assessments are undertaken for all processes. Reactions are very well characterised including lab scale investigation, analytical analysis, calorimetry etc.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
	f. pressure relief.		No change associated with the introduction of activity AR4. The wet chemistry and precipitation phases of the process are controlled by the rate of addition of key materials and the dryer operation can be turned off and allowed to cool. Appropriate automated control loop and manual control systems are in place to ensure the safe operation of the process. No Change resultant for the proposed changes to AR1 to AR4. The reaction phases associated with Activity AR5 are controlled by the rate of addition of key materials and are not likely to lead to uncontrolled reaction. The Control systems for activity AR5 will be confirmed as part of the detailed design.
Section 5.22	**Environmental Management Systems** BAT is to implement and adhere to an Environmental Management System (EMS) that incorporates, as appropriate to individual circumstances, the following features (see Section 4.7.6): a. definition of an environmental policy for the installation by top management (commitment of the top management is regarded as a precondition for the successful application of other features of the EMS). b. planning and establishing the necessary procedures. c. implementation of the procedures, paying particular attention to: • structure and responsibility. • training, awareness and competence. • communication. • employee involvement. • documentation. • efficient process control. • maintenance programmes. • emergency preparedness and response. • safeguarding compliance with environmental legislation. d. checking performance and taking corrective action, paying particular attention to: • monitoring and measurement (see also the Reference Document on General Principles of Monitoring). • corrective and preventive action. • maintenance of records. • independent (where practicable) internal auditing in order to determine whether or not the environmental management system conforms to planned arrangements and has been properly implemented and maintained . e. review by top management. f. having the management system and audit procedure examined and validated by an accredited certification body or an external EMS verifier. g. preparation and publication (and possibly external validation) of a regular environmental statement describing all the significant environmental aspects of the installation, allowing for year-by-year comparison against environmental objectives and targets as well as with sector benchmarks as appropriate. h. implementation and adherence to an internationally accepted voluntary system such as EMAS and EN ISO 14001:1996. This voluntary step could give higher credibility to the EMS. In particular EMAS, which embodies all the above mentioned features, gives higher credibility. However, non-standardised systems can, in principle be equally effective provided that they are properly designed and implemented. Specifically for the SIC sector, it is also important to consider the following potential features of the EMS: i. the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant. j. the development of cleaner technologies. k. where practicable, the application of sectoral benchmarking on a regular basis, including energy efficiency and energy conservation activities, choice of input materials, emissions to air, discharges to water, consumption of water and generation of waste.	Yes	The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management. The EMS includes all the requirements specified in a – k. No change associated with the introduction of activity AR4 No Change

Table 2: Additional Guidance for the Inorganic Chemicals Sector (EPR 4.03) March 2009

BAT No.	BAT Justification	Operating to BAT	Operator Comments
1.1	**Environmental Performance Indicators** Monitor and benchmark your environmental performance, and review this at least once a year. Your plans for minimising environmental impacts should be incorporated into on-going Improvement Programmes. Indicators can be derived using the Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1). It is suggested that indicators are based on tonnes of inorganics produced (tOP) as they provide a good basis for measuring performance within an installation or a single company year on year.	Yes	The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management. The site operates under the JM Group Sustainability programme. There are a number of key performance indicators that are measured for the business as a whole. The programme includes items such as waste minimisation, increasing recycling, water usage, energy minimisation, efficient use of raw materials etc. The goals are published on the JM website. No change associated with the introduction of activity AR4. No Change.
1.2	**Accident Management** Provisions in place for accident management.	Yes	The site maintains an Accident Management Plan (AMP) in line with the site's Environmental Permit. This has been reviewed as a consequence of the introduction of the new process. There are also site emergency response procedures including “Actions in the Event of a Chilton Site Emergency” and “Emergency Planning and Response”. Emergency simulations are undertaken periodically. No change associated with the introduction of activity AR4. The accident risks associated with Activity AR4 will be incorporated into the existing systems and assessments. No Change - The accident risks associated with Activity AR5 will be incorporated into the existing systems and assessments.
1.3	**Energy Management** Optimise energy efficiency.	Yes	The nature of R&D operations is to optimise the process prior to scale up and thereby minimise the consumption of energy in the scale up. The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management and continuous improvement. The site also operates to the JM Group Sustainability programme. Activities at the site level are fed into the JM Group that monitors and publishes progress against each of the goals. The programme includes items such as waste minimisation, increasing recycling, water usage, energy minimisation, efficient use of raw materials etc. These systems, along with the JM Energy Policy, require energy to be managed and minimised as far as possible. The Johnson Matthey Group has a target of reducing greenhouse gas emissions per unit of production by 25% by 2025 against a 2016 to 2017 baseline. Equipment used in the MSC and Pilot Plant tends to be relatively new and replaced on a regular basis and thereby tends to be the most up to date and efficient as possible. No change associated with the introduction of activity AR4. Where possible, new equipment (e.g. the dryer) has been purchased to high energy efficiency standards. The new equipment proposed for Activities AR2 and AR5 will all be selected with due consideration of energy efficiency, and the detailed design process for activity AR5 will include consideration of energy use optimisation.
1.4	**Efficient Use of Raw Materials** Assess the environmental impact of each process and choose the one with the lowest environmental impact. As a general principle, you need to demonstrate the measures you take to: • reduce your use of all raw materials and intermediates. • substitute less harmful materials, or those which can be more readily abated and when abated lead to substances that are more readily dealt with. • understand the fate of by-products and contaminants and their environmental impact.	Yes	The purpose of the R&D operations at the site is to optimise the process prior to scale up and hence ensure efficient use of raw materials at full scale. The products that JM generate enable their customers to achieve high rates of process efficiency. Activity AR4 uses high quality feedstocks are used to avoid the generation of by-products, and the processes applied are expected to achieve extremely high yields. Raw materials and products within extracted air streams are captured (bag and HEPA filters) and returned to the process where possible. Solids are also returned into the process from wet chemistry phases of the process to optimise yield and minimise raw materials use. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of materials, but will not alter the yields or efficiencies – These activities will continue to run on a pre-planned campaign basis. New Activity AR5 will be designed to optimise yield where possible and to use less harmful materials where possible.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
1.5	**Avoidance, Recovery Disposal of Wastes** 1. Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system. 2. Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances. 3. Use cleaning techniques that reduce the quantity of water needed. 4. Establish opportunities for reuse using pinch analysis.	Yes	The processes are small scale R&D with only small quantities of waste generated per year. Due to the need for flexible unit operations it is difficult to recover heat from the processes. The processes are also too small or too short term to facilitate recovery operations. Water is not in direct contact with process materials. Small vessels are not suitable for cleaning in place systems and the cleaning generates only low volumes of liquid effluent. No change associated with the introduction of activity AR4. The changes proposed to activities AR1 – AR4 will not lead to any change. The increase in capacity of activity AR2 and AR4 to <60 tonnes per annum, will lead to greater throughput of materials, but will not alter the yields or efficiencies. New Activity AR5 will be designed to use high purity feedstocks where possible, and to optimise the leaching and separation / recovery processes during detailed design and initial commissioning to optimise yield and minimise waste. The process will be operated on a product campaign basis to minimise losses associated with cleaning, and hence minimise waste. Activity AR5 may incorporate a closed cleaning and rinsing system for process vessel cleaning between campaigns. There are no water based cooling systems within the process.
1.5	**Avoidance, Recovery Disposal of Wastes** 1. Demonstrate that the chosen routes for recovery or disposal represent the best environmental option. Consider avenues for recycling back into the process or reworking for another process wherever possible. 2. Where you cannot avoid disposing of waste, provide a detailed assessment identifying the best environmental options for waste disposal.	Yes	The existing processes are small scale and short duration operations. This makes it difficult to identify routes to recover, reuse or recycle materials. Where the process uses precious metals, these are refined (off-site) and reused where possible. For the new processes, the use of recovered materials would present quality risks for high purity products. However, the process is very efficient with no normal / routine solid or liquid waste streams. Wastes are disposed of using approved waste disposal contractors. JM works with the contractors to identify the best environmental option for wastes. However, the scale of operations makes it difficult to identify routes for reuse or recycling of materials. Activity AR4 uses high quality feedstocks are used to avoid the generation of by-products, and the processes applied are expected to achieve extremely high yield. Raw materials and products within extracted air streams are captured (bag and HEPA filters) and returned to the process where possible. Solids are also returned into the process from wet chemistry phases of the process to optimise yield and minimise raw materials use. There will be and aqueous waste stream, which will result from the process, however the generation of this waste stream is an inherent characteristic of the reaction processes and cannot be further minimised. This aqueous waste will be sent offsite for treatment /disposal, but given the nature of the effluent and the scale of operations, opportunities for offsite reuse / recycling are limited. The changes proposed to activities AR1 – AR4 will not lead to any change. All process wastewater from AR4 and AR5 will be collected for appropriate offsite treatment / disposal. Other site wastes will be managed in accordance with the site waste management procedures which will include the periodic review of waste disposal options to priorities recycling where possible through application of the waste hierarchy. As noted above, the process activities at the installation are used to produce high quality products which have limited tolerances for impurities, so in many cases in-process recycling is not possible.
2.1	**Design of a new process** 1. Consider all potential environmental impacts from the outset in any new project for manufacturing chemicals. 2. Undertake the appropriate stages of a formal HAZOP study as the project progresses through the process design and plant design phases. The HAZOP studies should consider amongst other things the points noted above.	Yes	Prior to new processes being introduced, a full 'ICI-Style 6 Stage Hazard Study Process" is undertaken. The study initially looks at the conceptual level all the way to full detail level, and then reviews commissioning and operation. Environmental impacts are considered using the new product introduction process and management of change procedures. Emissions and wastes are minimised as far as practicable. Yields are typically greater than 90% for the site processes. No change associated with the introduction of activity AR4 – the process design has been reviewed using the HAZOP process, and all environmental implications have been reviewed and appropriate control or mitigation measures applied. The changes proposed to activities AR1 – AR4 will not lead to any change. The detailed process design of Activity AR5 will include safety reviews using a full 'ICI-Style 6 Stage Hazard Study Process" which will include consideration of all environmental implications and the implementation of appropriate control or mitigation measures applied.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
2.2	**Storage and handling of raw materials, products and wastes** 1. Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions. 2. Vent storage tanks to a safe location. 3. Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels. 4. Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place.	Yes	The inorganic materials that are used are relatively stable (air stable, temperature stable) therefore preventative measures are unnecessary. Bulk storage tanks are not used. Solvents are not used in the processes. HAZOPs are carried out where appropriate. Risk assessments are in place for all new materials introduced to the site. The quantities of materials stored on site are minimised. No change associated with the introduction of activity AR4– the process design has been reviewed using the HAZOP process, and materials storage and handling aspects considered. The changes proposed to activities AR1 – AR4 will not lead to any change. The detailed process design of Activity AR5 will include safety reviews using a full 'ICI-Style 6 Stage Hazard Study Process" which will include consideration of all environmental implications and the implementation of appropriate control or mitigation measures applied. All bulk storage tanks for AR5 will be provided with suitable secondary containment bunds with sufficient capacity to prevent a loss in the event of a primary tank failure and provide an impermeable barrier to pollution of soil or groundwater. All bulk storage tanks will be provided with suitable tank instrumentation which will be specified following completion of a quantified risk assessment (LOPA) to ensure risk of tank overfill is adequately controlled. This expected to include multiple independent level monitoring devices with alarms and/or trip functionality.
2.3	**Plant systems and equipment** 1. Formally consider potential emissions from plant systems and equipment and have plans and timetables for improvements, where the potential for substance or noise pollution from plant systems and equipment has been identified. 2. Carry out systematic HAZOP studies on all plant systems and equipment to identify and quantify risks to the environment. 3. Choose vacuum systems that are designed for the load and keep them well maintained. Install sufficient instrumentation to detect reduced performance and to warn that remedial action should be taken.	Yes	Thermalgravimetric Analysis (TGA) analysis is undertaken for new materials to be introduced. This provides accurate information on the expected emissions profile. HAZOPs and Process Hazard Reviews are undertaken. No change associated with the introduction of activity AR4– the process design has been reviewed using the HAZOP process, emissions from Activity AR4 have been calculated, control and abatement options have been specified e.g. bag filters, HEPA filters, wet chemical scrubber, and the potential environmental impacts assessed and confirmed to not have significant environmental implications. The changes proposed to activities AR1 – AR4 will not lead to any change. The detailed process design of Activity AR5 will include safety reviews using a full 'ICI-Style 6 Stage Hazard Study Process" which will include consideration of all environmental implications and the implementation of appropriate control or mitigation measures applied. Plant emissions have been assessed using atmospheric dispersion modelling which has demonstrated that no significant environmental impact will occur. No significant changes to noise profile are anticipated as a result of the introduction of the new processes. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. All process operations are undertaken within buildings which minimises the potential for noise nuisance at nearby receptors. Process equipment will be selected to avoid the need for hearing protection for employees working within the buildings. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). For activity AR5, all equipment with the potential to producing noise will be selected to not exceed the limit of 80 dBA at 1 m, with the exception of housed compressors which may have noise levels <90 dBA at 1 m. It is likely that the briquette grinding area will exceed this noise limit, hence as part of the design process, options to contain and attenuate the noise generated by the grinding systems will be investigated so as to minimise the potential for offsite nuisance e.g. location within an acoustic enclosure or room. The site has not received any justifiable noise complaints in relation to the permitted activities, and through the application of appropriate design and specification of plant supported by scheduled maintenance and other site management controls, no significant noise impacts are anticipated.
2.4	**Plant systems and equipment Over Pressure** 1. Carry out a systematic HAZOP study for all relief systems, to identify and quantify significant risks to the environment from the technique chosen. 2. Identify procedures to protect against overpressure of equipment. This requires the identification of all conceivable over-pressure situations, calculation of relief rates, selection of relief method, design of the vent system, discharge and disposal considerations, and dispersion calculations. In some cases careful design can provide intrinsic protection against all conceivable over-pressure scenarios, so relief systems and their consequential emissions can be avoided. 3. Maintain in a state of readiness all equipment installed in the venting system even though the system is rarely used.	Not Applicable	No liquid vapour separations undertaken. Activity AR4 is undertaken at atmospheric pressure, there are no pressure vessels associated with the process, and no risk of runaway reactions. The process has been reviewed using the HAZOP methodology which has considered overpressure risks and no significant risks exist. The changes proposed to activities AR1 – AR4 will not lead to any change. The detailed process design of Activity AR5 will include safety reviews using a full 'ICI-Style 6 Stage Hazard Study Process" which will include consideration of all potential overpressure scenarios and the implementation of appropriate control or mitigation measures applied. However, the reaction phases associated with Activity AR5 are controlled by the rate of addition of key materials and are not likely to lead to uncontrolled reaction.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
2.5	**Separation Stage - Liquid-Vapour Separations** 1. Choose your separation technique following a detailed process design and HAZOP study. Follow formal operating instructions to ensure effective separation and minimisation of losses. Adhere to design conditions such as heat input, reflux flows and ratios, etc. 2. Install instrumentation to warn of faults in the system, such as a temperature, pressure or low coolant-flow.	Not Applicable	No liquid vapour separations undertaken. No change associated with the introduction of activity AR4. No Change – no liquid - vapor separation to be undertaken as part of the proposed changes.
2.5	**Liquid-Vapour Separations** 1. Use techniques which maximise physical separation of the phases (and also aim to minimise mutual solubility) where practicable. 2. When the phases are separated, use techniques which prevent (or minimise the probability and size of) breakthrough of the organics phase into a waste-water stream. This is particularly important where the environmental consequences of subsequent releases of organics to air or into controlled waters may be significant (e.g. where the effluent is treated in a DAF unit or some of the organic components are resistant to biological treatment). 3. When a separation is done by hand, use a "dead man's handle", backed-up by good management, to improve the chance of the flow being properly controlled as the phase-boundary approaches. 4. Consider if automatic detection of the interface is practicable. 5. Where you are discharging to drain, consider whether there should be an intermediate holding or "guard" tank to protect against accidental losses from the organics phase.	Not Applicable	No liquid separations undertaken. No change associated with the introduction of activity AR4. No Change – no liquid - vapor separation to be undertaken as part of the proposed changes.
2.5	**Solid-Vapour Separations** 1. Use techniques to minimise, re-use and/or recycle rinse water, and to prevent breakthrough of solids. 2. Install instrumentation or other means of detecting malfunction as all of the techniques are vulnerable to solids breakthrough. 3. Consider installing "guard" filters of smaller capacity downstream which, in the event of breakthrough, rapidly 'clog' and prevent further losses. 4. Have good management procedures to minimise loss of solids, escape of volatiles to air and excessive production of waste water.	Yes	The activities in the MSC are R&D operations have the aim of optimising the processes prior to going to full scale at other facilities. Standard filtration techniques are used and the nature of the process operations is small scale and short duration, which do not lead to breakthrough and breakdown etc. Should these occur; the materials would simply be collected to be reprocessed. Activity AR4 includes a dryer which is used to dry the product i.e. removing water. The air from the dryer is extracted via a bag filter followed by double HEPA filtration, the extracted air is then fed into the wet chemical scrubber prior to discharge to atmosphere. These systems allow recovery of particulate materials into the process and prevent particulate emissions to air. The filtration systems are installed with pressure differential monitoring which will alarm on blockage or failure of the filtration systems. The changes proposed to activities AR1 – AR4 will not lead to any change. No solid vapour separations are proposed as part of activity AR5.
2.6	**Purification Stage - Purification of Liquid Products** Liquid products are usually refined by distillation, with filtration used to remove solid contaminants. Sources of loss are: • gas entrainment. • ineffective separation. • filtration.	Not applicable	No liquid products. No change associated with the introduction of activity AR4 The changes proposed to activities AR1 – AR4 will not lead to any change. AR5 will include a solids separation process via filtration. Solvent Separation and ion exchange will also be used within activity AR5, and will used to separate impurities from the product. The purification methods have been selected to achieve high quality product requirements and to selectively target the removal of specific impurities.
2.6	**Purification of Solid Products** Washing and crystallising activities have the potential to produce large volumes of dilute liquors so counter-current systems should be used wherever possible. During drying, you should aim to produce the maximum concentration of solvent in the gas to allow recovery of the solvent. The use of vacuum can improve both solvent recovery and energy efficiency.	Yes	Washing of products is required to achieve required purity. However, the processes are small scale and do not generate large volumes of liquid effluent. Small scale operations are not conducive to counter current flow and rinse water reuse. Organic solvents are not used on site. No change associated with the introduction of activity AR4. There are no product washing activities in Activity AR4, and no organic solvents are used in the process.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
			No Change – no product washing is undertaken as part of the proposed changes.
2.7	**Chemical Process Controls** 1. Monitor the relevant process controls and set with alarms to ensure they do not go out of the required range.	Yes	Processes are small scale and short duration. The processes are attended by site personnel that monitor process conditions carefully. Due to the nature of operations it is not applicable to install process alarms. The drying and calcining operations however do have pre-set controls. No change associated with the introduction of activity AR4. Condition monitoring control loops are installed where appropriate and will initiate an alarm when levels outwith the desired parameters are experienced. The changes proposed to activities AR1 – AR4 will not lead to any change. Activity AR5 processes are anticipated to include control and monitoring systems with pre-set alarms and control loops. These specific systems will be developed during detailed design of the plant.
2.8	**Analysis** 1. Analyse the components and concentrations of by products and waste streams to ensure correct decisions are made regarding onward treatment or disposal. Keep detailed records of decisions based on this analysis in accordance with management systems.	Yes	Data is retained. No change associated with the introduction of activity AR4. No Change.
3.1	**Point source emissions to air** 1. Formally consider the information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (see Reference 1, Annex 2) as part of the assessment of BAT for point-source releases to air, in addition to the information in this note. 2. The benchmark values for point source emissions to air listed in Annex 1 should be achieved unless we have agreed alternative values. 3. Identify the main chemical constituents of the emissions, including VOC speciation where practicable. 4. Assess vent and chimney heights for dispersion capability. Benchmarks: Ammonia 10 - 50 mg/m^3 Nitrogen Oxides (as NO_2) 50 - 200 mg/m^3 Particulate Matter 5 - 20 mg/m^3	Yes	The emissions to air from the site are expected to meet the benchmarks presented in the CWW BREF. No formal monitoring has been undertaken at the site. However, TGA analysis of process is undertaken prior to introducing them on the site. This analysis enables the emission profiles to be quantified. The benchmarks that relate to the site are Nitrogen Oxides, Ammonia and Particulate Matter. Emissions of NOx are managed through internal management controls. Existing batch ovens are sequenced such that peaks of emissions do not coincide. For the existing processes, the site has an internal limit for NOx (as NO_2) of 113 mg/m^3 and for the new processes the emissions will be managed such that the emission benchmark of 200 mg/m^3 will be achieved using management procedures and physical controls (i.e. limiting the size of the trays such that the quantity of material processed cannot physically emit >200 mg/m^3 NOx) Emissions of ammonia result from the use of equipment that uses tiny quantities of ammonia in the formulation. This results in only trivial quantities of ammonia that are significantly below the emission benchmarks and have been shown to be “insignificant” using the H1 risk assessment tool. Management controls are in place to limit the emissions of particulate matter. Batch ovens (which potentially emit via either A1/A2/A3 or A9/A10/A11) are considered to be low risk operations (in respect of dust emissions) because a static bed of powder is subject only to minimal disturbance The batch ovens that vent to A1/A2/A3 contain powder in covered trays and the only gas flow around the oven is caused by the circulating fan within the oven. There is limited potential for emissions of particulate matter from this system. The batch ovens that vent to A9/A10/A11 contain powder in open trays and these ovens have a gas injection system to maintain a controlled atmosphere for product treatment. Furthermore, the nature of the material that is to be processed in these ovens means that estimates foresee particulate release occurring principally during a relatively short time period (of one hour) during a 20 hour batch treatment cycle. . A programme of testing was completed in 2018 to assess the typical levels of entrainment of powder from a typical batch furnace. This assessment was completed in the new facility, using a furnace which includes gas injection, using a fine powder and using a tray with no lid. This programme of testing demonstrated that the emissions of dust to atmosphere from the batch ovens (A9/A10/A11) are insignificant with emissions levels from all vents are expected to be <1 mg/m^3. Emissions of particulate from the batch ovens using covered product trays (A1/A2/A3) are therefore expected to be at even lower levels than those monitored for A9 – A11. Hence, there is no particulate abatement system downstream of the batch ovens as the emissions are expected to meet the emission benchmarks stated in the guidance. Emissions from a continuous kiln that moves product in trays through a heated zone (and which feeds into emission points A9/A10/A11) are controlled via the use of HEPA filters. Further existing operations have the potential to emit small quantities of particulate matter to A5, A6 and A8. Equipment relating to these emission points all vent via a HEPA filtration system and calculations have demonstrated that emissions are negligible. The emissions to air from activity AR4 via emission point A12 are expected to comply with the published BAT emission levels. • Ammonia will be at or below 1mg/m^3. • Emissions of Particulates are not expected and will be below the BAT range of 5 – 20 mg/m^3.

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			The potential environmental impacts of the emissions via A12 have been reviewed using the H1 assessment tool and have been demonstrated as not leading to any significant impact. The changes proposed to activities AR1 – AR4 will not lead to any change with existing permit emission limits being complied with. The AR5 activities will lead to new emission points and emissions, but all will comply with emission benchmarks. Plant emissions have been assessed using atmospheric dispersion modelling which has demonstrated that no significant environmental impact will occur.
3.2	**Point source emissions to water** 1. Control all emissions to avoid a breach of water quality standards as a minimum. Where another technique can deliver better results at reasonable cost it will be considered BAT and should be used. 2. Use the following measures to minimise water use and emissions to water: • Where water is needed for cooling, minimize its use by maximising heat transfer between process streams. • Use water in recirculating systems with indirect heat exchangers and a cooling tower rather than a once through system. (A water make-up treatment plant and a concentrated purge stream from the system to avoid the build up of contaminants are likely to be necessary). • Leaks of process fluids into cooling water in heat exchangers are a frequent source of contamination. Monitoring of the cooling water at relevant points should be appropriate to the nature of the process fluids. In a re-circulatory cooling system, leaks can be identified before significant emission to the environment has occurred. The potential for environmental impact is likely to be greater from a once through system. Planned maintenance can help to avoid such occurrences. • Strip process liquor and treat if necessary, then recycle/reuse. • Use wet air oxidation for low volumes of aqueous effluent with high levels of organic content, such as waste streams from condensers and scrubbers. • Neutralise waste streams containing acids or alkalis to achieve the required pH for the receiving water. • Strip chlorinated hydrocarbons in waste streams with air or steam and recycle by returning to process where possible. • Recover co-products for re-use or sale. • Periodically regenerate ion exchange columns. • Pass waste water containing solids through settling tanks, prior to disposal. • Treat waste waters containing chlorinated hydrocarbons separately where possible to ensure proper control and treatment of the chlorinated compounds. Contain released volatile chlorinated hydrocarbons and vent to suitably designed incineration equipment. • Non-biodegradable organic material can be treated by thermal incineration. However, the thermal destruction of mixed liquids can be highly inefficient and the waste should be dewatered prior to incineration.	Yes	The site does not discharge process generated effluent to the Billingham site effluent drainage system and does not have an effluent treatment plant. All liquids associated with processing are collected in IBC's and removed from the site by a licenced waste disposal contractor for offsite disposal. Consequently process effluents are not discharged to controlled waters. The site does however discharge some process washi waters (i.e. filter cake washings) to the effluent drainage system which is discharged to the Tees via RT01. This is a discharge point that is managed by CF Fertilisers and both JM and Fuji discharge through this point which allows for significant dilution. It should be recognised that the quantity of wash waters sent to the effluent drainage system (and hence RT01) is small; for example only ~23 wash water IBC's were discharged to drain in 2017. This is the total sum of discharges from R&D activities (which form the bulk of operations) and a small number of commercial manufacturing campaigns. Discharges to the chemical drain are undertaken in compliance with the CF Fertilisers discharge consent "Billingham Site Effluent Agreement: RT01/INTCON/3/C". The site has an internal limit that requires any effluent to meet the emission limit values at the discharge point and does not rely on any dilution taking place within the drainage system. Effluent is pH adjusted if necessary prior to discharge, no other treatment is undertaken. The dilution from rainwater and the effluent from the adjacent manufacturing sites (Fuji Films) will also afford significant dilution prior to discharge to the River Tees. A risk assessment (H1) based on the worse case effluent without dilution was undertaken and showed the impact of the site's effluent to be "insignificant". No change associated with the introduction of activity AR4. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence Activity AR4 does not discharge into either site or municipal drainage systems, and there is no onsite treatment of aqueous wastes. The changes proposed to activities AR1 – AR4 will not lead to any change. All aqueous wastes generated by Activity AR5 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence Activity AR5 does not discharge into either site or municipal drainage systems, and there is no onsite treatment of aqueous wastes.
3.3	**Point source emissions to land** 1. Use the following measures to minimise emissions to land: • Use settling ponds to separate out sludge (Note: Sludge can be disposed of to incinerator, encapsulation, land or lagoon depending upon its make up.) • Chlorinated residues should be incinerated and not released to land. (Chlorinated hydrocarbons are not to be released to the environment due to their high global warming and ozone depletion potentials). • Either recycle off specification product into the process or blend to make lower grade products where possible. • Many catalysts are based on precious metals and these should be recovered, usually by return to the supplier.	Not Applicable	There are no point source emissions to land for site operations. No change associated with the introduction of activity AR4. No Change.
3.4	**Fugitive emissions – to Air** 1. Identify all potential sources and develop and maintain procedures for monitoring and eliminating or minimising leaks. 2. Choose vent systems to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment.	Not Applicable	No storage tanks. No solvents used. All of the process activities (including powder and product handling) will be undertaken within enclosed equipment within the Installation buildings, The enclosed process systems are all linked into an air extraction system such that they are all under slight negative pressure such that diffuse emissions from the process should not occur. Hence the controls implemented for diffuse dust emissions are all representative of BAT, and there are not expected to be any diffuse dust emissions from the process.

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	3. Use the following techniques (together or in any combination) to reduce losses from storage tanks at atmospheric pressure: • maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc. • tank paint with low solar absorbency. • temperature control. • tank insulation. • inventory management. • floating roof tanks. • bladder roof tanks. • pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations. • specific release treatment (such as adsorption condensation).		The changes proposed to activities AR1 – AR4 will not lead to any change. The statement above also applies to activity AR5.
3.4	**Fugitive Emissions to Surface Water, Sewer and Groundwater** 1. Provide hard surfacing in areas where accidental spillage or leakage may occur, e.g. beneath prime movers, pumps, in storage areas, and in handling, loading and unloading areas. The surfacing should be impermeable to process liquors. 2. Drain hard surfacing of areas subject to potential contamination so that potentially contaminated surface run-off does not discharge to ground. 3. Hold stocks of suitable absorbents at appropriate locations for use in mopping up minor leaks and spills, and dispose to leak-proof containers. 4. Take particular care in areas of inherent sensitivity to groundwater pollution. Poorly maintained drainage systems are known to be the main cause of groundwater contamination and surface/above-ground drains are preferred to facilitate leak detection (and to reduce explosion risks). 5. Additional measures could be justified in locations of particular environmental sensitivity. Decisions on the measures to be taken should take account of the risk to groundwater. 6. Surveys of plant that may continue to contribute to leakage should also be considered, as part of an overall environmental management system. In particular, you should consider undertaking leakage tests and/or integrity surveys to confirm the containment of underground drains and tanks.	Yes	The majority of the processes undertaken at the MSC are small scale R&D operations. Due to the small scale nature, there is limited potential for significant fugitive losses of materials. However, the MSC and the Pilot Plant do have control measure in place. 1) The MSC and Pilot Plant building floors have an epoxy coating to prevent any ingress of materials into the ground. The majority of materials are stored inside the Installation buildings. However, where materials are stored outdoors they are on hard standing in the drum park which is also isolated from the site drains. Other materials are stored within IBC's on portable bunds and also under cover. 2) The drum park has an isolated internal drainage sump installed. Any liquids collected in the sump are tested prior to manually initiated discharge to the Billingham site drains. 3) Spill kits are located in strategic areas on site. The site also has specialist equipment for vacuuming dusts. 4) The drainage system is maintained regularly and is subject to CCTV inspection. 5) Not applicable. 6) The site has an overarching environmental management system and an extensive maintenance programme. Activity AR4 introduces a number of new potential areas where sources of contamination may be present (scrubber, effluent tank, liquid ring buffer tank, new covered materials storage area) as well as a new tanker loading area. All of these areas are appropriately bunded, or provided with appropriate containment provisions to contain a loss and prevent contamination reaching soil, groundwater or surface watercourses. Rainwater collecting in all of these areas will be tested prior to discharge to the site chemical drain. Should contamination be identified then the liquid will be removed for offsite disposal. The same controls applied to the rest of the installation apply to Activity AR4. No change for activities AR1 – AR4. Activity AR5 will introduce additional materials storage areas and a tanker loading / unloading area. All storage and containment areas will have impermeable concrete hardstanding and will be isolated from the storm water systems with rainwater only being pumped out from the containment areas if it is found to be uncontaminated. All process activities will be undertaken within the new site building. Hence the risk of fugitive losses to surface or ground water is extremely low.
3.5	**Odour** 1. Manage the operations to prevent release of odour at all times. 2. Where odour releases are expected to be acknowledged in the permit, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion): • for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to minimise the frequency of exposure to ground level concentrations that are likely to cause annoyance. • for new installations, or for significant changes, the releases should be modelled and it is expected that you will achieve the highest level of protection that is achievable with BAT from the outset. • where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made. • where, despite all reasonable steps in the design of the plant, extreme weather or other incidents are liable, in our view, to increase the odour impact at receptors, you should take appropriate and timely action, as agreed with us, to prevent further annoyance (these agreed actions will be defined either in the permit or in an odour management statement).	Yes	One of the processes emits extremely low quantities of ammonia to atmosphere. The findings of the impact assessment submitted in support of the permit variation in 2014 demonstrated that the concentration of ammonia was significantly below the odour threshold. Other raw materials and products are not considered to be odorous. None of the permitted operations use organic solvents. Activity AR4 can generate ammonia, and all potential sources are extracted to the wet chemical scrubber where a 15% solution of sulphuric acid is used as the scrubbing media. The scrubber is guaranteed to achieve emissions of NH_3 no higher than 1mg/m³. The scrubbing liquor is recirculated within the scrubber with an intermittent purge and acid dosing to maintain the scrubbing liquor efficacy. The potential for odour impacts associated with the abated emission of ammonia has been undertaken and has demonstrated that no significant odour impact will occur. Due to the addition of ammonium salts to activity AR1, there is the potential for trace ammonia emissions from the thermal treatment ovens venting via emission points A1 – A3 and A16. No abatement of these emissions is proposed as they have been modelled and demonstrated to lead to no significant impacts. The plant will meet the existing guidance emission limits in the S4.03 guidance of 10 mg/Nm³. No change is anticipated as a result of the increase in throughout of activity AR4.

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	3. Where odour generating activities take place in the open, or potentially odorous materials are stored outside, a high level of management control and use of best practice will be expected. 4. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors, it is expected that you will work towards achieving the standards described in this guidance note, but the timescales allowed to achieve this might be adjusted according to the perceived risk. 5. Where further guidance is needed to meet local needs, refer to Horizontal Guidance Note H4 Odour (see GTBR, Annex 1).		None of the new materials proposed for use within the AR5 process are considered to be odorous. The materials to be used are of a similar composition to those already on site and do not present a risk of offsite nuisance.
3.6	**Nosie and Vibration** 1. Install particularly noisy machines such as compactors and pelletisers in a noise control booth or encapsulate the noise source. 2. Where possible without compromising safety, fit suitable silencers on safety valves. 3. Minimise the blow-off from boilers and air compressors, for example during start up, and provide silencers.	Yes	The majority of the equipment is housed within the Installation buildings thereby limiting environmental noise. Noise maps have been generated for the site. There are a small number of unit operations that are used occasionally that require ear protection to be worn within the building. Where new equipment is introduced a noise assessment would be undertaken. No significant changes to the site noise profile are anticipated as a result of the introduction of activity AR4. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. New sources of noise are from the wet scrubber with noise potentially resulting from the external fan. The scrubber will be located in close proximity to the MSC and Pilot Plant buildings and is not expected to result in offsite nuisance. However, noise monitoring will be undertaken during start up and acoustic housing will be considered if deemed necessary. All other unit operations are undertaken within a building which minimises the potential for noise nuisance at nearby receptors. Process equipment has been selected to avoid the need for hearing protection for employees working within the building. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). Under normal conditions, tanker loading operations will be undertaken during daylight hours to prevent nuisance from additional vehicle movements on the site. No significant changes to noise profile are anticipated as a result of the introduction of the new processes. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. All process operations are undertaken within buildings which minimises the potential for noise nuisance at nearby receptors. Process equipment will be selected to avoid the need for hearing protection for employees working within the buildings. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). For activity AR5, all equipment with the potential to producing noise will be selected to not exceed the limit of 80 dBA at 1 m, with the exception of housed compressors which may have noise levels <90 dBA at 1 m. It is likely that the briquette grinding area will exceed this noise limit, hence as part of the design process, options to contain and attenuate the noise generated by the grinding systems will be investigated so as to minimise the potential for offsite nuisance e.g. location within an acoustic enclosure or room. The site has not received any justifiable noise complaints in relation to the permitted activities, and through the application of appropriate design and specification of plant supported by scheduled maintenance and other site management controls, no significant noise impacts are anticipated.
3.7	**Monitoring and Reporting of Emissions to Air** 1. Carry out an analysis covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. The need to repeat such a test will depend upon the potential variability in the process and, for example, the potential for contamination of raw materials. Where there is such potential, tests may be appropriate. 2. Monitor more regularly any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively. 3. If there are releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances, then "whole effluent toxicity" monitoring techniques can be appropriate to provide direct measurements of harm, for example, direct toxicity assessment.	Not Applicable	Emissions monitoring is not currently required as part of the Environmental Permit. Due to the small scale and R&D nature of the process operations, monitoring of emissions to atmosphere are not deemed necessary. Emissions of NOx are controlled using management controls, procedures and physical controls. Thermal Gravimetric Analysis is undertaken for new processes. This allows the emission profile of the process to be understood. Where necessary the thermal processing equipment in the MSC (ovens) and Pilot Plant can be scheduled to avoid peaks of NOx. Gas-tech tubes are used for checking that the emissions are as expected. The site has an internal management limit of 113mg/m^3 for NOx (as NO_2) for the existing processes and 200 mg/m^3 for the new processes. Various controls are in place for the abatement of particulate matter (see Section 3.1) A risk assessment using the H1 methodology on calculated particulate emissions demonstrated that the predicted emissions were insignificant. Emissions of ammonia are considered to be trivial. The Environmental Permit does not require monitoring of ammonia emissions. Activity AR4 will lead to emissions via emission point A12 – This plant has not yet been commissioned, and it is expected that confirmatory emissions sampling and analysis for ammonia and particulates will be undertaken as part of the performance testing during commissioning and prior to full operation of the process. Requirements for any scheduled monitoring during the plants operational lifetime will be agreed with the regulator as part of the permit variation determination. No significant changes to noise profile are anticipated as a result of the introduction of the new processes or changes to the existing activities.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
			The installation is in an industrial setting. However, there is some residential housing and a school in the locality. All process operations are undertaken within buildings which minimises the potential for noise nuisance at nearby receptors. Process equipment will be selected to avoid the need for hearing protection for employees working within the buildings. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). For activity AR5, all equipment with the potential to producing noise will be selected to not exceed the limit of 80 dBA at 1 m, with the exception of housed compressors which may have noise levels <90 dBA at 1 m. It is likely that the briquette grinding area will exceed this noise limit, hence as part of the design process, options to contain and attenuate the noise generated by the grinding systems will be investigated so as to minimise the potential for offsite nuisance e.g. location within an acoustic enclosure or room. The site has not received any justifiable noise complaints in relation to the permitted activities, and through the application of appropriate design and specification of plant supported by scheduled maintenance and other site management controls, no significant noise impacts are anticipated.
3.7	**Monitoring and Reporting of Waste Emissions** 1. Monitor and record: • the physical and chemical composition of the waste. • its hazard characteristics. • handling precautions and substances with which it cannot be mixed.	Yes	The disposal of waste is undertaken in compliance with stringent waste management procedures. Records are maintained within the sites Waste Database. The site identifies the composition of waste and its hazards as far as reasonably practicable. Material safety datasheets (MSDS) are available for the materials used on site. Waste disposal is undertaken by approved third party contractors. Duty of Care audits are undertaken on all carriers and all disposal sites used, with records kept in the document management system. A review of all the waste streams and disposal sites is undertaken annually. From this review, three to four disposal sites are chosen to undertake site led Duty of Care audits, these are prioritised based on risk. For all other disposal sites not subject to a site visit, a desk-top Duty of Care check is carried out to ensure that Carrier Licences, Site Permits and Site Exemptions not only are valid, but that they cover the EWC Codes for the relevant waste streams that are sent there. No change associated with the introduction of activity AR4. No Change.
3.7	**Environmental Monitoring Beyond the Installation** 1. Consider the following in drawing up proposals: • determinands to be monitored, standard reference methods, sampling protocols. • monitoring strategy, selection of monitoring points, optimisation of monitoring approach. • determination of background levels contributed by other sources. • uncertainty for the employed methodologies and the resultant overall uncertainty of measurement. • quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail. • reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information.	Not Applicable	The majority of the process operations are small scale R&D activities. It is therefore not considered appropriate to undertake monitoring beyond the installation boundary. Dispersion modelling of the worst case emission profile demonstrated that the impact at key sensitive receptors was not significant. No further monitoring is proposed. No change associated with the introduction of activity AR4. The potential impacts associated with emissions via A12 have been assessed using the H1 calculation tool which demonstrated that no significant impacts will occur. Hence no additional offsite monitoring is proposed. The changes proposed to activities AR1 – AR4 will not lead to any change with existing permit emission limits being complied with. The AR5 activities will lead to new emission points and emissions, but all will comply with emission benchmarks. Plant emissions have been assessed using atmospheric dispersion modelling which has demonstrated that no significant environmental impact will occur. Hence no additional offsite monitoring is proposed.
	Process Variables 1. Identify those process variables that may affect the environment and monitor as appropriate.		Thermo Gravimetric analysis (TGA) is undertaken to fully understand the process and emissions. Thermal processing equipment (for the existing processes) is sequenced such that NOx emissions do not peak at the same time, Differential pressure across the HEPA filters in the dust booths is monitored and if the filters were to fail the process would be shut down and powder handling operations would cease immediately. Activity AR4 emissions direct to the environment are all via emission point A12. The wet chemistry and precipitation phases of the process are controlled by the rate of addition of key materials, and control of the temperature within the precipitation tank to around 60°C. Emissions from the dryer are dependent on the temperature of the dryer which is controlled to be around 120°C. Appropriate automated control loop and manual control systems are in place to ensure the safe operation of the process within the desired operating parameters, and maintaining the process within these desired parameters controls the rate of emission to A12 from the process. The filtration systems on the air extracted from the process are installed with pressure differential monitoring which will alarm on blockage or failure of the filtration systems. The wet chemical scrubber also has control and monitoring of key parameters (e.g. fan operation, scrubber liquor flow) which will alarm if the plant is not operating correctly and interlocks are present which will shut Activity AR4 down should the scrubber abatement system fail.

BAT No.	BAT Justification	Operating to BAT	Operator Comments
			No change for activities AR1 – AR4. Process and emissions monitoring requirements for activity AR5 will be developed during detailed design.

Table 3: Common Waste Water and Waste Gas Treatment / Management in the Chemical Sector – May 2016

BAT No.	BAT Justification	Operating to BAT	Operator Comments
Scope	These BAT conclusions concern the activities specified in Sections 4 and 6.11 of Annex I to Directive 2010/75/EU, namely: — Section 4: Chemical industry; — Section 6.11: Independently operated treatment of waste water not covered by Council Directive 91/271/EEC and discharged by an installation undertaking activities covered under Section 4 of Annex I to Directive 2010/75/EU.	-	The BREF document applies as the site activities is defined under 4.2 Part A(1)(a)(v) of Schedule 1 to the Environmental Permitting Regulations 2016 No change associated with the introduction of activity AR4. No Change.
BAT 1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS).	Yes	See SIC Section 5.22 responses (Table 1 – above). No change associated with the introduction of activity AR4. No Change.
BAT 2	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features: (i) information about the chemical production processes, including: (a) chemical reaction equations, also showing side products; (b) simplified process flow sheets that show the origin of the emissions; (c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances; (ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as: (a) average values and variability of flow, pH, temperature, and conductivity; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds); (c) data on bio-eliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification)); (iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as: (a) average values and variability of flow and temperature; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride); (c) flammability, lower and higher explosive limits, reactivity; (d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust).	Yes	The MSC operations are small scale or R&D processes. Due to the short term nature of the processes, the MSC is limited to the extent that BAT can be achieved. However, the MSC is compliant with many of the requirements. i) Chemical reactions are well understood and quantified. Where appropriate TGA analysis is undertaken to understand the emission profile of the process. Process flow sheets are available for each of the processes under development. Wastes and emissions are well understood prior to introducing a product to the plant. Inventories of emissions and wastes are maintained, however, process operations may be transient due to the R&D nature of the site. ii) Effluent from the processes is limited to process washing and vessel cleaning. These result in only dilute effluent being discharged to controlled waters and in only small quantities (~23 IBC's in 2017). iii) Processes are developed in the laboratory prior to scale up within the MSC. Emissions profiles are well understood using TGA analysis prior to scale up. Emissions consist of particulate matter and NOx with trivial emissions of ammonia. Activity AR4 has been appropriately designed and the operator has full details of the process, and the expected aqueous waste stream and the emissions to air. This will be supplemented by in house operational checks and plant performance monitoring undertaken during commissioning to confirm the expected performance parameters, with intermittent process performance checks being undertaken as part of routine plant operations. No change for activities AR1 – AR4. Process and emissions data and monitoring requirements for activity AR5 will be developed during detailed design. Initial data based on the current basis of design has been provided as part of the permit application documentation and the process and its emissions are well understood and characterised.
BAT 3	For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pre-treatment and influent to final treatment).	Not Applicable	Emissions of effluent to controlled waters are limited to dilute process washing and effluent from vessel cleaning. These operations result in only small quantities of dilute effluent being generated. Effluent is isolated in IBC's prior to discharge to a given specification to the Billingham site drains (thence RT01 discharge). Therefore continuous monitoring is not applicable. No change associated with the introduction of activity AR4. There will be no process effluent emission to controlled waters. No Change - There will be no process effluent emission to controlled waters.

BAT 4	**Monitoring** BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality. **Substance** / **Standard** / **Minimum Monitoring Frequency** Total Organic Carbon (TOC)[3] / EN 1484 Chemical Oxygen Demand (COD)[3] / No EN Standard Total Suspended Solids (TSS) / EN 872 Total Nitrogen (TN)[4] / EN 12260 / Daily Total Inorganic Nitrogen[4] (N_{inorg}) / Various EN Standards Total Phosphorus / Various EN Standards [3] TOC monitoring and COD monitoring are alternatives. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds. [4]TN and $_{Ninorg}$ monitoring are alternatives	No	The site does not discharge process generated effluent to the Billingham site drains and does not have an effluent treatment plant. All liquids associated with processing are collected in IBC's and removed from the site by a licenced waste disposal contractor. Consequently, no process effluents are discharged to controlled waters. The only emissions to water are process washings (i.e. filter cake washings) and effluent from vessel cleaning. This effluent is collected in IBC's and is discharged via the adjacent Fuji and CF Fertilisers sites into the River Tees. Discharges are made in accordance to a discharge consent managed by CF Fertilisers "Billingham Site Effluent Agreement. RT01/INTCON/3/C" for RT01. The site has an internal control mechanism such that effluent must meet the consent limits prior to discharge to the common drains and thereby does not rely on any dilution in the drainage system. Effluent is tested for metal using analytical testing sticks (Merck MQuant). Should the test stick identify any concentration of metals then the effluent is quantitatively assayed using X-ray fluorescence (XRF) spectrometry. The tests do not conform to the EN standards but the business that manages the analytical laboratories is accredited to ISO 90001. However, the tests are considered to be sufficient given the extremely low concentrations of materials in the effluent. The site does not handle organic material and therefore does not test for TOC or COD in the effluent. Prior to effluent being discharged, it is stored within IBC's which allows any solids to settle prior to discharge. The supernatant is pumped to the Billingham site common drainage system (RT01) and any retained solids are removed for offsite disposal. No change associated with the introduction of activity AR4. There will be no process effluent emission to controlled waters, and hence no monitoring is proposed. No Change - There will be no process effluent emission to controlled waters and hence no monitoring is proposed.
BAT 5	**Diffuse VOC's** BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I-III or, where large amounts of VOC are handled, all of the techniques I-III. I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment; II. optical gas imaging methods; III. Calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements. Where large amounts of VOCs are handled, the screening and quantification of emissions from the installation by periodic campaigns with optical absorption-based techniques, such as Differential absorption light detection and ranging (DIAL) or Solar occultation flux (SOF), is a useful complementary technique to the techniques I to III.	Not Applicable	The site does not use organic solvents in process operations. Site operations are not included as an activity in the Solvent Emissions Directive as part of IED. No change associated with the introduction of activity AR4. No change for activities AR1 – AR4. Activity AR5 does use a high boiling point non-VOC solvent, but no VOC's are proposed for use.
BAT 6	**Odour** BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.	Not Applicable	One of the processes emits extremely low quantities of ammonia to atmosphere. The findings of the impact assessment submitted in support of the permit variation in 2014 demonstrated that the concentration of ammonia was significantly below the odour threshold and therefore the potential for odours from this single process is considered "insignificant". Other raw materials and products are not considered to be odorous. None of the permitted operations use organic solvents Odour monitoring is therefore not required. No change associated with the introduction of activity AR4 Activity AR4 can generate ammonia, and all potential sources are extracted to the wet chemical scrubber where a 15% solution of sulphuric acid is used as the scrubbing media. The scrubber is guaranteed to achieve emissions of NH_3 no higher than 1mg/m³. The scrubbing liquor is recirculated within the scrubber with an intermittent purge and acid dosing to maintain the scrubbing liquor efficacy. The potential for odour impacts associated with the abated emission of ammonia has been undertaken and has demonstrated that no significant odour impact will occur. Hence no additional odour monitoring is proposed. Due to the addition of ammonium salts to activity AR1, there is the potential for trace ammonia emissions from the thermal treatment ovens venting via emission points A1 – A3 and A16. No abatement of these emissions is proposed as they have been modelled and demonstrated to lead to no significant impacts. The plant will meet the existing guidance emission limits in the S4.03 guidance of 10 mg/Nm³.

			No change is anticipated as a result of the increase in throughout of activity AR4. None of the new materials proposed for use within the AR5 process are considered to be odorous. The materials to be used are of a similar composition to those already on site and do not present a risk of offsite nuisance. Hence no additional odour monitoring is proposed.
BAT 7	**Emission to water** In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	Yes	Site operations do not result in the generation of large volumes of waste water. Effluent is segregated in IBC prior to offsite disposal or discharge to the Billingham site drains. The effluent consists of process (filter cake) and vessel washings and is not heavily contaminated. If the effluent does not meet the emission limit values described in the consent limits for RT01 then the material would be removed from site for offsite disposal. No change associated with the introduction of activity AR4. The process is not water intensive and has limited water use Activity AR4 uses high quality feedstocks are used to avoid the generation of by-products, and the processes applied are expected to achieve extremely high yield. Raw materials and products within extracted air streams are captured (bag and HEPA filters) and returned to the process where possible. Solids are also returned into the process from wet chemistry phases of the process to optimise yield and minimise raw materials use. There will be and aqueous waste stream, which will result from the process, however the generation of this waste stream is an inherent characteristic of the reaction processes and cannot be further minimised. This aqueous waste will be sent offsite for treatment /disposal, but given the nature of the effluent and the scale of operations, opportunities for offsite reuse / recycling are limited. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence Activity AR4 does not discharge into either site or municipal drainage systems, and there is no onsite treatment of aqueous wastes. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. As noted above, the process activities at the installation are used to produce high quality products which have limited tolerances for impurities, so in many cases in-process recycling is not possible.
BAT 8	In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment.	Yes	Effluent is segregated in IBCs prior to offsite disposal or discharge to the Billingham site drains. The effluent consists of process (filter cake) and vessel washings and is not heavily contaminated. If the effluent does not meet the emission limit values described in the consent limits for RT01 then the material would be removed from site for offsite disposal. All aqueous wastes generated by activity AR4 will be inorganic in nature and are transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. Hence activity AR4 does not discharge into either site or municipal drainage systems, there is no requirement to segregate organic from inorganic waste streams, and there is no onsite treatment of aqueous wastes. No Change – all process wastewater will have inorganic contamination and will be collected for appropriate offsite treatment / disposal.
BAT 9	In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).	Not Applicable	Not Applicable - effluent is stored in IBC's prior to discharge. No change associated with the introduction of Activity AR4. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal.
BAT 10	In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques in the priority order given below. a) Process integrated techniques - prevent or reduce pollutants. b) Recovery of pollutants at source. c) Waste water pre-treatment. d) Final waste water treatment.	Not Applicable	Not considered to be applicable as effluent is removed for offsite disposal – only small quantities of process washings and vessel cleaning effluent are discharged to drain, obeying the consent limits of the RT01 discharge consent. Activity AR4 uses high quality feedstocks to avoid the generation of by-products, and the processes applied are expected to achieve extremely high yield. Raw materials and products within extracted air streams are captured (bag and HEPA filters) and returned to the process where possible. Solids are also returned into the process from wet chemistry phases of the process to optimise yield and minimise raw materials use. There will be an aqueous waste stream, which will result from the process, however the generation of this waste stream is an inherent characteristic of the reaction processes and cannot be further minimised. This aqueous waste will be sent

			offsite for treatment /disposal, but given the nature of the effluent and the scale of operations, opportunities for offsite reuse / recycling are limited. There is no provision of on-site treatment of aqueous effluent. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. As noted above, the process activities at the installation are used to produce high quality products which have limited tolerances for impurities, so in many cases in-process recycling is not possible. There is no provision for on-site treatment of process effluent.
BAT 11	In order to reduce emissions to water, BAT is to pre-treat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques.	Not Applicable	Not considered to be applicable as effluent is removed for offsite disposal – only small quantities of process washings and vessel cleaning effluent are discharged to drain, obeying the consent limits of the RT01 discharge consent. No change associated with the introduction of Activity AR4. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent.
BAT 12	In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.	Not Applicable	Not considered to be applicable as effluent is removed for offsite disposal – only small quantities of process washings and vessel cleaning effluent are discharged to drain, obeying the consent limits of the RT01 discharge consent. No change associated with the introduction of Activity AR4. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. There is no on-site waste water treatment. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent.
BAT 13	**Waste** In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.	Yes	The site is accredited by Lloyds Register Quality Assurance (LRQA) to the ISO14001:2015 standard and therefore has extensive procedures relating to environmental management and continuous improvement The site also operates to the JM Group Sustainability programme. Activities at the site level are fed into the JM Group that monitors and publishes progress against each of the goals. The programme includes items such as waste minimisation, increasing recycling, water usage, energy minimisation, efficient use of raw materials etc. Where possible waste will be recycled. Metals are recovered where practicable. The quantities of waste materials generated at the site are limited with typically production yields being in the range of 90%+. No change associated with the introduction of Activity AR4. No Change – all site wastes will be managed in accordance with the existing site waste management procedures which will include the periodic review of waste disposal options to priorities recycling where possible through application of the waste hierarchy.
BAT 14	In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below.	Not Applicable	Not Applicable - no on site waste water treatment plant. No change associated with the introduction of Activity AR4. There is no on-site waste water treatment plant. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent.
	BAT-AELs for direct emissions of TOC, COD and TSS to a receiving water body **Parameter** **BAT-AEL's (Yearly Average)** **Conditions**	Not Applicable	The site does not handle organic material within process operations. Therefore, discharges of TOC and COD do not apply. The site discharges small quantities of effluent from process washing (filter cakes) and vessel cleaning. Effluent is retained in IBC's prior to discharge.

Total Organic Carbon (TOC)[1][2]	10-33 mg/l [3][4][5][6]	The BAT-AEL applies if the emission exceeds 3.3 Te/yr
Chemical Oxygen Demand (COD)[1][2]	30-100 mg/l[3][4][5][6]	The BAT-AEL applies if the emission exceeds 10Te/yr
Total Suspended Solids (TSS)	5-35 mg/l[7][8]	The BAT-AEL applies if the emission exceeds 3.5 Te/yr

1 No BAT-AEL applies for BOD.
2 Either BAT-AEL for TOC or COD applies. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.
3 The lower end of the range is typically achieved when few tributary waste water streams contain organic compounds and/or the waste water mostly contains easily biodegradable organic compounds.
4 The upper end of the range may be up to 100 mg/l for TOC or up to 300 mg/l for COD, both as yearly averages, if both of the following conditions are fulfilled:

- Condition A: Abatement efficiency ≥ 90 % as a yearly average (including both pre-treatment and final treatment).
- Condition B:If a biological treatment is used, at least one of the following criteria is met:
- A low-loaded biological treatment step is used (i.e. ≤ 0,25 kg COD/kg of organic dry matter of sludge). This implies that the BOD5 level in the effluent is ≤ 20 mg/l.
- Nitrification is used.

5 The upper end of the range may not apply if all of the following conditions are fulfilled:

- Condition A: Abatement efficiency ≥ 95 % as a yearly average (including both pre-treatment and final treatment).
- Condition B: same as Condition B in footnote (4).
- Condition C: The influent to the final waste water treatment shows the following characteristics: TOC > 2 g/l (or COD > 6 g/l) as a yearly average and a high proportion of refractory organic compounds.

6 The upper end of the range may not apply when the main pollutant load originates from the production of methylcellulose.
7 The lower end of the range is typically achieved when using filtration (e.g. sand filtration, microfiltration, ultrafiltration, membrane bioreactor), while the upper end of the range is typically achieved when using sedimentation only.
8 This BAT-AEL may not apply when the main pollutant load originates from the production of soda ash via the Solvay process or from the production of titanium dioxide.

Effluent is left to stand to allow solids to settle out of solution prior to discharge (i.e. to clarify). The effluent is checked visually and is not discharged if it appears cloudy. If the effluent failed visual checks, inductively coupled plasma (ICP) mass spectrometry could be used to analyse the effluent.

No change associated with the introduction of Activity AR4.
All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. There is no on-site waste water treatment, and no discharge to a receiving water body.

No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent.

BAT-AELs for direct emissions of nutrients to a receiving water body.

Parameter	BAT-AEL's (Yearly Average)	Conditions
Total Nitrogen	5-25 mg/l	The BAT-AEL applies if the emission exceeds 2.5 Te/yr
Total Inorganic Nitrogen	5-20 mg/l	The BAT-AEL applies if the emission exceeds 2.0 Te/yr
Total Phosphorus	0.5-3.0 mg/l	The BAT-AEL applies if the emission exceeds 300 kg/yr

NB table conditions apply

Not Applicable

The site does not discharge nutrients to controlled waters.

No change associated with the introduction of Activity AR4.
All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. There is no on-site waste water treatment, and no discharge to a receiving water body.

No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent and no discharge to a receiving water body.

	BAT-AELs for direct emission of AOX and metals to a receiving water body **Parameter** / **BAT-AEL's (Yearly Average)** / **Conditions** Adsorbable organically bound halogens (AOX) — 0.2-1.0 mg/l — The BAT-AEL applies if the emission exceeds 100 kg/yr Chromium (expressed as Cr) — 5-25 mg/l — The BAT-AEL applies if the emission exceeds 2.5 kg/yr Copper (expressed as Cu) — 5-50 mg/l — The BAT-AEL applies if the emission exceeds 50 kg/yr Nickel (expressed as Ni) — 5-50 mg/l — The BAT-AEL applies if the emission exceeds 5 kg/yr Zinc (expressed as Zn) — 20-300 mg/l — The BAT-AEL applies if the emission exceeds 30 kg/yr NB table conditions apply	Not Applicable	The site does not discharge halogenated compounds to controlled waters. The BAT-AELs do not apply to the emissions of metals as the effluent does not exceed the mass emissions stated in the table opposite. The data presented below is from the period April 2017 to March 2018. The data is for all of the discharges made to S1 (RT01) and include effluent that was generated during R&D activities and small scale manufacturing campaigns. **Parameter** / **Annual Mass Emission (kg)** Cobalt (Co) — 0.190 Chromium (expressed as Cr) — N/A Copper (expressed as Cu) — 0.214 Iron (expressed as Fe) — 0.057 Nickel (expressed as Ni) — 0.190 Zinc (expressed as Zn) — 0.120 The data clearly demonstrate that the emissions of metal salts were significantly below the mass emission limit above which a BAT-AEL would be applied.. No chromium containing work was undertaken during this period and, hence, there are no data available for this metal. A review of data from laboratory based experiments that have involved the use of this metal suggests that chromium levels in aqueous waste stream from such preparations are commonly at a level of <0.2mg/l. Any preparations involving chromium use chromium (III) salts as a raw material and the operating conditions (principally pH and temperature) are designed to ensure that there is insufficient oxidation potential with the system to effect the transformation of the Cr (III) starting material to Cr (VI). No change associated with the introduction of Activity AR4. All aqueous wastes generated by Activity AR4 will be transferred to the effluent tank for collection by road tanker for appropriate offsite treatment / disposal. There is no on-site waste water treatment, and no discharge to a receiving water body. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent and no discharge to a receiving water body.
BAT 15	**Emissions to Air** In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.	Yes	See Section 5.6 of the Inorganic Speciality Chemicals guidance in Table 1 and Section 3.1 of Table 2. All of the process activities (including powder and product handling) will be undertaken within enclosed equipment within the MSC and Pilot Plant buildings. The enclosed process systems are all linked into an air extraction system such that they are all under slight negative pressure and feed into appropriate emissions abatement systems. Activity AR4 will also undertake all powder handling operations in dust booth with recirculating extraction systems installed with double HEPA filter protection. There will be no emission to atmosphere from this source. There is the limited potential for dust generation during vessel charging which is extracted via an extraction hood (primarily for Operator protection) to a wet chemical scrubber. The powders used at this stage of the process do not contain fine particles, and laboratory testing has shown that the materials present at this stage do not have PM_{10} or $PM_{2.5}$ present; hence the potential for dust generation at this stage is limited. Any larger particulates transferred to the scrubber would either be captured or be dissolved into the scrubber liquor. Dusts can also be generated by the dryer activities, and the extracted air is treated using a bag filter followed by double HEPA filtration, the extracted air is then fed into the wet chemical scrubber prior to discharge to atmosphere. No change for activities AR1 – AR4. The expansion of activity AR2 and increase in throughput of AR4 will continue to apply the same controls as stated above. Powder handling operations are generally undertaken within dust booths that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filter system and there are no releases via A13/A14/A15. The relocated ovens for AR1 (emission point A16) will perform at the same emission levels as discussed above.

			Activity AR5 will also apply appropriate controls to all dust handling activities through the use of dust booths / enclosures that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filtration system and there will be no releases of dusts to atmosphere. Other point source emissions from activity AR5 will be abated through the use of wet scrubbing techniques where appropriate. Plant emissions have been assessed using atmospheric dispersion modelling which has demonstrated that no significant environmental impact will occur.
BAT 16	In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques. (The integrated waste gas management and treatment strategy is based on the inventory of waste gas streams (see BAT 2) giving priority to process-integrated techniques)	Yes	The site operations are small scale R&D processes. Due to the short term nature of the processes, the site is limited to the extent that BAT can be achieved. See BAT 2 for further details. Activity AR4 emissions direct to the environment are all via emission point A12. The following controls are applied to the emissions from the process. The wet chemistry and precipitation phases of the process are controlled by the rate of addition of key materials, and control of the temperature within the precipitation tank to around 60°C. Emissions from the dryer are dependent on the temperature of the dryer which is controlled to be around 120°C. Appropriate automated control loop and manual control systems are in place to ensure the safe operation of the process within the desired operating parameters, and maintaining the process within these desired parameters controls the rate of emission to A12 from the process. The filtration systems on the air extracted from the process are installed with pressure differential monitoring which will alarm on blockage or failure of the filtration systems. The wet chemical scrubber also has control and monitoring of key parameters (e.g. fan operation, scrubber liquor flow) which will alarm if the plant is not operating correctly and interlocks are present which will shut Activity AR4 down should the scrubber abatement system fail. No change for activities AR1 – AR4. Activity AR5 will also apply appropriate controls to all dust handling activities through the use of dust booths / enclosures that use a double HEPA filter system with a pre-filter. Emissions from the dust booths are fed through a recirculating HEPA filtration system and there will be no releases of dusts to atmosphere. Other point source emissions from activity AR5 will be abated through the use of wet scrubbing techniques where appropriate. Plant emissions have been assessed using atmospheric dispersion modelling which has demonstrated that no significant environmental impact will occur.
BAT 17	**Flaring** In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below.	Not Applicable	Not Applicable - no flaring is undertaken on site. No change associated with the introduction of Activity AR4. No Change – no flaring is undertaken on site.
BAT 18	In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques given below.	Not Applicable	Not Applicable - no flaring is undertaken on site. No change associated with the introduction of Activity AR4. No Change – no flaring is undertaken on site.
BAT 19	**Diffuse VOC's to Air** In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below. a) limit the number of potential emission sources. b) maximise process-inherent containment features. c) select high-integrity equipment. d) facilitate maintenance activities by ensuring access to potentially leaky equipment. e) ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using designed gasket stress for flanged joint assembly. f) ensure robust plant/equipment commissioning and handover procedures in line with the design requirements.	Not Applicable	Organic materials are not used within process operations and therefore emissions of VOC are not applicable. No change associated with the introduction of Activity AR4. Activity AR4 does not involve any organic solvents or VOC's. No change for activities AR1 – AR4. Activity AR5 does use a high boiling point non-VOC solvent, but no VOC's are proposed for use.

	g) ensure good maintenance and timely replacement of equipment. h) use a risk based leak detection and repair programme. i) as far is it is reasonable, prevent diffuse VOC emissions, collect them at source and treat them.		
BAT 20	**Odour Emissions** In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting odour monitoring; (iii) a protocol for response to identified odour incidents; and (iv) an odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.	Not Applicable	One of the processes emits extremely low quantities of ammonia to atmosphere. The findings of the impact assessment submitted in support of the permit variation in 2014 demonstrated that the concentration of ammonia was significantly below the odour threshold. Other raw materials and products are not considered to be odorous. None of the permitted operations use organic solvents. No change associated with the introduction of Activity AR4 Activity AR4 can generate ammonia, and all potential sources are extracted to the wet chemical scrubber where a 15% solution of sulphuric acid is used as the scrubbing media. The scrubber is guaranteed to achieve emissions of NH_3 no higher than 1mg/m³. The scrubbing liquor is recirculated within the scrubber with an intermittent purge and acid dosing to maintain the scrubbing liquor efficacy. The potential for odour impacts associated with the abated emission of ammonia has been undertaken and has demonstrated that no significant odour impact will occur. Hence no additional odour monitoring is proposed. Due to the addition of ammonium salts to activity AR1, there is the potential for trace ammonia emissions from the thermal treatment ovens venting via emission points A1 – A3 and A16. No abatement of these emissions is proposed as they have been modelled and demonstrated to lead to no significant impacts. The plant will meet the existing guidance emission limits in the S4.03 guidance of 10 mg/Nm³. No change is anticipated as a result of the increase in throughout of activity AR4. None of the new materials proposed for use within the AR5 process are considered to be odorous. The materials to be used are of a similar composition to those already on site and do not present a risk of offsite nuisance. Hence no additional odour monitoring is proposed.
BAT 21	**Odour** In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below. Techniques not reproduced as BAT requirement not applicable.	Not Applicable	Not applicable - no waste water treatment is undertaken on site. No change associated with the introduction of Activity AR4. No Change – all process wastewater will be collected for appropriate offsite treatment / disposal. There is no provision for on-site treatment of process effluent.
BAT 22	**Noise** In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting noise monitoring; (iii) a protocol for response to identified noise ; and (iv) a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.	Yes	The majority of the equipment is housed within the MSC and Pilot Plant buildings thereby limiting environmental noise. Noise maps have been generated for the site. There are a small number of unit operations that are occasionally used that require ear protection to be worn within the building. However, there are no sources which could give rise to significant levels of noise outside of the building. Where new equipment is introduced a noise assessment would be undertaken. No significant changes to the site noise profile are anticipated as a result of the introduction of Activity AR4. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. New sources of noise are from the wet scrubber with noise potentially resulting from the external fan. The scrubber will be located in close proximity to the MSC and Pilot Plant buildings and is not expected to result in offsite nuisance. However, noise monitoring will be undertaken during start up and acoustic housing will be considered if deemed necessary. All other unit operations are undertaken within a building which minimises the potential for noise nuisance at nearby receptors. Process equipment has been selected to avoid the need for hearing protection for employees working within the building. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). Under normal conditions, tanker loading operations will be undertaken during daylight hours to prevent nuisance from additional vehicle movements on the site. No additional noise monitoring is proposed. No significant changes to noise profile are anticipated as a result of the introduction of the new processes. The installation is in an industrial setting. However, there is some residential housing and a school in the locality.

			All process operations are undertaken within buildings which minimises the potential for noise nuisance at nearby receptors. Process equipment will be selected to avoid the need for hearing protection for employees working within the buildings. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). For activity AR5, all equipment with the potential to producing noise will be selected to not exceed the limit of 80 dBA at 1 m, with the exception of housed compressors which may have noise levels <90 dBA at 1 m. It is likely that the briquette grinding area will exceed this noise limit, hence as part of the design process, options to contain and attenuate the noise generated by the grinding systems will be investigated so as to minimise the potential for offsite nuisance e.g. location within an acoustic enclosure or room. The site has not received any justifiable noise complaints in relation to the permitted activities, and through the application of appropriate design and specification of plant supported by scheduled maintenance and other site management controls, no significant noise impacts are anticipated.
BAT 23	**Noise** In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below. a) Appropriate location of equipment and buildings. b) Operational measures. c) Low noise equipment. d) Noise control equipment. e) Noise abatement.	Not Applicable	Current noise levels do not necessitate noise reduction methods. No significant changes to the site noise profile are anticipated as a result of the introduction of Activity AR4. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. New sources of noise are from the wet scrubber with noise potentially resulting from the external fan. The scrubber will be located in close proximity to the MSC and Pilot Plant buildings and is not expected to result in offsite nuisance. However, noise monitoring will be undertaken during start up and acoustic housing will be considered if deemed necessary. All other unit operations are undertaken within a building which minimises the potential for noise nuisance at nearby receptors. Process equipment has been selected to avoid the need for hearing protection for employees working within the building. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). Under normal conditions, tanker loading operations will be undertaken during daylight hours to prevent nuisance from additional vehicle movements on the site. No significant changes to noise profile are anticipated as a result of the introduction of the new processes. The installation is in an industrial setting. However, there is some residential housing and a school in the locality. All process operations are undertaken within buildings which minimises the potential for noise nuisance at nearby receptors. Process equipment will be selected to avoid the need for hearing protection for employees working within the buildings. JM has limits for occupational noise based on health protection and these will meet all relevant legal limits (85dB(A) 8 hour TWA). For activity AR5, all equipment with the potential to producing noise will be selected to not exceed the limit of 80 dBA at 1 m, with the exception of housed compressors which may have noise levels <90 dBA at 1 m. It is likely that the briquette grinding area will exceed this noise limit, hence as part of the design process, options to contain and attenuate the noise generated by the grinding systems will be investigated so as to minimise the potential for offsite nuisance e.g. location within an acoustic enclosure or room. The site has not received any justifiable noise complaints in relation to the permitted activities, and through the application of appropriate design and specification of plant supported by scheduled maintenance and other site management controls, no significant noise impacts are anticipated.