BREEDON

REPORT

BREEDON CEMENT LTD
HOPE CEMENT WORKS

PERMIT REF EPR/3731/VJ v006

SO_2 EMISSIONS SUBSTANTIAL VARIATION REQUEST

Doc Ref BCSVR22

March 2022

www.breedongroup.com

Contents

Appendices:

1. SO_3 Control Strategy
2. Dispersion Modelling
3. ARM project Overview
4. Ecology
5. Noise
6. IP 16 Improvement Conditions
7. ETC Report - Hope solutions to extend quarry life
8. Cost Benefit Analysis
9. CPI Report 2010 UK Hope Solutions to extend quarry life

Forms and supplementary information:

1. Application-form-for-an-environmental-permit-Part- A - *Standard application form provided and used by the Environment Agency*
2. Form-EPC-Application-for-an-environmental-permit-Part-C2 - *Standard application form provided and used by the Environment Agency*
3. Appendix 10 _ Management System - BS EN ISO 14001-2015--[2015-09-30--10-10-50 AM] - *Provided in relation question 3d in EA form C2 – for information only*
4. Appendix 11 _ Site Plan - Hope Works Site Plan - *Provided in relation to the question 5a in EA form C2 – for information only*
5. Application form for an environmental permit Part C3 Variation to a bespoke installation permit LIT_6783 - *Standard application form provided and used by the Environment Agency*
6. BCSVR22 -C3 - *Provided in relation to questions 3c, 4a, 4b, Appendix 1 – Q1 in EA form C3 – for information only*
7. Appendix 12 _ Raw Materials SDS- Drax_masterSIS_bottom ash_22 12 2010.pdf - *Provided in relation to question 3c Table 5 in EA form C3 – for information only*
8. Appendix 12 _ Raw Materials SDS- Drax_masterSIS_Pulverised Fuel Ash_22 12 2010.pdf - *Provided in relation to question 3c Table 5 in EA form C3 – for information only*
9. Appendix 12 _ Raw Materials SDS- Gypsum Crushed.pdf - *Provided in relation to the question 3c Table 5 in EA form C3 – for information only*
10. Pulverised fuel ash.pdf - *Provided in relation to question 3c Table 5 in EA form C3 – for information only*
11. Appendix 12 _ Raw Materials SDS- Raw Meal Breedon Cement Ltd.pdf - *Provided in relation to question 3c Table 5 in EA form C3 – for information only*
12. Appendix 12 _ Raw Materials SDS_ soda_ash_europe (3).pdf - *Provided in relation to the referenced question 3c Table 5 in EA form C3 – for information only*
13. Form-EPF-Application-for-an-environmental-permit-Part_F1 - *Standard application form provided and used by the Environment Agency*
14. Supporting Statement Confidential Information 23 11 18 - *Provided in relation to question 4 in EA form F1 – for information only - Supporting Statement claiming commercial confidentiality for IED_CBA_Tool_v6.17 Claimed Confidential*
15. Appendices Forms & Supplementary Information - *Provided in relation to question 6 in EA form F1 – for information only*

Executive Summary

Hope Cement Works is requesting a substantial permit variation application, Permit Reference EPR/BP3731VJ/V006, issued November 2020. The document details the request for a variation from the Emission Limit Value (ELV) of <400 mg/Nm^3 to be imposed on 01/04/2022, see Table S3.1 of the Permit. The derogation criteria under Article 15(4) of the directive primarily relates to the ***technical characteristics*** of the installation, which sit in combination with both the ***local environmental conditions*** and the ***geographical location*** criteria, in line with cl 4.39 of the DEFRA IED Guidance dated February 2013. The ***technical characteristics*** of the installation are such that they preclude the use of the shale reserves containing high levels of pyritic sulphur, even in conjunction with the installation of a wet scrubber. As detailed in section 5.2.1.3, the amount of sulphur retained within the kiln system if this material were to be used would lead to process control, reliability and quality issues, in effect rendering the kiln inoperable. The ***local environmental conditions*** relate to the chemistry of the remaining, available reserves of Hope shale, as described in section 3.0. The ***geographical location*** refers the installation's position within the Peak District National Park and the additional constraints that this place upon the site in terms of planning, which is expanded on in section 4.2 and 5.1.3.

The assessment within this paper provides a detailed explanation of the sulphur dioxide emissions background and current scope of activities at Hope Cement Works. It uses the BREF BAT Conclusions document to provide the basis of the consideration of the use of primary and abatement techniques in order to reduce emissions of SO_2 and ensure compliance to the BAT-AEL of <400 mg/Nm^3. The paper clearly demonstrates that the use of primary techniques, as detailed in the BATC document, is the preferred option from both an environmental benefit and cost benefit perspective. For clarity, partial shale substitution is the only viable solution for achieving both the reduction of SO_2 emissions and the long-term future of Hope Cement Works.

The following document discusses the control options and presents a cost benefit analysis (CBA). It is proposed that the Best Available Technique (BAT) for Hope Cement Works, given its current and future business plans, needs and processes is to minimise the SO_2 emission through the use of the primary techniques detailed in 1.2.1 of the BATC. This will be achieved by reformulating the raw material mix to substitute a percentage of the Hope shale content with a carefully selected, appropriate alternative. This option is considered BAT for environmental protection and enhancement and is substantially, the most cost-effective option. Hope shale is already being partially substituted as a matter of business need to secure the long-term future of the installation. In order to successfully achieve the required substitution rates, a new alternative raw material handling and storage infrastructure will need to be constructed at Hope Cement Works, subject to the successful approval of the planning application submitted by Breedon Cement LTD.

Hope Cement Works full planning application was submitted on the 01/10/2020 to the Peak District National Park Authority (PDNPA) to permit the installation of alternative raw material handling and storage infrastructure. Extensive delays to the planning application and approval process have now meant that the final application will be in front of the planning committee during May 2022. If approval is granted there follows a 6-week period in which the decision can be appealed and recent discussions with Peak District National Park Authority (PDNPA) have indicated planning permission could be subject to S106 legal agreements. S106 agreements are estimated to take 3 – 6 months to draft and agree following grant of planning, being pragmatic by w/c 5th September 2022 detailed design and construction processes could begin without risk. Breedon will therefore be unable to achieve the timescales set out within the previous derogation applications submitted 16/11/2018. These delays have been through no fault of Breedon Cement

LTD, and all deadlines have been met on time as required. The full details of the planning application process and associated delays are outlined in section 4.2.

It has therefore been deemed necessary that a further time limited derogation will be required to allow sufficient time for the planning approval to be granted and progression to detailed design, installation and commissioning of the alternative raw material handling and storage infrastructure.

Breedon Cement therefore requests a time-limited derogation to be granted until the end of **March 2025**:

SO_2 Daily Average ELV of 695 mg/Nm^3 to allow sufficient time for completion of the planning and implementation of the partial shale substitution project.

The proposed timescale stated above may be revised during the duly made process following the planning application being granted.

1.0 Introduction

Breedon Cement Ltd is submitting this document as part of a substantial permit variation application for Hope Cement Works, Permit Reference EPR/BP3731VJ/V006, issued 30/11/2020. The document details the request for a variation from the Emission Limit Value (ELV) of <400 mg/Nm^3 to be imposed on 01/04/2022, see Table S3.1 of the Permit. The paper provides a description of the scope of activities covered, the objectives of and reasons for the derogation request. It will go into the detail required by the Environment Agency's Cost Benefit Analysis in the discussion and comparison of the control options available. Finally, this document will present the specific details of the variation requested by Breedon Cement, for the installation at Hope Cement Works.

The derogation criteria under Article 15(4) of the directive primarily relates to the ***technical characteristics*** of the installation, which sit in combination with both the ***local environmental conditions*** and the ***geographical location*** criteria, in line with cl 4.39 of the DEFRA IED Guidance dated February 2013. The ***technical characteristics*** of the installation are such that they preclude the use of the shale reserves containing high levels of pyritic sulphur, even in conjunction with the installation of a wet scrubber. As detailed in section 5.2.1.3, the amount of sulphur retained within the kiln system if this material were to be used would lead to process control, reliability and quality issues, in effect rendering the kiln inoperable. The ***local environmental conditions*** relate to the chemistry of the remaining, available reserves of Hope shale, as described in section 3.0. The ***geographical location*** refers the installation's position within the Peak District National Park and the additional constraints that this place upon the site in terms of planning, which is expanded on in section 5.1.3.

2.0 Scope of Activities

Clinker is produced at Hope Cement Works from two kilns at a rate of approximately 2,000 tonnes per day per kiln. The installation aims to operate 24 hours per day, 7 days per week, with planned outages on each kiln annually for maintenance, repair and upgrade work. Limestone and shale are provided by on-site quarries as core raw materials and are transported into the Works, via field conveyors, where they are ground and dried, prior to blending and storage in silos. The resulting powder is then transported into the top of the four-stage pre-heater, from where it is fed into the kiln, having been heated by the up-flow of kiln exhaust gases. The kiln feed achieves a temperature of around 900ºC as it enters the inlet of the kiln. The pre-heated material passes through the rotary kilns, reaching a final temperature of approximately 1,450ºC in the kiln combustion zone. This causes the materials to convert into a combination of minerals known as clinker. Exhaust gases from the kiln process are released to atmosphere via bag filters (one filter dedicated to each kiln) and ultimately through the main 132-metre-high stack. The main heat source for each kiln is a multi-channel burner, which uses a combination of pulverised coal and non-hazardous waste derived fuels, each specifically permitted. Non-hazardous waste derived fuels are also fired into the inlet area of the kiln via the lower stage four of the pre-heater.

Hope Cement Works is the only cement manufacturing facility within the Breedon Cement GB portfolio, and currently contributes around 15% of the UK cement market share. In the event of cessation (i.e. loss of both kilns) of the cement supply from Hope Cement Works, Breedon Cement GB's only possible alternative would be to import clinker or cement from outside the UK, which is covered in more detail in 5.2.3.

The objective of this paper is to present a successful argument for a variation to the environmental permit, to consider all appropriate control methods, including the Best Available Techniques (BAT) detailed in the BAT Reference (BREF) document, to present the cost-benefit analysis of the options and compare the details. The paper will then determine the most appropriate control option for Hope Cement Works and propose how this will be implemented, in order to comply with the Permit and also meet the legislative requirements.

The variation application relates to the combustion process in both kilns, and the associated emissions of sulphur dioxide (SO_2) from the Main Stack. The Best Available Technique-associated emission level (BAT-AEL) is detailed in the BREF as follows:

"*for SOx from the flue-gases of kiln firing and/or preheating / precalcining processes in the cement industry*

BAT-AEL (daily average value) - SOx expressed as SO2 - < 50 – 400 mg/Nm^3"

The current Permit (Ref EPR/BP3731VJ/V006 states that this ELV must be achieved and complied with by 01/04/2022. The variation application seeks to obtain a higher ELV for a time limited period in order to gain planning permission to implement the significant process and infrastructure improvements required to achieve the lower ELV consistently.

3.0 Sulphur Dioxide – Background

Sulphur dioxide (SO_2) is generated by two mechanisms at Hope Works. Firstly, it is produced by the combustion of fuels, which, at Hope, are introduced at the clinker discharge (or front) end of the kiln and, in smaller quantities, at the gas riser from the kiln (or back end). Through the preheater, the combustion products are in intimate contact with alkaline materials, in particular within the lower, hotter stages of the preheater, with calcium oxide at temperatures up to 900ºC. Under these conditions the oxides of sulphur are absorbed by the lime with only insignificant quantities remaining for contribution to emissions. Secondly, SO_2 is produced by the clinker raw materials as they are heated in the presence of oxygen, in their travel from the point of input – between stages 1 and 2 (at temperatures less than 1000ºC) to the kiln.

Sulphur is present in two main forms in the raw materials: as sulphides and sulphates. As the temperature of the raw materials is raised, SO_2 is more likely to be formed from sulphides. This is because sulphates are more stable under the prevailing conditions in the preheater; consequently, the majority of the sulphur generated by sulphates is trapped in the clinker. The SO_2 from the oxidation of sulphides is, however, produced further up the preheater, where temperatures are lower and there are small amounts of CaO (free lime) and therefore the SO_2 absorption rate is low. As a result, the SO_2 has a greater chance of escaping to the atmosphere through the Main Stack. In normal operating conditions, about 45% of the hot gases coming from the preheater tower are sent directly to the raw mill circuit, the rest (~55%) being sent to the bag filter. This distribution is naturally obtained when the relevant circuit damper is opened fully at 100%. When the raw mill circuit is not running, 100% of the hot gases from the preheater are sent to the bag filter. It has been observed that the SO_2 levels at the stack are noticeably higher than those seen when the raw mill circuit is running. The raw mill is therefore considered as providing some level of SO_2 scrubbing. The SO_2 absorbed in the mill forms calcium sulphite ($CaSO_3$).

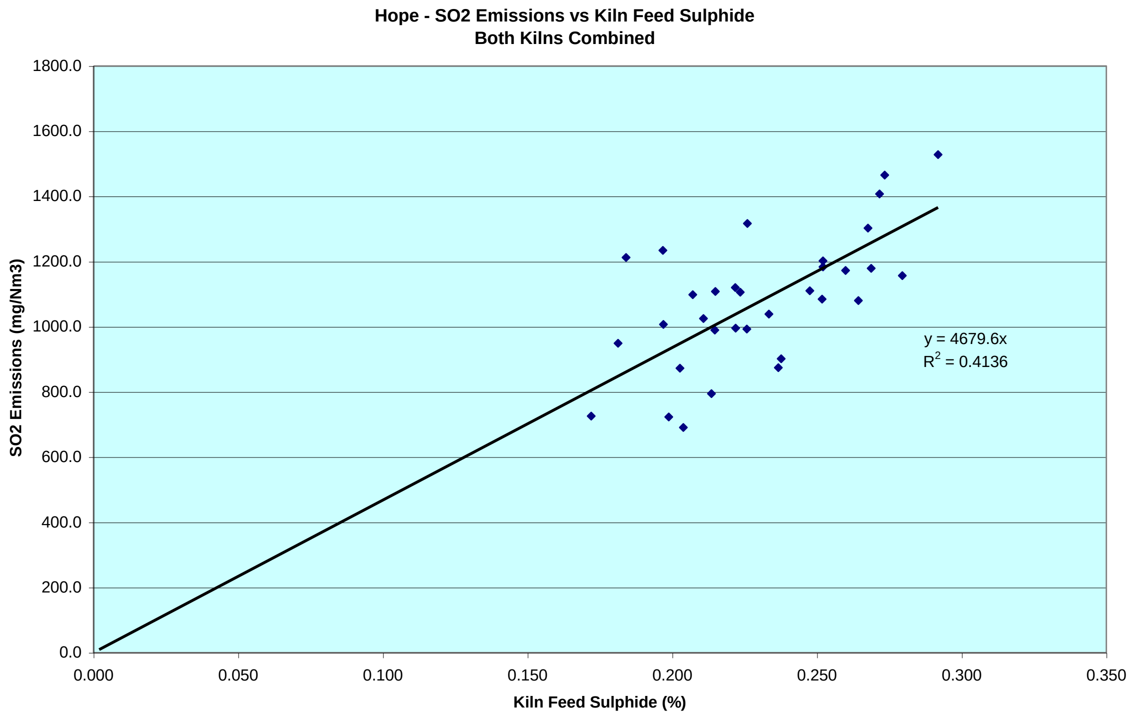
Pyritic sulphur (present predominantly as FeS_2) will generate SO_2 when material is heated above 450-600°C, corresponding to the upper (1^{st} & 2^{nd}) stages of the Hope preheater tower. The form of the pyrites in the raw meal is often small crystals or assemblies of crystals embedded in the individual meal particles. The retention time for the particles in the upper part of the preheater, and the size of the individual pyrite-containing particles, together with their type and form, are all parameters decisive for the rate at which the SO_2 is formed and therefore, the fraction, typically between 40% and 60% of the potential SO_2 from the sulphide, that will be emitted. Analysis has determined that at Hope Works, this fraction is around 40%.

As an exercise to demonstrate the relationship between kiln feed sulphide and emitted SO_2 and to predict the change in expected levels of emitted SO_2 where the raw material chemistry changes in the future, a sampling exercise was carried out, with kiln feed sulphide being measured for a range of emitted sulphur dioxide levels (See appendix 9). Only SO_2 emissions when the raw mill was not running were used, as this shows the lowest level of absorption and is a required operating condition. SO_2 levels with the raw mill running are considerably lower due to absorption in the mill. The running of the mill is determined by kiln feed quantity requirements, whist the kiln running time is maximised to meet market demand. The raw mill is not normally running whilst the kiln is stopped. The emitted SO_2 was based on a 4–hourly average to correspond with the sampled kiln feed.

These results show again that there is a correlation between the SO_2 and kiln feed sulphide and that if there was a low level of sulphide in the kiln feed, the emitted SO_2 would also be low. The SO_2 generated from the fuels is absorbed by the raw materials.

The trial results have confirmed most of the cement industry's accepted knowledge concerning SO_2 generation, trapping and environmental emissions. The specific data obtained at the Hope plant indicates that there is a range from very little to no impact from sulphur in fuels on SO_2 environmental emissions, in a stabilised process condition.

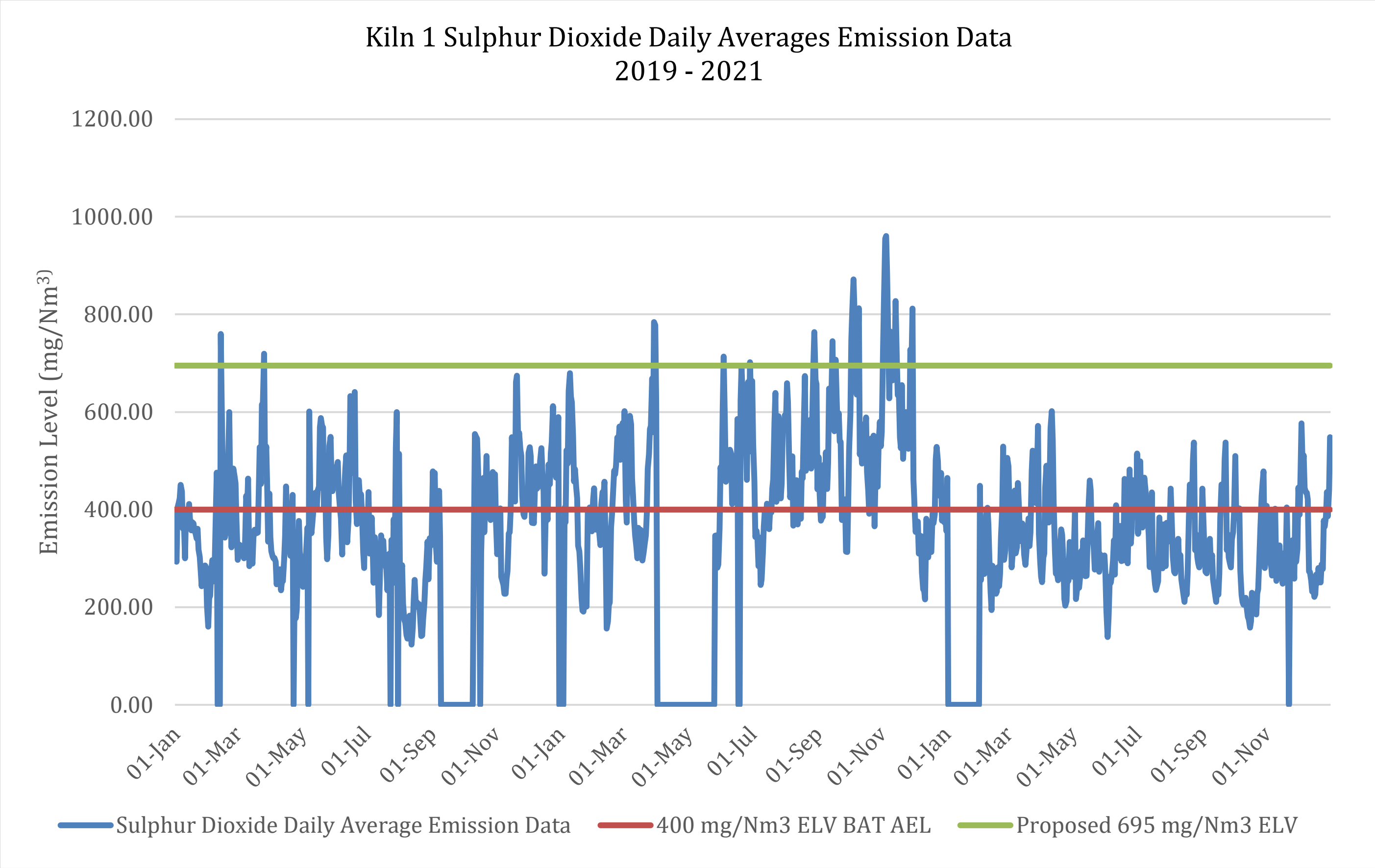
The results of the analysis are as follows:

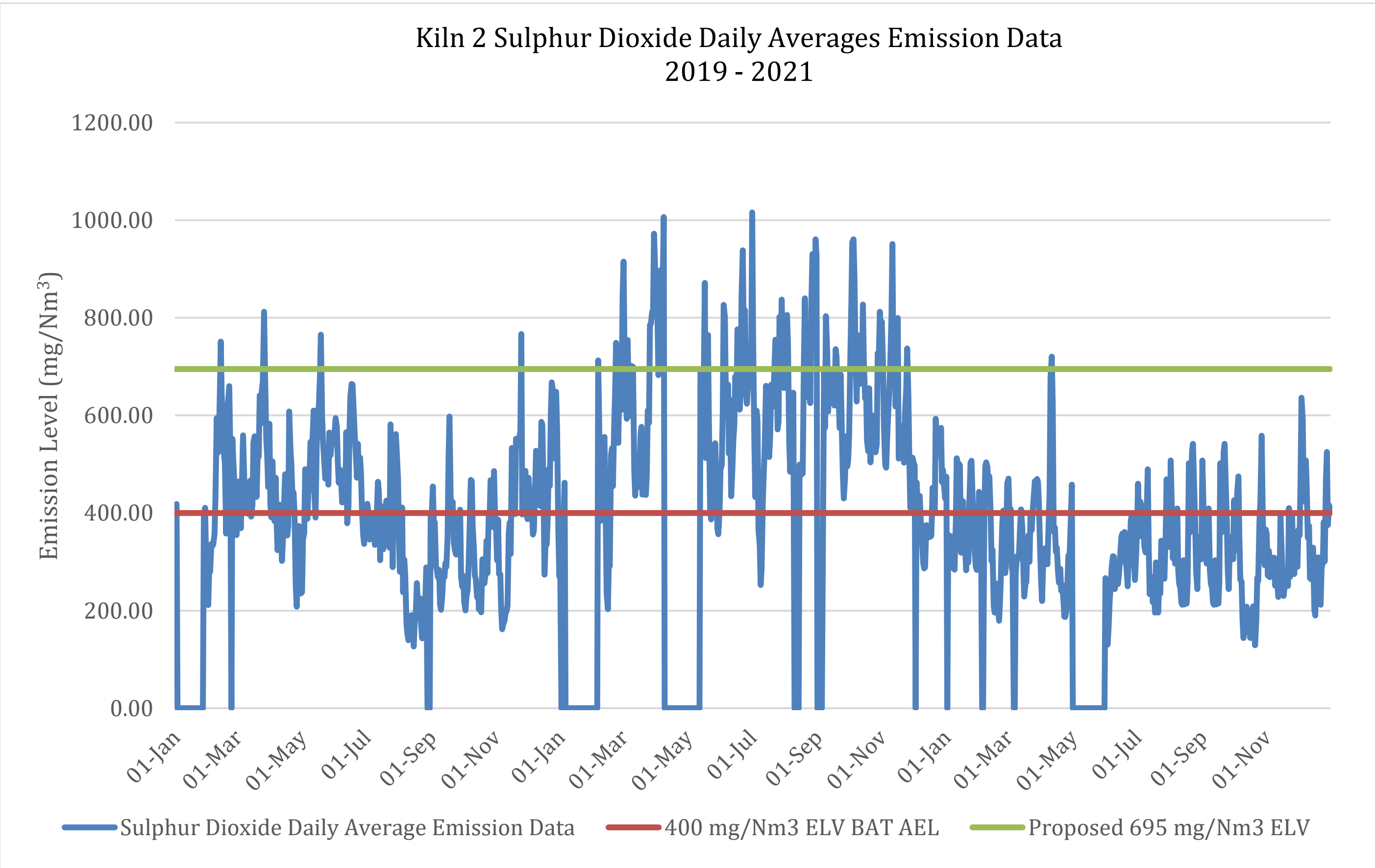


3.1 Emissions Performance

3.1.1 SO_2 Emissions Profile & Recent Performance

Daily average SO_2 emission data for Hope Cement Works has been collated from January 2019 to December 2021 for Kilns 1 and 2. This data is shown in the graphs below plotting emissions data against the derogated 695mg/Nm^3 ELV and the 400 mg/Nm^3 BAT AEL:


Kiln 1 Sulphur Dioxide Daily Averages Emission Data
2019 - 2021
Emission Level (mg/Nm3)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
Sulphur Dioxide Daily Average Emission Data
400 mg/Nm3 ELV BAT AEL
Proposed 695 mg/Nm3 ELV


Kiln 2 Sulphur Dioxide Daily Averages Emission Data
2019 - 2021
Emission Level (mg/Nm3)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
01-Jan
01-Mar
01-May
01-Jul
01-Sep
01-Nov
Sulphur Dioxide Daily Average Emission Data
400 mg/Nm3 ELV BAT AEL
Proposed 695 mg/Nm3 ELV

Since the start of 2019, both kilns have remained at a good level of compliance with the daily average SO_2 ELV of 695 mg/Nm^3. A summary of both kilns' performance can be found in Table 1 and 2 below;

Table 1				
2019 - 2021				
KILN 1	Days Less than 400 mg/Nm^3 ELV	% Compliance with 400 mg/Nm^3 ELV	Days Less than 695 mg/Nm^3 ELV	% Compliance with 695 mg/Nm^3 ELV
	551	57%	873	91%

Table 2				
2019 - 2021				
KILN 2	Days Less than 400 mg/Nm^3 ELV	% Compliance with 400 mg/Nm^3 ELV	Days Less than 695 mg/Nm^3 ELV	% Compliance with 695 mg/Nm^3 ELV
	541	57%	863	90%

Since the issue of the revised permit and the derogated SO_2 ELV was received 30/11/2021 only one exceedance of the 695 mg/Nm^3 has been recorded on No.2 Kiln.

This improved performance has been due to three main operational factors:

1) Operating with a base level of shale substitute in the raw mix – Hope Cement Works is currently trialling three sources of conditioned PFA brought in via road and further sources will be trialled later in 2022. To minimise the local impact of this operation, this is currently circa 12 loads per weekday which enables development of understanding in relation to the impact on the manufacturing process. This has improved the consistency of shale substitution and also reduced the time that the kilns operate solely on Hope shale in the raw mix. It must be noted that, during the trial period, this conditioned ash supply is not subject to a contract and could be terminated at any time. Hope also carried out a small-scale handling trial off site of low sulphur shale. A key objective for Hope is to have multiple materials tested at the plant so that following planning permission being granted, there is less risk associated with signing commercial agreements for suitable materials.

2) Utilising ROS PFA from other sources – Hope Cement Works is also utilising a source of biomass-derived PFA when available from another power station which is also under contract until the end of 2022. This is currently being used at the maximum rate possible considering the alkali content of the incoming material and its impact on clinker composition.

3) Raw meal sulphur content control – As described in section 3.1.2 below, the current control strategy for the sulphur content of the raw meal has been standardised and improved. The ability to cope with fluctuating amounts of PFA, due to availability, as well as an improved knowledge of the shale quarry chemistry has helped to enable this. The current target is unsustainable in the longer term without some form of shale substitute as it will consume the existing reserves of lower sulphur shale within the Hope Cement Works shale quarry.

3.1.2 Current Control Strategy

The sulphur content within the shale is very variable. The upper 15m of Hope's shale reserve is classed as low to medium sulphur shale, containing SO_3 levels typically <3%. The next 13m depth of reserve is classed as med/high sulphur shale with an SO_3 content ranging typically between 3-7%. Below this point, we classify the shale as ultra-high sulphur with an SO_3 content above 7%. The blends of high, medium and low sulphur shales used for raw mix have to be monitored continually and adjusted as the SO_3 content of the different shales vary.

Raw meal samples are taken hourly and analysed by the laboratory. The resultant SO_3 content of the raw meal is displayed continually on the site's Process Information system. Actions are taken during operation to control the SO_3 levels if they deviate from target. Quarry management monitor the raw meal SO_3 results daily and instruct the shale extraction operators to increase or decrease the amount of high sulphur shale input into the blend to maintain the raw meal SO_3 target.

Quarry management monitor the raw meal SO_3 results on a daily basis and instruct the shale extraction operators to modify the shale blends by adjusting the ratios of low/med or high sulphur shale sulphur shale input to maintain the raw meal SO_3 target.

Representative samples of shale being crushed are collected from the shale quarry on a daily basis and analysed by the laboratory. These results are displayed on the AQCNet quality information system, and this provides supporting data to inform of changes in the SO_3 content of the shales being extracted. Consideration will be given to any unexpected chemistry data and this will be fed back into the quarries development reviews.

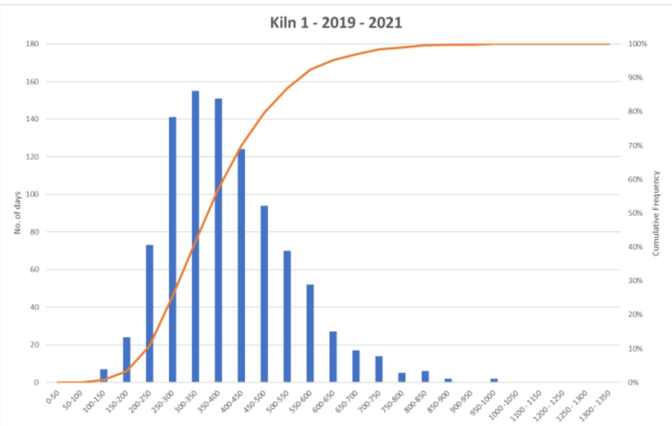
Furthermore, the shale extraction team are instructed only to feed low sulphur shale at the start of each day as part of the blending process. This is to avoid a sudden spike of high SO_3 raw meal being produced which could cause process instability and elevate the SO_2 levels in the kiln exhaust gas. From January 2022 the shale extraction team is under full time employment of Breedon rather than being a contracted operation. This allows improved control and consistency of shale extraction.

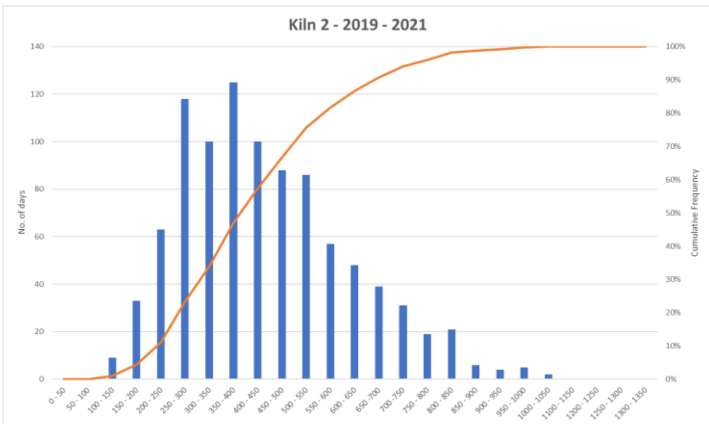
Kiln exhaust gas emissions, including SO_2, are continually monitored, levels and this information is displayed on the environmental screen in the Control Room. The control strategy for Raw Meal Sulphur control is set out within Appendix 1, standard operating procedure HSQ-SOP1-Raw Meal Sulphur control.

This strategy will not be subject to change as a result of this application but will be revised to incorporate eventual changes as a result of increased shale substitution, enabling us to meet the BAT-AEL whilst maximising shale reserves.

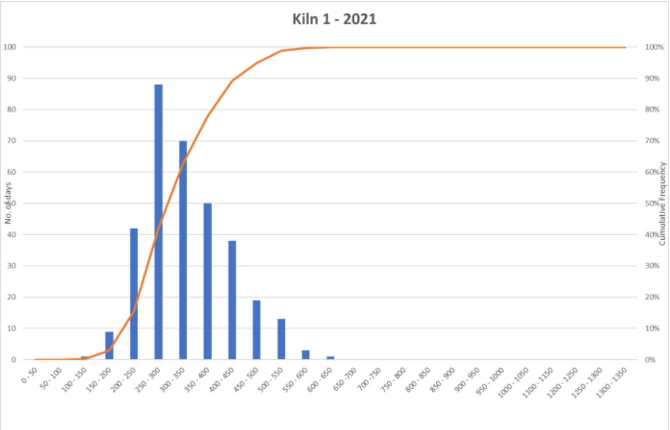
3.1.3 Assessment of Potential Future Reduction in SO_2 ELV

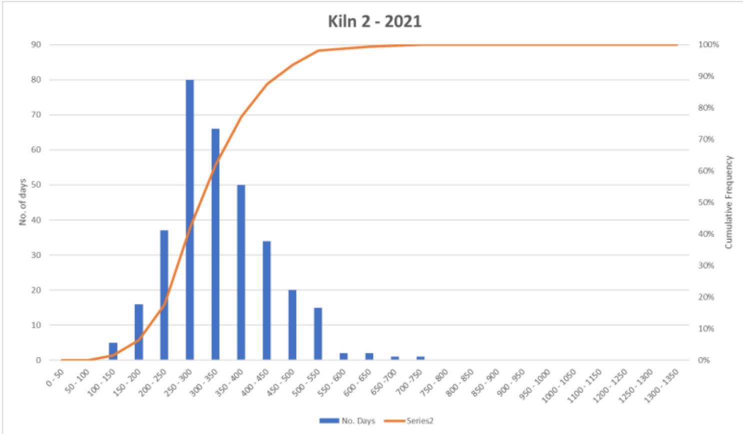
As explained above, in section 3.1.1, compliance with the current permitted SO_2 ELV of 695 mg/Nm^3, is shown in the below histograms.





This data shows that the achieved compliance with the BAT-AEL between January 2019 – Dec 2021. The daily average SO_2 ELV of 400 mg/Nm^3 was only achieved for 57% of valid days for both Kiln 1 and kiln 2. This would suggest that compliance with the BAT-EAL using the current operational techniques remains unachievable. Looking at the data for the period from 2021 onwards, does show performance has significantly improved.





Based on 2021 performance it should be possible to achieve consistent compliance, with a daily SO_2 ELV of 695 mg/Nm^3, and compliance with the BAT AEL 400 mg/Nm^3 around 70% of the time, using the current strategy and infrastructure. It is believed that it will be possible to maintain this level of performance in the short - term, until a shale alternative and the system to handle it is in place.

As noted above there is potential supply risk associated with the conditioned PFA, as no formal contract exists with the supplier at this time. However, given the operational importance of such a supply, it is believed that such material will be sourced continually until a permanent solution is in place. Fundamentally, despite the improved level of compliance, a permanent solution has not been implemented.

3.2 Current Dispersion Modelling

Detailed dispersion modelling was commissioned in 2022 by Bureau Veritas utilising the ADMS 5 version 5.2.4 modelling Software, (See appendix 2). This model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the EA and local authorities.

The assessment included the predicted impacts of emissions to air of sulphur dioxide on local human and ecological receptors. Hope Cement Works provided Bureau Veritas with stack parameters and emission data from continuous emission monitors (CEMs) between 2019 - Dec 2021. The updated dispersion modelling considered two scenarios:

- **Scenario 1**: Based on actual daily average running emissions from 1st Jan 2019 – 31st Dec 2021;
- **Scenario 2**: Operation at the current Emission Limit Value (ELV) of 695 mg/Nm^3 (per kiln) *i.e. a worst case scenario daily average emission of 695 mg/Nm^3 every day*

The dispersion modelling concluded that for both scenarios, Predicted Environmental Concentrations (PECs) of sulphur dioxide did not exceed the relevant Air Quality Assessment Levels (AQALs) at any of the human receptors assessed. It is therefore unlikely that there would be any significant effects to human receptors from either modelled scenario.

The air dispersion modelling also considered ecological receptors. Results from the assessment indicate that at all ecological sites considered, there are no exceedances of the relevant long-term AQAL at any of the assessed ecological sites. The predicted environmental concentration was greater than 70% of the long-term AQAL at one of the sites considered (73.5%) in scenario 2. It should be noted that the PECs are based on the worst-case background concentrations, due to the use of Defra's 2001 background maps.

Considering scenario 1 as the likely operational norm for the duration of the proposed derogation period, it would be reasonable to conclude from the impact assessment that there would be minimal human or ecological impact from sulphur dioxide emissions and no exceedances of the relevant long term AQALs at human or ecological receptors.

4.0 Permit Variation Detail

As outlined above Breedon Cement requests the following time-limited derogation to be granted until the end of **March 2025**:

SO_2 Daily Average ELV of 695 mg/Nm^3 to allow sufficient time for completion of the planning and implementation of the partial shale substitution project.

4.1 Variation Application

The following section outlines the proposed alternative raw material project in more detail and sets in context the reason for the variation application, explaining what issues have arisen and what progress has been made since the previous application.

4.1.1 Hope Shale Replacement Project

To identify the best practical option for infrastructure at Hope Cement Works to allow the importation of alternative raw materials which will partially replace shale quarried at Hope a front-end engineering design (FEED) using WSP has been completed. This included:

- Material handling methods
- Rail offloading methods
- Identification of storage and dosing locations
- Operational and control methods
- An order of magnitude (+/- 25%) cost estimate
- Detailed material handling characteristics of PFA which is expected to be the most problematic material the system will need to handle

4.1.1.1 Infrastructure

Hope Cement Works' rail yard is connected to the Hope Valley mainline by a 1.8 km branch line owned and operated by Breedon Cement Ltd which is currently used to transport cement, coal and dry PFA wagons.

The interface between the branch line and Network Rail's infrastructure is Earles Siding which is operated by Freightliner Heavy Haul. The proposed scope of infrastructure changes do not significantly affect either the branch line or Earles Siding with both configurations remaining largely as current. Relatively minor configuration changes on the branch line have been proposed to the Peak District National Park Authority (PDNPA) to improve noise mitigation which include removal of a set of points and the installation of a noise attenuation barrier, although these and other similar measures are subject to review by the PDNPA at the time of writing.

The rail yard at Hope Cement Works consists of sidings labelled A to G with the following main features:

- A Point cement loading
- B Point cement loading
- C Point cement loading
- Coal tippler / unloading station
- PFA (run of station) pressure unloading
- Locomotive repair workshop
- Wagon repair workshop

It is proposed to reconfigure the rail yard to allow the unloading of materials with similar properties to Hope shale with the exception that they contain lower levels of pyritic sulphur than Hope shale. The concept study identified C & D sidings as the most suitable location to site an unloading station for such alternative raw materials. Having been transported into Hope Cement Works by rail, the unloading station will be either:

- Mechanised grab emptying MWA type rail trucks
- Container tippler which will invert container type wagons to remove the material

In addition to the unloading station, which will be 50 m long, remodelling of various rail turnouts within the rail yard will be required and an additional siding which will be known as “H”. The general layout / scheme can be found in Appendix 3. This may be subject to change following detailed engineering design and the planning approval process.

At the train unloading station an enclosed overhead conveyor will be installed to transfer material to a newly built material storage building located behind the main office on the area currently known as the contractor’s compound.

The proposed material storage building will be fully enclosed and will also be able to receive material from road going tipper trailers to allow minor raw mix additions such as alkali adjusters to be accurately blended into the system. There are two potential configurations of equipment within the material storage building:

- Front end loader (FEL) which will feed material into blending hoppers
- Mechanical overhead grab which will feed material into blending hoppers

Post the blending hoppers, two conveyors contained within an enclosure, will be installed to convey the material to the raw mill feed conveyors 16 and 17. The feed system to the conveyors will be a dosing system to allow accurate control of raw meal composition.

All infrastructure, equipment and operational techniques will meet the requirements of BAT and all the installed equipment is within an established section of the works with negligible visual impact. Please note external colour schemes will be agreed with PDNPA during the planning process.

Time frames for the design, planning and construction of the proposed infrastructure can be seen in table 3 below:

Table 3

Activity	Timescale	Completion
Planning approval*		Mid May 22
Period for planning decision challenge	6 weeks	30th June 22
Period for drafting & agreement of S106	10 weeks	5th September 22
Mechanical equipment tender	7 weeks	31st October 22
Initial mechanical equipment supplier design	4 weeks	28th November 22
Detailed Mech equipment design	4 weeks	31st December 22
Civil / elec / mech design for tender	10 weeks	11th March 23
Main contractor tender period	8 weeks	6th May 23
Construction civils design	7 weeks	24th June 23
Contingency – preconstruction	2 weeks	8th July 23
Construction	18 months	8th January 25
Contingency - construction	4 weeks	5th February 25
Commissioning	4 weeks	5th March 25

Note – If Planning permission is refused an additional 12 months will be required for a planning appeal

4.1.1.2 Operation

These alternative raw materials will arrive by rail into Earles Sidings. If arrival into the Earles Sidings does take place during the night, they will be collected after 07:00 by Breedon personnel and taken up the branch line into the works rail yard. Please note that the night time movement of such materials will be avoided wherever possible in line with planning conditions to be agreed. During the day the rail wagons will be emptied, and the material transferred by conveyor to the material storage hall. It will be stored here until it is required and will then be dosed by weigh feeders into the raw mill process via conveyors. All equipment will be controlled by the plant distributed control system (DCS) allowing the automation of operation and continual monitoring.

The empty rail wagons will be stored in the rail yard after emptying until they are transported down the branch line back to Earles Sidings before 22:00. All equipment installed will be designed to allow the emptying of a train within the day. It is anticipated that a complete train of MWA type box wagons will contain up to 1,500 tonnes of material. The infrastructure and equipment are sized to provide the capacity for the complete replacement of Hope shale in the future. Table 4 below illustrates the estimated volumes that the plant will be designed to handle.

Table 4: Volume estimates		
Description	**Initial anticipated run rate**	**Maximum run rate**
Annual tonnage per year, *note worst case assumed of 25% moisture*	145,600	436,800
Trains per year	104	312
Trains per week	2	6
Storage Capacity (te)	8,000	8,000

4.1.1.3 Ecological impact

Breedon Cement Ltd commissioned BSG Ecology in Sept 2020 to undertake an extended Phase 1 habitat survey of the site, in order to identify habitats or species that may be affected by the proposed works (see Appendix 4), and to provide a preliminary ecological assessment based on currently available information.

The report concluded that the proposed infrastructure would have no impact on any of the Sites of Special Scientific Interest (SSSI's) located within 2 km of the site. No protected species or notable species of bird were recorded within the proposed area of development. The works will be completed using the methodologies set out within the ecological survey where applicable.

Breedon has committed to habitat enhancement and creation to ensure the project achieves a biodiversity net gain of 13% during construction to, and 121% net change from operational phase to restoration. Detailed plans of the habitat development can be found in Appendix 4.

4.1.1.4 Noise Impact

In order to satisfy the Peak District National Park (PDNP) Mineral Planning Authority noise conditions, environmental noise monitoring is carried out at Hope Cement Works on a 3-yearly basis. The conditions state that noise from site operations, including vehicle movements, should not exceed specific limits at five sensitive receptors during day, evening and night hours including weekends.

The most recent survey was conducted in November 2020 by SOCOTEC UK over a 24-hour period at the five locations, for one-hour periods on a rotational basis. Based on the results of this survey (see appendix 5), none of the limits are likely to be exceeded when noise sources, not associated with the plant are removed from the measurements.

A noise and vibration assessment was undertaken for the proposed development's outlined in 4.1.1.1 The assessment considered both the construction and operational phases, to assess the potential impact at nearby existing sensitive receptors (ESRs).

The assessment has shown that both existing and proposed operations will not have a significant impact at receptors when assessed over a 16-hour daytime period.

The assessment summarised that the effects of noise during operation of the proposed ARM facility is not significant in environmental impact assessment (EIA) terms, and the effect of noise and vibration during construction was found to be not significant in EIA terms. However, the use of best practice during construction would be employed to reduce the potential impact and examples have been provided within the planning application.

Despite the above conclusions from the assessment, additional noise mitigation measures have also been considered for implementation following feedback received during public and statutory consultation. These are outlined in detail within of the planning application and in Appendix 5 of the evidence pack submitted with this application. The mitigation measures focus predominantly on reducing the noise impact from rail operations and movements on the Hope branch line.

4.2 Justification for Variation Application

Progress reports have been submitted to the Environment Agency in accordance with the requirements of improvement condition IP16 of the current permit. These reports include details of both performance against the BAT-AEL of 400 mg/Nm^3, the existing 695 mg/Nm^3 as well as progress on the planning application and infrastructure installation of the shale replacement project. See Appendix 6 for copies of progress reports submitted as part of improvement condition IP16. The key reason for the timescales of the original derogation not being achieved is due to delays associated with the planning application process

At the time the previous derogation request was being submitted (Q3 2018) and duly made (Q1 2019) Breedon Cement LTD planning application was in its early stages with the Peak District National Park Authority PDNPA and local community liaison committee. An initial pre application advice request was submitted to the PDNPA on the 4th April 2019.

Pre-application advice was received from PDNPA 30th August 2019, noting a divergence from our business view that the project is classified as “major development” and would require a full Environmental Impact Assessment (EIA). This added significant complexity to the application, with the Environmental Impact Assessment (EIA) being just one aspect. Breedon does not consider the application to be classified as major development for a number of reasons, including:

- The proposed installation being an industrial building, located well within the boundary of an existing industrial complex and in keeping with the general manufacturing equipment & buildings
- There would be minimal visual impact from off site (Refer to Appendix 3 of the evidence pack submitted alongside this document)
- The development would be constructed on land with minimal ecological value that already contained buildings used for an industrial purpose

The primary driver for the PDNPA’s decision to determine the application as major development appears to be the size of the main storage building and the potential visual impact on the surroundings. There were other less critical elements listed within the preapplication document that also contributed to this decision. The pre application advice document is a long complex document, requiring competent legal advisors to assist with its interpretation in full. Although Breedon did not agree with decision, the PDNPA formed their opinion following their own policies and processes. The EIA has therefore been just one of several time-consuming additional requirements generated due to this opinion.

From Sept 2019 until Sept 2020 elements of the EIA were being prepared, it is also worth noting that in common with most sectors of the UK we incurred delays associated with Covid-19 lockdowns and restrictions.

Physical and virtual public consultations were held in August and September 2020, Breedon did take the decision to delay consultation marginally, this was to ensure that a physical offering could be made which ensured accessibility to the consultation to all stakeholders.

The full planning application was submitted on the 1st of October 2020 incorporating feedback from the consultation processes and validated by the PDNPA on 28th October 2020. It should be noted that there was an immediate request from the PDNPA for an 8-week extension to the statutory determination period

Since the application has been submitted and validated, numerous extensions of time have been granted to the planning authority for various reasons such as Covid-19, resource shortages & changes to planning personnel. In addition to these delays, public consultation produced a considerable amount of additional work with regards to rail noise on the Breedon branch line & Network Rail Sidings operating by Freightliner Heavy Haul to achieve a position closer to environmental betterment.

A re-write of the relevant environmental chapters to include the work carried out in response to consultation processes was submitted on Dec 23rd 2021 based on conversations with PDNPA. Whilst it was expected that the application would be in front of the planning committee 11th March 2022, it is now believed there will be a further delay until at least May 2022. This is due to some elements of the resubmitted information having to go back out for consultation.

If approval is granted there follows a 6-week period in which the decision can be appealed and recent discussions with Peak District National Park Authority (PDNPA) have indicated planning permission could be subject to S106 legal agreements. S106 agreements are estimated to take 3 – 6 months to draft and agree following grant of planning, being pragmatic by w/c 5th September 2022 detailed design and construction processes could begin without risk.

Construction timelines had been estimated at 18-20 months however with the current post expansion construction boost we feel this will be 24-26 months including detailed design, procurement, deliveries, construction & commissioning. If planning permission is declined Breedon would appeal the decision to the Secretary of State with an anticipated timescale of 12 months.

Expenditure for the project will receive sign off once the planning application has been granted. The business leadership team including CEO and Board have been briefed throughout and are aware of both the significance and need to have funding available when required

Breedon Group have been actively identifying reserves both internal and external to the business, and we are now confident there is adequate material availability based on the extensive evaluation process which has been completed.

The aforementioned delays to the planning application and approval process, have therefore prevented Breedon from meeting the timescales set out within the previous derogation application, these delays have been through no fault of Breedon Cement LTD, and all deadlines have been met as required by the planning authority. It has therefore been deemed necessary that a further time limited derogation will be required to allow sufficient time for planning approval to be granted. This will give sufficient time to complete the detailed design, installation and commissioning of the alternative raw material handling and storage infrastructure.

5.0 Control Options

The BREF BAT Conclusions document (BATC) provides details of the BAT to be implemented, in order to achieve the revised BAT-AEL. The detail copied directly from the BATC is as follows:

“1.2.6.2 SO_x emissions

In order to reduce/minimise the emissions of SO_x from the flue-gases of kiln firing and/or preheating/precalcining processes, BAT is to use one of the following techniques:

Technique

a) *Absorbent addition - Absorbent addition is, in principle, applicable to all kiln systems, although it is mostly used in suspension preheaters. Lime addition to the kiln feed reduces the quality of the granules/ nodules and causes flow problems in Lepol kilns. For preheater kilns it has been found that direct injection of slaked lime into the flue-gas is less efficient than adding slaked lime to the kiln feed*
b) *Wet scrubber - Applicable to all cement kiln types with appropriate (sufficient) SO_2 levels for manufacturing the gypsum*

Description

Depending on the raw materials and the fuel quality, levels of SO_x emissions can be kept low enough to not require the use of an abatement technique. If necessary, primary techniques and/or abatement techniques such as absorbent addition or wet scrubber can be used to reduce SO_x emissions. Wet scrubbers have already been operated in plants with initial unabated SO_x levels higher than 800 – 1000 mg/Nm^3."

The use of primary techniques, and the two abatement options detailed in BATC 1.2.6.2. will be discussed in this paper, along with a cost benefit analysis of the most relevant options. There is a need for a specified amount of sulphur in the raw material mix, for the production of a high-quality clinker. The sulphur balance is critical to clinker quality and consequently is closely managed through the input of an appropriate blend of high and low sulphur shale, together with carefully selected alternatives.

5.1 Use of Primary Techniques

BATC 4 states the following:

> *"4. In order to prevent and/or reduce emissions, BAT is to carry out a careful selection and control of all substances entering the kiln.*
>
> ***Description***
>
> *Careful selection and control of substances entering the kiln can reduce emissions. The chemical composition of the substances and the way they are fed in the kiln are factors that should be taken into account during the selection."*

This conclusion refers to the careful selection of all materials entering the kilns, both raw materials and fuels. The selection processes applied to fuels, including waste derived fuels is achieved through the implementation of BATC 6 (1.2.3 Energy consumption and process selection) and BATC 11 (1.2.4 Use of Waste). Details of all raw materials and fuels permitted are contained within the Environmental Permit, Schedule 2, Table S2.1.

The use of natural raw materials is dependent upon availability, and typically a cement plant will be located in an area where the necessary raw materials may be available. The selection and use of raw materials is a primary technique described by the BREF useful in the reduction or minimisation of emissions. It is acknowledged that whilst changing raw material sources is an unusual practice for an operation of this size, it is not without precedent within the UK.

5.1.1 Partial shale substitution

There are approximately 4.15 million tonnes of shale reserves currently available for extraction and use in the cement clinker manufacturing process and, if all this reserve were usable, would supply the plant with sufficient raw material to maintain operations until around 2032. So, even if it were all of a suitable quality for clinker production some additional volumes of a shale-like material would be required to match the limestone reserves. These shale reserves, however, are not uniform and have varying concentrations of sulphur content in the form of sulphides and so this total tonnage does not consider the blending requirements which are required to manage the material quality and, therefore, the kiln process conditions and stack emissions due to the variability of this sulphide content. Taking this into account the proven usable shale reserves are only 0.999kT, which represents only **3** years of supply to the cement clinker manufacturing process assuming no substitution of shale with other secondary raw materials (projecting forward from 2021). This would mean the cessation of cement production at the site in 2025, which is plainly not the intention of Breedon Cement. It is therefore of paramount importance to the operation that some means of increasing the availability of shale-like materials is identified to match the limestone reserves and maintain production at the Hope Works site.

Table 4 below shows the change in reserves and quarry life as partial shale substitution is increased. These are the latest shale reserves, which assume a best-case scenario that all the proven shale reserve is usable in the process, including some higher sulphur shales within the 0.999kT. This does not include the 2.8 million tonnes of ultra-high sulphur shale reserve which cannot presently be used in the process as it would lead to an increase in shale sulphur of between 300 and 400%, resulting in estimated SO_2 emissions of up to 4,000 mg/Nm^3. However, at higher substitution rates it may become feasible to use some of the ultra-high shale reserves. Reserves remain under constant review, as a normal part of quarry and reserve management.

Table 4: Shale Quarry Proven Reserves & Depletion with Differing Substitution Rates (Jan 2022).	
Proven Shale Quarry Reserves – **999,000** tonnes	
Shale Only	**3** years
Shale with 5% substitution	**4.5** years
Shale with 10% substitution	**9.1** years

To extend the life of the shale quarry and control SO_2 emissions, Hope Cement Works has used conditioned and run of station PFA as an appropriate shale replacement. PFA is imported by road and rail and is used to substitute the shale at a ratio determined by availability and process conditions. The PFA substitution ratio has typically varied between 2% and 8% of the total raw mix, dependent upon operating conditions, quality parameters and, increasingly, material availability. The material is imported to Hope Cement Works via rail, currently under Planning Permission NP/HPK/0710/0665. This gives approval for the import of 150,000 tonnes of PFA per annum by rail for the use as an additive in the grinding of cement. The permission also gives approval for 100,000 tonnes of PFA to be imported by rail as a substitute low sulphur content raw material to replace shale. As shown in table 4 Hope Cement Works needs the ability to import up to 440,000 tonnes per annum of low sulphur content secondary raw material as a shale replacement in order to achieve a sufficient substitution rate of secondary raw materials and thus match the overall reserve of secondary raw materials with that of the primary raw material (limestone), more if the limestone quarry extension is approved. This will require an amendment to the existing planning permission. As previously stated, due to the significant reduction in run of station PFA availability, other alternative secondary low sulphur raw materials will need to be imported. This will require significant further investment at the cement works and a new planning permission.

As outlined in section 3.0, partially substituting the sulphur-rich shale with lower sulphur alternative materials reduces the input of pyritic sulphur to the process, reduces the emissions of SO_2 from the main stack and is, therefore, a primary technique for SO_2 abatement.

This option is looked at in three scenarios within the CBA. The first is to achieve a lower ELV of 695 mg/Nm^3, as mentioned above, whilst the new importation system is installed, which will enable the goal of utilising sufficient shale substitution materials to enable the long-term operation of the works. This is proposed to be the preferred option for Hope Cement Works. The second, which will ensure the achievement of BAT-AEL from the 1st April 2022, is to cease clinker production at Hope Cement Works until the new system is in place and operational. As is detailed below, in section 5.2.3, the costs of doing so would, however, be catastrophic to the Breedon Cement GB business. Finally, the third is to use this technique in conjunction with the use of a wet scrubber.

5.1.2 Advantages

As stated above, the need to extend the life of the shale quarry is a pre-existing business condition as there is only 3 years of suitable shale reserve left without any substitution with alternative, low sulphur secondary raw materials. Increasing partial shale substitution early enough will extend the life adequately to enable the continued use of a shale blend, and facilitate the appropriate consideration, selection and introduction of a permanent substitute, or combination of substitutes for the shale.

The increase in partial shale substitution will provide several environmental benefits which are desirable for the installation and its activities. As the substitution rate is increased, the emission of SO_2 from the installation will reduce and comply with the appropriate BAT-AEL, when shale substitution is optimised with an appropriate alternative. The replacement of shale at Hope Cement Works will have a minimal impact on power consumption, as any new infrastructure would tend to use mechanical, rather than pneumatic conveying, to deliver the material to the process. There is a zero impact on water consumption.

The ability to use a waste material, if conditioned PFA can be sourced and made available, respects the waste hierarchy, as to recover and reuse is higher up than disposal.

5.1.3 Disadvantages

The environmental disadvantage of partial shale substitution primarily consists of a potential rise in import traffic into Hope Works, as the tonnage of shale replacement is increased. This element of the project will require planning permission from the PDNPA, to ensure that an adequate tonnage can be imported using the most appropriate method i.e. rail. There are potential objectors to this transport method in the local communities, which will be of significance to the PDNPA, and which will require careful control and management. Quarry operations at Hope Works are to be the subject of a complex planning permission application, to agree future working and restoration schemes for both quarries. The permitted tonnage of imported shale replacement, and also rail and road movements generally, will be an element of the application. The planning process is detailed, complex and requires a significant contribution from the organisation, in order to meet the needs of the installation, the community and the regulators. There are pre-work requirements which include investigation and consultation, to be completed to inform the planning permission process and prior to the application being made. Once the pre-work is complete and has been agreed by the authorities, the information will be used in the completion of a formal planning permission application and submitted to the PDNPA for consideration. This process generally takes a considerable length of time. The planning authority may wish to impose a Section 106 legal agreement to cover certain planning conditions which will add yet a further level of complexity and time extension for the process. These factors need to be accommodated into the wider business plans.

Examples of previous projects at Hope Cement Works which have required planning permission are:

i) Change to limestone quarry design and consolidation of existing permissions – 2.5 years pre-application design and Environmental Impact Assessment (EIA) stages followed by 3.5 years of statutory process to obtain the planning permission
ii) Rail infrastructure upgrade projects – 2 years design and EIA stages followed by up to 1.5 years of statutory process
iii) Silos and intake equipment installation for processed sewage pellets – 1-year statutory process post design submission
iv) Limestone quarry soil strip approval – discussions commenced October 2017. Walkover of area for ecology 31st January 2018. Draft scheme agreed and submitted 5th March 2018. Request for further archaeology trenching received and work implemented during April and May. Formal submission made for approval following archaeology sign off on 16th May 2018. Formal written approval yet to be received.
v) Shale quarry soil strip approval – discussions commenced October 2017. Scheme agreed, and draft submission made 9th March 2013. Formal submission made for the soil strip on 20th March 2018. Formal written approval yet to be received.
vi) Limestone Quarry Extension Phase 1 pre-application request – submission made on 26th April 2018. Written response received 10th September 2018.

As mentioned previously, there appears remarkably little chance of there being a single "silver bullet" solution to Breedon Cement's secondary raw material requirement i.e. a single reserve of approximately six million tonnes of suitable material with rail network access. Hence the plant believes that it will need the potential to handle more than one material stream and a wider variety of materials, such as shale or slate, as well as PFA. This should now allow a more detailed design and selection process for the system to be finalised that, in turn, will enable Breedon Cement to begin the planning application process in earnest. However, this does highlight the risk of ensuring a continual supply of a shale substitute to the plant. In order to mitigate this, Breedon Cement intends to ensure that it has more than one source of supply.

5.1.4 Costs of Partial shale substitution

Up to now partial shale substitution has been achieved using the existing infrastructure. However, to increase this substitution to the required amount, and to handle the new types of material currently being explored, there will need to be a significant investment in new equipment. These costs are shown in tables 6 & 6a below, alongside estimates of the operating and maintenance cost.

Table 6: Capital cost estimates	
Description	**Capital Cost Estimate 2022**
Planning, Site Investigation, Prelims, Site preparation	£728,005
New Rail Siding H	£436,803
Rail Upgrades to Sidings C, D & E	£487,091
Grab crane and overhead gantry at train unloading	£750,405
Hopper and Feeder for train unloading grab crane	£123,201
Train Unloading from C-Siding to storage building	£1,545,611
Storage building with grab crane + hopper / feeder	£2,553,618
Mill Feed from storage to C16/C17 inc surge bins	£761,605
Electrical, Instrumentation & Control	£606,596
Roads and Hardstands	£649,605
Indirects/Provisions/Contingency	£4,418,750
Total Capital Expenditure	**£13,061,292**

Table 6a: Operating cost estimates		
Description	**Operational Cost 2022**	
	QTY	
Unloading Labour (hrs)	1,920	£55,911
Storage Labour (hrs)	8,760	£255,093
Maintenance	1	£162,659
Electricity (kWh)	585,194	£47,986
Total Operating Expenditure (£/a)		**£521,649**

5.2 Abatement Techniques

In 2014 Breedon commissioned a study by the consultants Cement Performance International (CPI) which discussed in detail the two abatement techniques proposed in the BREF. The report provides detailed consideration of the advantages and disadvantages of both, and an assessment of the costs associated with wet scrubbing. This report was provided as an addendum to Hope's previous derogation variation request.

5.2.1 Wet Scrubber

Wet scrubbing systems provide the highest removal efficiencies for soluble acid gases of all flue-gas desulphurisation (FGD) methods with the lowest excess stoichiometric factors and the lowest solid waste production rate. The wet scrubber is a proven and commonly used technique for flue-gas desulphurisation within the power sector. For cement manufacturing processes, the wet process for reducing SO_2 emissions is also an established technique. The SO_2 is absorbed by a liquid/slurry which is sprayed in a spray tower. The absorbent used is calcium carbonate. The slurry is sprayed in counter-currently to the exhaust gas and collected in a recycle tank at the bottom of the scrubber where the formed sulphite is oxidised with air to sulphate and forms calcium sulphate dihydrate. This synthetic gypsum material can be used in controlled amounts in the cement milling process, although other disposal routes for this waste may be required. The water used can be recirculated through the scrubber.

Aside from the technical constraints, there is one fundamental issue with the installation of wet scrubbers at Hope cement Works. This is that such an installation does not solve the basic issue that Hope requires additional secondary raw materials in order to match limestone reserves and continue cement manufacturing at the site. The scrubbers will not enable the plant to utilise all of the additional 2.8 million tonnes of ultra-high sulphur shale as this would lead to unsupportable levels of sulphur being retained within the cement kiln system, rendering the process inoperable. This was the conclusion of a study into wet scrubbers at Hope conducted by Lafarge's European Technical Centre (ETC) in 2010 "2010 UK Hope Solutions to extend quarry life". This is relevant to support this application and is described in more detail below and included as Appendix 7 in the evidence pack submitted alongside this application.

There are also further significant concerns with respect to the detail around the installation of wet scrubbers into the Hope Cement Works process. Hope Cement Works operates two kilns adjacent to one another, however, the lines are independent and would require separate abatement systems, which would greatly increase the cost of such a solution. The scrubbed gases will require re-heating to provide sufficient buoyancy for the efficient stack emission which would involve major additional investment and infrastructure in order to route the cooler exhaust gases to the wet scrubber exhaust gases. The wet scrubbing systems would create a visible stack plume, which would be of significant concern to stakeholders, including local residents, the Environment Agency and the PDNPA.

Due to the disadvantages listed below the only scenario in which a wet scrubber would be of additional benefit to the environment is if it were to be used in combination with the shale replacement solution. The twin effects of both schemes would achieve a "belt and braces" approach which would ensure that the BAT-AEL could be achieved in the advent of a loss of shale substitution material supply. Therefore, it is only this wet scrubber option that is considered within the CBA.

5.2.1.2 Advantages

The SO_2 removal efficiency of a wet scrubber system is known to be high. The BREF quotes 75% and this quoted BREF efficiency is used as part of this assessment. An efficiency of only 42.4% would provide a reduction of SO_2 emitted of 817 tonnes per annum if the BAT-AEL of 400 mg/Nm^3 is compared to the current ELV of 695 mg/Nm^3.

A wet scrubbing system would generate quantities of synthetic gypsum, which could be used within the cement milling process, replacing a proportion of natural gypsum, dependent upon the chemistry and other quality/process parameters. The current gypsum handling system at Hope is however, unsuited to the use of synthetic material in large quantities. Without significant investment this material would need to be removed from site and disposed of. Table 7 below confirms the SO_2 reduction amount.

Table 7

SO_2 input set by proposed ELV of 695 mg/Nm^3 dry gas @10% oxygen and Stack exit 400 mg/Nm^3 dry gas @10% oxygen			
Maximum SO2 mg/Nm^3 dry gas @10% oxygen - No WS	695		
Average SO2 mg/Nm^3 dry gas @10% oxygen - With WS	400		
Reduction in SO2 mg/Nm^3 dry gas @10% oxygen with WS	295		
SO2 collection efficiency %	42.4%		
Kiln system	1	2	Total
Tonnes SO2 per annum captured	409	409	817
Equivalent tonnes of FGD Gypsum tpa	1,098	1,098	2,196
Tonnes CaO used for FGD Gypsum conversion tpa	358	358	715
Raw meal required tpa	815	815	1,630
Add 10% to cover higher use when raw mill is down	897	897	1,793

5.2.1.3 Disadvantages

The biggest disadvantage of the wet scrubbing system is that it does not solve the fundamental problem that the plant faces i.e. with such limited usable shale reserves available the long-term future of the plant is not currently guaranteed. The installation of wet scrubbers does not permit the use of the 2.8 million tonnes of ultra-high shale reserves due to the amount of sulphur they contain and the way that this would influence the kiln process at Hope. This is detailed in the ETC report Appendix 7 “2010 UK Hope Solutions to extend quarry life” and summarised further below.

These reserves contain sulphur levels of between 9% and 12.5% sulphur the vast majority of which, circa 90%, is pyritic. In theory all this pyritic sulphur should be driven off as SO_2 at temperatures of between 400°C and 600°C, in the upper stages of the kiln preheater tower and become a part of the exhaust gases. However, in reality, the efficiency of this removal in kilns with high levels of SO_2 is far lower, at 40% to 60%, with the data showing Hope to be at the lower end at 42%. Hence over half this sulphur passes through the preheater and enters the kiln process. Of that 42% that exits with the exhaust gases around half passes through the raw mill, which has a trapping efficiency of about 30%. The SO_2 trapped in the raw mill is, in effect, absorbed by the raw meal and this is also then fed back to the kiln, thus exacerbating this cycle still further. The report demonstrates, using historical evidence from Hope and more general industry information, that to run kilns with these levels of sulphur input and, by extension, sulphur to alkali ratios, is almost impossible. The potential amount of sulphur-based build-up within the kilns and preheater cyclones would be calamitous in terms of process control, reliability and would also severely affect clinker quality.

Even were the effects on the kiln found to be manageable this phenomenon would still leave around 35% of the original sulphur input in the form of SO_2 at the stack. As shown in section 4.1.7 of the ETC report this would still equate to unabated stack emissions, depending on the level of SO_3 in shale modelled, of between 2,500 and 2,900 mg/Nm³. Using the scrubber modelling tool shown in table 7b this shows that in order to reach the BAT-AEL of 400 mg/Nm³ an SO_2 collection efficiency of 84.0% is required by the scrubber. Whilst there are examples of this level of efficiency the BREF quotes 75% and therefore the level of risk of the wet scrubbers achieving the desired outcome at Hope is increased still further.

Table 7b

SO_2 input set by ultra-high suphur shale of 2502 mg/Nm³ dry gas @10% oxygen and Stack exit 400 mg/Nm³ dry gas @10% oxygen			
Maximum SO2 mg/Nm³ dry gas @10% oxygen - No WS	2,502		
Average SO2 mg/Nm³ dry gas @10% oxygen - With WS	400		
Reduction in SO2 mg/Nm³ dry gas @10% oxygen with WS	2,102		
SO2 collection efficiency %	84.0%		
Kiln system	1	2	Total
Tonnes SO2 per annum captured	2,912	2,912	5,823
Equivalent tonnes of FGD Gypsum tpa	7,825	7,825	15,650
Tonnes CaO used for FGD Gypsum conversion tpa	2,548	2,548	5,095
Raw meal required tpa	5,809	5,809	11,617
Add 10% to cover higher use when raw mill is down	6,389	6,389	12,779

On top of this fundamental issue wet scrubbers will require significant capital costs to install as well as the ongoing added operational costs to operate them, all of which is detailed below.

A wet scrubber system on each of the kilns at Hope Cement Works would be required, which would have a significant impact on the visual aesthetics of the plant. The extra plant and equipment would be visible and would require planning consent. The system would considerably increase water consumption and cause the plume to become visible, an impact which regulators and local residents have traditionally been very reluctant to accept. There would be an increased power consumption at the plant to operate these systems. There would be an increase in emissions of carbon dioxide resulting from the increased power consumption required. As mentioned, there would need to be significant infrastructure and investment, in addition to the scrubber systems themselves, in order to reroute the cooler gases to re-heat the scrubbed gases to provide sufficient plume buoyancy.

Table 8 below demonstrates the potential impact of scrubbing system on water consumption and the CO_2 impact is shown in Table 8.

Table 8

Water Consumption			
Ribblesdale consumption factor (m3 water per tonne clinker)	0.154		
Kiln Number	**1**	**2**	**Total**
Clinker tpa	632,822	632,822	1,265,645
Water Consumption (m3 per annum)	97,455	97,455	194,909

5.2.1.4 Costs of Wet Scrubbers

Tables 9 and 10, which follow, provide the details of both the capital and operational costs of wet scrubber use at Hope Cement Works provided in the 2014 assessment study, updated to use current prices, and were based upon operational experience from other UK and European cement producers.

Table 9

Capital Cost -Wet Scrubber (£m - 2021)	**1**	**2**	**Total**
Mechanical and Electrical supply inc Basic Engineering	£7.64	£7.37	£14.74
Carriage, freight, insurances, taxes	£0.56	£0.54	£1.08
Site preparation	£1.56	£1.51	£3.02
Installation	£2.76	£2.66	£5.32
Sub total no contingencies	£12.52	£12.08	£24.17
Contingencies (10%)	£1.25	£1.21	£2.42
Total Capex with 10% contingencies	£13.77	£13.29	£26.58
Operating costs -Electric Power only plus CO2 emission			
Electric power consumption kwh/tonne clinker	13	13	13
Kwh per annum	8513668.8	8,226,691	16,453,382
Unit price pence/kwh	8.20		
Electric power costs per annum	698120.84	698120.84	1396241.68
CO2 generated by additional electric power consumption			
gms CO2 per Kwh (UK average 2017)	232		
Tonnes CO2 generated per annum	1,754,471	1,754,471	3,508,942
Operating costs - Overall			
Overall operating cost £/tonne clinker average	£2.68		
Overall operating cost £ per annum	£1,508,734	£1,508,734	£1,508,734

Table 10 below shows how the operating costs were originally calculated in the 2014 assessment study. These figures have been adjusted to reflect current prices using RPI inflation rates 2018 - 2021

Table 10

BREF 2013 Opex for WS	Min	Max	Average
Quoted Euro/tonne clinker	1	2	1.5
Date	2008	2008	2008
Current Euro/tonne May 2014	1.22	2.45	1.84
£/tonne clinker in 2014	£0.98	£1.96	£1.47
USA study -WS	Min	Max	Average
£/tonne clinker in 2014	£1.00	£2.09	£1.55
USA Study - WS	Min	Max	Average
£/tonne clinker in 2014	£2.24	£4.63	£3.44
Average	Min	Max	Average
£/tonne clinker in 2014	£1.41	£2.89	£2.15
£/tonne clinker in 2018	£1.58	£3.21	£2.39
£/tonne clinker in 2021	£1.76	£3.59	£2.68

5.2.2 Absorbent Injection

This method works through the input of a suitable alkali material (for example lime) into the gas flow in an appropriate location and temperature in the process to allow the effective capture of the SO_2. It is a proven technology and suitable for modest reductions in SO_2 emissions. The BREF document quotes efficiencies of absorbent injection of around 60%. As has been established (Section 3.0), the primary source of the SO_2 at Hope Cement Works is the shale, which contains high levels of pyritic sulphur. Lime injection is currently used at Hope to abate and manage emissions of hydrogen chloride (HCl); however, its efficiency is not sufficient to provide compliance to the new lower SO_2 limits. An amount of around 800 tonnes of lime per year is injected for HCl control; but as this preferentially controls the HCl over SO_2, little positive impact is seen on Hope emissions of SO_2. In order to have a meaningful impact on both HCl and SO_2, there would be a need for substantially increased injection rates.

It is accepted within the BREF that absorbent injection does not suit applications where large SO_2 reductions are required and, as the shale sulphur level would increase to very high levels this method would become increasingly ineffective. As any SO_2 captured by this method is retained within the kiln bag filter dust, which is all returned to the kiln via the kiln feed, this would lead to a large internal cycle of sulphur building up that would ultimately have a detrimental effect on process stability and clinker quality. It is, therefore, not a suitable method for Hope Cement Works and, consequently, this control option will not be considered further.

5.2.3 Manufacture of Cement / Clinker Cessation

Breedon Cement GB has a single cement manufacturing facility, and consequently relies upon the production of cement from Hope Cement Works for supply to its own internal customers and the wider GB construction market. In the event of the derogation request being refused, the remaining option for the reduction of emissions of SO_2 from Hope Cement Works is to cease clinker manufacture at the installation. If this supply was terminated the only alternative would be to import either clinker (for grinding at Hope) or cement from outside Great Britain, in order to meet business needs. Practically, cement importation would be the only possible business solution.

It is estimated that the cost to the Breedon group of importing the total volume of cement to the UK would result in (at current 2022 prices) a profit loss in excess of £28 million per annum. This figure includes the import, and handling costs to import an equivalent quantity of cement to Hope Cement Work's average historic output, which is approximately 1,400,000 tonnes. This does not account for the required increase in network import and storage capacity that would be required and the cost of construction and purchase of new import terminals and distribution depots.

The import of any cement into Hope Works would significantly increase the amount of road or rail traffic in the local area, an impact which would be of concern to the PDNPA and local communities. In a recently updated socio-economic study of the contribution from Hope Cement Works to the local economy, undertaken by Mott Macdonald using 2017 data, their general conclusion is that the local economic benefit of the plant is currently assessed to be £61 million Gross Value Added (GVA) per year. Clearly this would be substantially reduced if clinker or cement manufacture at Hope Cement Works was to cease, through the shutting down of both kilns.

It is considered that the option to import cement into the UK to support Breedon Cement's production requirements is not feasible due to the significant and disproportionate financial costs, negative impacts on the UK cement market and the adverse environmental impacts from increased road and rail traffic. Nevertheless, for completeness this option has been considered in the CBA.

6.0 Cost Benefit Analysis

The CBA (see appendix 8) prepared for this variation request considers four potential, credible options alongside the Business as Usual (BAU) scenario. The environmental impacts of some elements of these options are detailed below, and the results of the CBA are determined using the costs presented previously but adjusted for RPI inflation rates. Note the BAU scenario includes the construction of the alternative raw material handling infrastructure as this is a fundamental business requirement to continue to operate, it does however assume continued operation at a 695 mg/Nm^3 ELV.

In the preferred "Proposed derogation" option outlined in the CBA, initially SO_2 emission management and the partial substitution of shale will be achieved through the existing plant and equipment, using the levers described in section 3.1.1 above. This is until such time as the new infrastructure required to meet the long-term targets for shale substitution via a rail-fed system is in place. It is a fundamental business requirement to replace Hope Cement Works shale within the raw mix, driven by the fact that usable reserves are diminishing, and, at present production and usage rates, the life of the shale quarry is limited to 3 years with no substitution. This scenario considers a worst-case scenario in which a 12-month planning delay occurs, and the new infrastructure is commissioned 31st December 2025.

As mentioned the use of cessation of cement production at Hope is also considered in the CBA, both on a temporary basis whilst the new importation system is installed, as well as on a permanent basis. The first is the "BAT-AEL" option, the second the "Cessation" option.

The final option considered is the use of both partial shale substitution and wet scrubbers in parallel. This is the "Wet scrubber and shale substitution" option.

The estimated costs of wet scrubbing systems are detailed in the tables 9 and 10 above. Wet scrubbers have a high capital cost and high operating cost, as is clearly demonstrated by the information in section 5.2.1.4 However, they are proven to be effective in removing SO_2 from the gas stream up to a point. An assessment is given below in table 11 of the environmental impacts of a wet scrubbing system, which are considerable.

Table 11: Assessment of environmental impacts of wet scrubber					
		Low	**Med**	**High**	**Comments**
Releases to Air	Long term		X		
	Short term			X	Heavy visible plume
Deposition to Land				X	Plume grounding
Power Consumption				X	Potential increase – 13 kWh/tonne clinker
Water Consumption				X	Potential increase 204,000 m^3
Releases to Water		X			No extra impact expected
Noise		X			
Consequences of accidents			X		
Visual				X	Significant impact from scrubber & plume
Odour				X	Potential for plume grounding / stack rain
Ozone Creation Potential		X			
Global Warming Potential		X			
Traffic – Road / Rail			X		Increase in road traffic to remove waste for disposal
Planning Requirement				X	Installation of scrubber and visible plume
Waste Disposal				X	Up to 6,000 tonnes of FGD

Of significant concern would be the creation of a heavy and very visible plume – currently the Hope Cement Works plume is rarely visible. The PDNPA and the local community are known to be reluctant to accept this impact and there have been complaints in the past on this topic. They would also be very concerned if this change to the plume characteristics created a potential for plume grounding or deposition (e.g., stack rain or mist droplets). There would be significant increases in power consumption and water use, both of which are known impacts from the use of this type of abatement. Hope Cement Works would not be able to use all the waste material that would be produced, due to the process & product characteristics, so the remaining quantities would be removed as hazardous waste. Planning permission and approval would need to be sought for the installation of the scrubbing systems and the change to plume behaviour and visibility. Considering the protracted planning process the shale substitution project is currently undergoing, this would likely undergo similar timeframes and delays.

As stated repeatedly the wet scrubber does not address the fundamental issue of raw material reserves that the plant faces and would also need to operate at a very high efficiency to achieve BAT-AEL with Hope's higher sulphur shales. For all these reasons the use of a scrubber alone was not an option considered within the CBA.

The following table, table 12, details the assessment of the environmental impacts of partial shale substitution. The majority are low impact and would be managed as part of the day-to-day management of the installation activities, and within the certified environmental management system. The most significant impacts are the new material handling system and the potential increase in import traffic, via rail transport, to bring in the increased tonnages required. These, and the tonnage needs, will all require planning permission to be granted by PDNPA.

Table 12: Assessment of environmental impacts of partial shale substitution

		Low	Med	High	Comments
Releases to Air	Long term	X			
	Short term		X		Potential for fugitive emissions
Deposition to Land		X			
Power Consumption		X			Comparable to or less than current consumption for ROS PFA usage
Water Consumption		X			
Releases to Water			X		Potential leachate from shale substitute to be managed
Noise		X			
Consequences of accidents		X			See releases to water comment
Visual			X		New infrastructure
Odour		X			
Ozone Creation Potential		X			
Global Warming Potential		X			
Traffic – road / rail				X	Increases expected
Planning Permissions			X		New infrastructure, increased tonnage & traffic movements
Waste Disposal				X	**Positive** impact on waste hierarchy if ARM used

The costs of the installation and operation of this new infrastructure required to facilitate the rail import and input of a shale substitute are presented above in tables 6 and 6a.

Table 13 compares the costs of the four options assessed in this paper, using the outputs from the Environment Agency Cost Benefit Analysis tool. The wet scrubbers would have an expected plant life of 20 years as an intermediate component. Cessation and partial shale substitution are categorised as major components, each with a 20-year life, as they are permanent changes which would be essential for the equivalent longevity of the operation, and not just for compliance with the requirements of the BATC.

Table 13 CBA Comparison	**Proposed derogation £M**	**BAT-AEL £M**	**Wet scrubber & shale sub. £M**	**Cessation £M**
Life of Option (years)	20	20	20	20
Capital Costs	13.1	13.1	39.7	0.0
Operating Costs	8.9	124	89.2	756.0
Net Present Value (c/w derogation)		-154.5	-383.37	-28.19

Breedon Cement LTD would like to point out that the weighted average capital cost values contained within the CBA tool are considered commercially sensitive information. As such we would like to request that the CBA tool be classed as commercially sensitive.

7.0 Cost of Benefits / Damage

As an element of the cost-benefit analysis process it is necessary to present the cost of damage, arising from the expected emissions, and demonstrate the benefit to the environment from the implementation of the BREF requirements. The current ELV for SO_2 emissions from Hope Cement Works is 695 mg/Nm^3. The assessment has been undertaken comparing the present

ELV, and the BAT-AEL of 400 mg/Nm^3. The reduction in tonnes SO_2 emitted is shown in table 14, and the cost of damage is calculated using the Interdepartmental Group on Costs and Benefits (IGCB) damage cost calculator.

Table 14: **Damage Costs Assessment**	**Existing/Proposed ELV** **695 mg/Nm³**	**BAT-AEL** **400 mg/Nm³**
SO_2 emission (t/a)	1,993	1,147
SO_2 reduction (t/a)	846	
Central damage cost £/t	13026	
Cost of damage (£k/a)*	25,961	14,941
Cost of damage savings (£k/a)	11,020	
* IGCB air quality damage costs per tonne SO_2 (2020 prices) – central estimate used		

The reduction from the present ELV to the BAT-AEL will result in a reduction of 846 tonnes of SO_2, the related cost of damage savings of which are £11M.

8.0 Justification for Option Selected

The Cost Benefit Analysis above is detailed in both financial and environmental terms. The partial shale substitution control option would guarantee the ability to achieve less than 400 mg/Nm^3. As detailed in section 5.2.1.3 above, the wet scrubber may be able to meet this limit but would require a high level of efficiency, 84%, to achieve this with high sulphur shale use.

The wet scrubbing systems can be seen to be extremely costly, both financially and to the environment. Hope Cement Works would require two systems, one for each kiln line, significantly increasing both capital and operating costs. Partial shale substitution has the same ability to reduce SO_2 emissions at less cost, both in terms of capital and operating costs. This strategy is also considerably less damaging to the environment.

It cannot be emphasised enough, however, that partial shale substitution is a strategy which must and will be implemented at the plant because there are such limited usable shale reserves available. This strategy is vital in order to guarantee the long-term future of the plant. As the new shale substitution infrastructure is commissioned and substitution rates are increased, there will be no requirement for wet scrubbing systems on the kilns at Hope. Consequently, any wet scrubbing plant installed at the site would be redundant within a few years of it’s installation.

Both options require planning permission applications and therefore the approval of the PDNPA. The wet scrubbers would require permission for the installation of a considerable amount of new plant and equipment, including at least one new stack, plus the visible plume. Partial shale substitution requires a review of current import planning conditions and planning permission for the new infrastructure to facilitate the change in raw material. The process for obtaining planning permission is complex and time-consuming, to ensure that all considerations are addressed appropriately to the planning authority’s requirements, and to ensure all questions or concerns raised by consultees and the community are addressed. Time to execute this process to its conclusion needs to be factored into the assessment. The planning process has been commenced for the general quarries' development needs for Hope Works, including shale replacement plans.

Table 14, below, is a direct comparison of each option. Partial shale substitution is the only satisfactory control option for the reduction of SO_2 emissions as it scores higher in all areas of assessment, including financial costs and environmental impacts. It is also the intended direction of the plant and will be implemented as a matter of business need, thus rendering the consideration of wet scrubbing systems unnecessary and superfluous.

Table 14: Direct comparison of areas for consideration, showing which option is preferable

Area	Wet Scrubber (WS)	Partial shale substitution (PSS)	Comments
Environmental Impact	×	✓	
Capital Costs	×	✓	
Operating Costs	×	✓	
Use of existing infrastructure	×	×	On a partial level shale substitution will utilise some existing infrastructure
Planning Permission – required	×	×	Both options require permission – PSS for plant future operations
Planning Permission – Likelihood to achieve	×	✓	Visible, heavy plume very unpopular
Waste Hierarchy	×	✓	PSS higher up hierarchy
Waste Disposal	×	✓	WS produces Haz-Waste
Long-term future	×	✓	PSS protects plant future

9.0 Variation Request Specifics

Partial shale substitution is a BAT primary technique and is part of the ongoing business strategy for Hope Cement Works; it is proposed that this option is BAT for Hope Cement Works. Hope Cement Works has completed and submitted a planning application to the peak district national park authority for the installation of alternative raw material handling and storage infrastructure however extensive delays to the planning application and approval process have prevented Breedon from meeting the timescales set out within previous derogation applications. The justification to extend the current derogation is detailed in section 4.2.

The derogation criteria under Article 15(4) of the directive primarily relates to the ***technical characteristics*** of the installation, which sit in combination with both the ***local environmental conditions*** and the ***geographical location*** criteria, in line with cl 4.39 of the DEFRA IED Guidance dated February 2013. The ***technical characteristics*** of the installation are such that they preclude the use of the shale reserves containing high levels of pyritic sulphur, even in conjunction with the installation of a wet scrubber. As detailed in section 5.2.1.3, the amount of sulphur retained within the kiln system if this material were to be used would lead to process control, reliability and quality issues, in effect rendering the kiln inoperable. The ***local environmental conditions*** relate to the chemistry of the remaining, available reserves of Hope shale, as described in section 3.0. The ***geographical location*** refers the installation's position within the Peak District National Park and the additional constraints that this place upon the site in terms of planning, which is expanded on in section 4.2 and 5.1.3.

A time-limited derogation from the requirement to comply with an ELV of 400 mg/Nm^3 will be required from 1st April 2022 for the following reasons:

- There have been extensive delays to the planning application and approval process which have prevented Breedon from meeting the timescales set out within previous derogation applications, these delays have been through no fault of Breedon Cement LTD and are listed clearly in section 4.2
- A further time limited derogation will allow sufficient time for approval to be granted to the planning application made for increased shale replacement material import volumes, and the installation of alternative raw material handling and storage infrastructure

Breedon Cement therefore requests the following time-limited derogation (which could be revised if there were extenuating circumstances) to be granted until the 31st **March 2025**:

- **SO_2 Daily Average ELV of 695 mg/Nm^3** - to allow sufficient time for planning application approval and implementation of the alternative raw material project.
  Note the proposed timescale of 31st March 2025 stated above may be revised during the duly made process following the planning application being granted.