Aberthaw Power Station: Unit 9 Low NOx Boiler

Post Commissioning Report

Environmental Permit RP3133LD/V012: Improvement Condition IC37

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1. Introduction

RWE Generation has carried out modifications to the Aberthaw Power Station Unit 9 boiler in order to reduce NOx emissions. The 'Low NOx Boiler' (LNBo) conversion was carried out following an application to Natural Resources Wales (NRW) in March 2015, to vary the operating permit (EPR/RP3133LD). The variation was granted, subject to certain pre-operational and improvement conditions.

Pre-operational condition 14 (POC14) required the submission of a commissioning plan for approval and this was duly submitted in February 2016, prior to the carrying out of commissioning tests (Ref. Low NOx Boiler Commissioning Plan, Aberthaw Power Station, EP/RP3133LD/VO12/POC14).

Following the completion of the commissioning tests this report has been prepared in response to **Environmental Permit Improvement Condition 37 (IC37)** -

Within 6 months of each Low NOx boiler unit being brought into operation.
Confirm the commissioning date of each Low NOx boiler unit and submit a written post-commissioning report regarding the emission reductions achieved and related performance parameters including, but not limited to –

- *Noise*
- *Ash quality (and identification of need for PFA HRA review)*
- *Carbon in ash levels*
- *Tube failure rates*
- *Start up, shut down thresholds and boiler stability*
- *Slagging*
- *Thermal performance*
- *Electrostatic precipitator performance*
- *NOx emissions*

The report should include a justification of the Best Available Techniques Associated Emissions Limits (BAT ELVs) to be adopted upon the full implementation of all low NOx boilers

The report shall be submitted to Natural Resources Wales for approval, and the measures and controls identified in the approved report shall be implemented within 12 months of the written approval of the report by Natural Resources Wales.

RWE Generation has completed the retrofitting, commissioning and performance testing of the Aberthaw Unit 9 boiler in accordance with the details contained in the Low-NOx Boiler Commissioning Plan submitted in compliance with POC14 (Report Ref. EP/RP3133LD/VO12/POC14).

Following the submission of the Commissioning Plan, NRW raised an action in the Compliance Assessment Report (CAR, Report Ref. CAR_NRW_0022709) requesting the following information –

The commissioning plan has been reviewed. The only point of query relates to the possibility of consequential effects associated with the mill ball charge increase. In particular whether changes in PF particle size distribution will result in changes in EP performance and balance of trace pollutants in seawater discharge.

ACTION: RWE to confirm whether or not these effects have been considered and if any assessment has been undertaken as part of the commissioning programme.

This report provides the information required by IC37 and the CAR. The data, or observations, referred to in this report have been collected through commissioning tests, combined with the existing site monitoring programs.

Unit 9 was returned to commercial operation on January 25th 2016. The four performance tests were carried out between the 21st of March and the 24th of April 2016. These tests and the parameters measured, relate to the performance guarantees required from the contractor only, rather specifically to NRW's requirements in IC37.

Whilst the unit has passed the guarantee tests set by RWE, this limited period can only give a 'snap shot' of the plant under test conditions, rather than the normal performance of plant under all potential operating conditions. Following return to commercial operation, the unit started a process to refine and optimise the operation of the boiler under different load and environmental conditions and also when operating on fuels of differing composition and moisture content. This refining and optimising process is expected to last at least a further twelve months.

2. Technology

The technology has been fully described in POC14 response, which summarised the overall objective of the refit as :

Aberthaw Power Station is installing LNBo Technology to reduce NOx emissions to air by up to 60%. The modifications provide a cost effective NOx abatement of stack gas concentrations expected to be in the range 450 to 600mg/Nm^3. The LNBo system controls NOx by creating a stable flame and controlling the staging of air to the boiler. This process limits the formation of NOx thermally and from nitrogen contained within the fuel.

The NOx abatement is achieved through controlling combustion and is focussed on three main areas:

- The air staging process
- Installing PF burner cyclone and vent dampers
- Finer PF size distribution from the mills

The refit comprised the following changes:

- 36 New Arch Cyclone Burners and Vents
- 36 New Overfire Air (OFA) ports
- 24 Combustion Secondary Air Damper Modifications
- Mill Modifications including optimizing ball charge and sizing
- Control System Modifications

At the time of the application to vary the EP to allow the LNBo conversion, RWE submitted a BAT report (Application for a variation to permit EPR/RP3133LD - March 2015) making the justification for this technology. The report identified that the LNBo technology provides a cost effective NOx abatement of stack gas concentrations to meet the Transitional National Plan compliance route under the Industrial Emissions Directive (IED).

The aspiration was that the technology would have the potential to reduce NOx levels from the previous level of 1050mg/Nm^3 to within the range of 450 – 600 mg/Nm^3, dependent upon fuel type and quality.

3. The Conversion and Commissioning Program

The Commissioning Plan set out the program for installation and commissioning as per the table below, which has been updated to reflect the actual timing of the work.

Table 1 – Aberthaw Unit 9 LNBo Conversion and Commissioning Program

Key Activity	Timing	Description
LNBo Installation	May-October 2015	Installation of the modified plant and control systems.
Cold testing	September - October 2015	Testing of equipment, instruments and cables before energising. Includes continuity testing of cables, pressure testing, dimensional checking of installed plant, cold setting of limits.
Hot testing	October – November 2015	Testing of any panel, or device where the power supply to the item has been energised. Hot testing proves local functionality of each panel, piece of equipment and instrument.
Dry testing	October – November 2015	Functional testing of devices, groups or systems of devices that have associated protection and trips without the process fluid.
Commissioning	November/December 2015	Commissioning with process fluid (air, oil, coal, water) after all testing is completed, these include: ▪ Pre-start-up checks ▪ Firing of oil burners ▪ Boiler safety valve test ▪ Checking group level control, sequences, protection ▪ Unit synchronisation ▪ Raising load ▪ Full load capability Primarily this is focused around the oil burner system and demonstrating that a large majority of oil burners are available for pressure raising the boiler. Then coal mills and burners are proven with the introduction of coal and running through each of the mills and coal burners to demonstrate each burner sequence to ensure they are all available for safe operation.
Commercial Return to Service	January 2016 (Actual 25/01/16)	The unit is fully available for generation within the commercial market.
Optimisation	January/February 2016	Carrying out a comprehensive range of tests and varying operational parameters and damper set-up to optimise the boiler

	(Optimisation is expected to be an ongoing process for at least a further 12 months.)	for environmental performance and efficiency, including:- ▪ Air ingress assessment ▪ Pulverised Fuel (PF) sampling ▪ Temperature, pressure and flow analysis ▪ Dust analysis ▪ Carbon in ash tests ▪ Ash analysis Primarily this is focused around ensuring the Unit can meet the load within the Safe Operating Limits (SOL) that we legally have to comply with for the safety of the plant. Secondary drivers are then to optimise the air staging of the burners for different load / mill configurations / coal types. This will be led by the technology provider supported by RWE combustion engineers with the ultimate goal of achieving full-load and jointly meeting the guarantees of the contract in terms of NOx reduction, whilst having compliant SOL and boiler efficiency.
Guarantee Performance Testing	March/April 2016 (Actual 21st March – 24th April)	Undertaking the contractual performance guarantee tests with the technology provider to demonstrate compliance with the guarantees set out in the design and supply contract.

Whilst the plant achieved its performance guarantee test levels during March and April, with a recently cleaned boiler an increased rate of slagging was observed. As part of the continuing optimisation process, modifications, designed to correct design factors believed to be leading to slagging, were carried out during the planned shut-down in May 2016.

4. Noise

4.1 Anticipated and Potential Impacts

The LNBo conversion was not expected to result in any change to the level of noise emissions from the power station under normal operation and no changes were recorded.

The LNBo conversion had the potential to increase levels of instability in the boiler, and it was considered possible that this could lead to an increased number of trips, accompanied by alarms and safety valve releases.

During commissioning, it was necessary to test steam pressure safety valves, giving rise to a short term, temporary noise event.

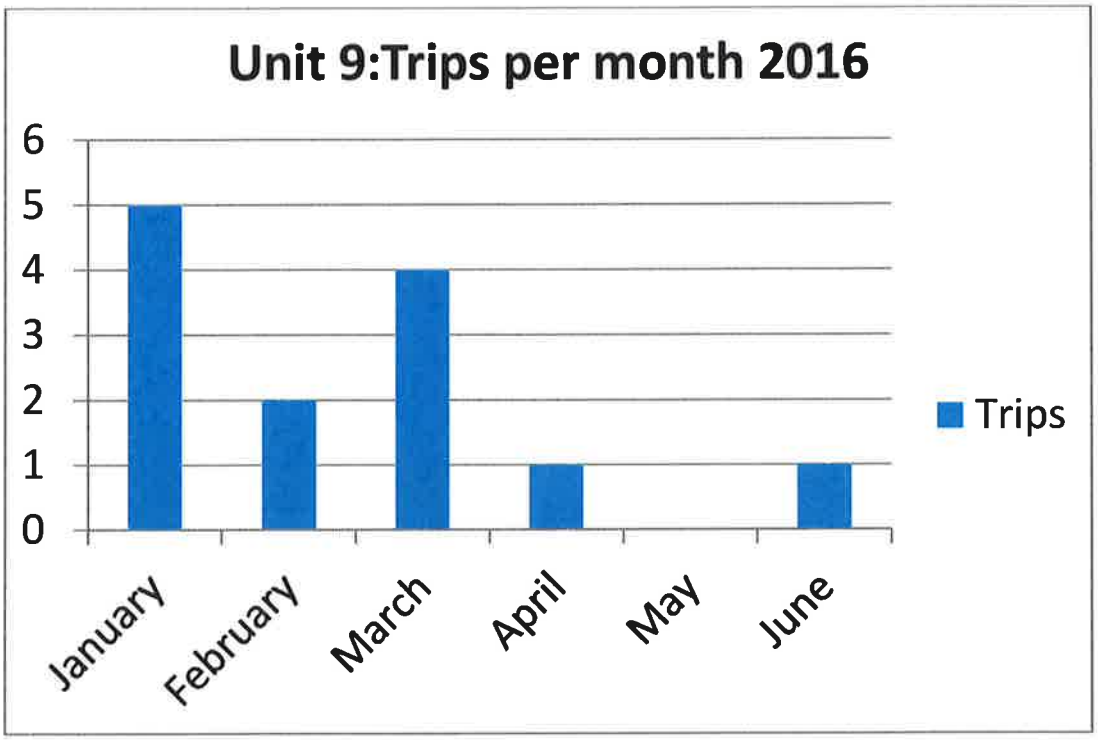
4.2 Monitoring Data

Aberthaw Power Station has a continuous noise monitoring system and no change to the normal noise operating level has been detected. At the same time as the LNBo project,

RWE has carried out a concurrent modification to the boiler safety system. During the commissioning of this system, there were a number of 'trips' which were not related directly to the LNBo conversion. Following one trip on January 16th2016, RWE received complaints from two local residents.

There were an unusually high number of trips during January, February and March associated with boiler safety system commissioning, but by April, the level of trips had returned to normal levels, as shown in Figure 1 below –

Figure 1 - Unit 9 Trips



4.3 Conclusions

It is considered unlikely that the LNBo conversion is leading to any increase in noise levels associated with the operation of the power station.

Changes to the boiler safety system resulted in a number of trips, which occurred during the optimisation and testing period. One event prompted two complaints from local residents. The rate of trips has now returned to a normal level for Aberthaw and there is no indication that the LNBo conversion has increased the number of trips giving rise to abnormal noise conditions.

5. Ash quality (and identification of need for PFA HRA review)

5.1 Anticipated and Potential Impacts

It was expected that the changes to the boiler dynamics as a result of the LNBo conversion could potentially bring about the following changes to ash 'quality', in terms of a change in Pulversied Fuel Ash (PFA) / Furnace Bottom Ash (FBA) proportions (due to increased ash fall out in the boiler).

Changes in PFA chemical composition needs to be considered with regard to the end use of the ash. The majority of the PFA from Aberthaw is sent to Aberthaw North Quarry, where it is used in the restoration of a former Limestone Quarry. The Hydrological Risk Assessment (HRA) relates to the deposition of ash in the quarry, where permit conditions require regular reviews of the HRA.

A proportion of the PFA is sold into the cement manufacturing industry, following a process of carbon separation to reduce the Carbon-in-ash (CIA) level. All FBA is sold for the manufacture of lightweight building blocks.

5.2 Monitoring Data

Routine sampling of ash composition is carried out on a quarterly basis at Aberthaw, using bulked samples. Tests are summarised in the Annual Performance Report to NRW.

It is too early to determine whether there has been any change in trace metal composition.

The Environmental Permit for the disposal of PFA in Aberthaw Quarry was granted following a Hydrological Risk Assessment, which is due for review in March 2017 and this will reflect on the 4 rounds of testing that will have been carried out after the return of Unit 9 to commercial operation.

Therefore, the March 2017 HRA review will address any changes in trace metal composition. This review will be submitted to NRW in accordance with the existing condition in the Environmental Permit.

During the commissioning trials, observations were made of an increase in the proportion of ash falling out as FBA. This is only an observation and as PFA/FBA proportions are not measured at the site, will be difficult to verify or quantify. Annual totals of materials leaving the site are reported and these figures will be reviewed to see if any change in PFA/FBA proportions is evident.

5.3 Conclusions

During commissioning, there has been an apparent observation of an increase in the proportion of ash falling out as FBA, rather than being precipitated from the flue gas as PFA.

The apparent increase in FBA should lead to an increase in the proportion of material suitable for recycling directly into the construction industry.

The Hydrological Risk Assessment is due for review in March 2017 and this will reflect on the 4 rounds of testing of PFA that will have been carried out after the return of Unit 9 to commercial operation.

6. Carbon in Ash Levels

6.1 Anticipated and Potential Impacts

Aberthaw Power Station is designed to burn coals with low volatility and the nature of the fuel predisposes the site to an incomplete burn out, resulting in unburnt coal or carbon in ash (CIA) levels, typically in the range of 12-20%. This will vary with the coal type, fineness of the milled product, boiler load, firing configuration and other environmental operating conditions.

The CIA will be directly affected by the boiler performance. Any increase in CIA indicates a loss of efficiency. The permit application identified the potential for an increase in CIA, especially during the period of commissioning and optimisation, when measures, such as the control of air, designed to reduced NOx could have the effect of increasing CIA.

6.2 Monitoring Data

In Test A (repeat) CIA was measured at 6 locations in the precipitators and the % was weighted according to the gas flow at that location. The 'average' was deemed to be 13.4%. Test results are shown in Table 2 below –

Table 2 - Test A (repeat) CIA levels

Precip Inlet Duct	CIA	Precip Inlet Gas Flow (Nm^3/s)	CIA weighted for gas flow
A1	9.3%	74.3	8.2%
A2	9.0%	96.6	10.3%
B1	10.1%	90.1	10.8%
B2	15.3%	84.5	15.3%
C1	19.0%	90.1	20.2%
C2	18.7%	72	15.9%
Average:			**13.4%**

Table 3 gives a comparison of the 'averaged' CIA% for samples taken at the 1st and 2nd precipitator field, for tests A (repeat), B & C.

Table 3 – Average Test Results for % Carbon in Ash

Test	Date	Coal	Generation	Monitoring point	Performance
A*	13/04/16	Ffos-y-Fran	535MW (MEL)	Precip 1st field av.	9.5%
				Precip 2nd field av.	16.3%
B	21/03/16	Ffos-y-Fran	395MW (SEL)	Precip 1st field av.	6.0%
				Precip 2nd field av.	7.4%
C	01/04/16	Tower	290MW (new SEL)	Precip 1st field av.	8.1%

*Test A Repeat

RWE had aspired to an average level of 13% CIA across the 6 precipitator inlet ducts and this was not achieved during the performance test A, on 24/03/16 when an average figure of 16.9% was recorded, when operating on Ffos-y-Fran coal, but under unsatisfactory test conditions, due to the late return to service of the unit on the test day.

Performance Test A was repeated on 13/04/16, with samples being taken from the precipitator inlet ducts. These were tested and 'averaged' to give an average figure of 13.4%, weighted according to the gas flow rates for each precipitator inlet duct.

Whilst not being below the guarantee 'target' level of 13%, the average figure 13.4% was judged to be within the margin of error of the performance guarantee level. This was achieved despite difficulties with the moisture content of the neat Ffos-y-Fran coal used

during the test, which led to the need to reduce dynamic classifier speeds with a resulting effect upon Pulverised Fuel quality, which would be expected to increase the level of CIA. The CIA% figures, for Tests B and C, when the plant was not operating at full load, but at the current and proposed SELs, were in the range of 6.0 – 8.1%.

Some variability has been seen in CIA levels during recent operation, monitoring and any further optimisation will continue to be carried out through the routine performance management which is reviewed on a weekly basis for each unit.

6.3 Conclusions

The monitoring data collected in the performance guarantee tests suggests that the CIA% of Unit 9 following the LNBo conversion are within the range expected at Aberthaw and no major change is evident.

What is also evident, from the first 'failed' test is that factors which can affect performance and reduce efficiency, will also lead to an increase in CIA. RWE will continue to refine and optimise the operation of the unit to ensure that operating conditions are optimised and CIA levels are maintained at the minimal level.

7. Tube failure rates

7.1 Anticipated and Potential Impacts

RWE did not anticipate that the LNBo conversion would lead to any increase in tube failure rates or failures of other boiler components.

It could be possible that fluctuations in steam temperature, as a result of the low NOx technology, could impose additional stress upon tubes, leading to an increase in the failure rate. This was considered unlikely and no increase to tube failure rates was anticipated.

If the rate of failures was to increase, this would lead to abnormal running conditions and unplanned shut downs, producing higher emissions when the plant would fail to meet the desired reduction in NOx and contributing to an overall reduction in reliability.

7.2 Monitoring Data

At the time of writing this report, Unit 9 has suffered 1 condenser tube leak since its return to service in January 2016. The condenser tubes are located in the turbine and not the boiler.

- 24th March 2016 U9 Condenser Tube Leak (Prior to Test A)

7.3 Conclusions

Clearly, for a parameter with a very low occurrence, it is too early to draw any conclusions regarding this topic, other than there has not been any suggestion of an increased failure rate during the first 5 months of operation.

8. Start up, shut down and boiler stability

8.1 Anticipated and Potential Impacts

No changes in time or energy consumption were anticipated to the start-up and shut-down performance, although it was anticipated that operating procedures might require 'fine tuning' before such performance was achieved. It was anticipated that following the LNBo, a reduced Stable Export Limit (SEL) could be justified and consequently a new Minimum start up and shut down load (MSUL/MSDL).

There was a potential that the changes to the boiler would result in instability, leading to incomplete combustion, loss of efficiency, need for supplementary firing and increased emissions.

8.2 Monitoring Data

Throughout the tests, boiler and flame stability has been observed to have improved following the LNBo conversion, allowing for a proposed reduction in Unit 9 Stable Export Limit (SEL) down to 290MW_{gen}. Boiler and flame stability has been tested at this lower limit by carrying out trip tests, both of the mills and a full firing trip.

Unit 9 has passed the SEL (Stable Export Limit) test at 290MW_{gen} running on 100% coal. The test needs to be repeated with the biomass plant in service.

Further testing has been carried out on stability on loss of ignition and on tripping a single mill.

Testing has also been carried out at the 290MW_{gen} proposed SEL when firing Tower coal with approximately 1.9% Hi-Carbon ash return included. Again, during this test, no negative effect was observed on boiler stability or mill performance.

Performance Test D was a load ramp up from 290MW_{gen} to 535MW_{gen} at a rate of 5MW per minute without oil support and this test was passed without any indication of boiler instability.

8.3 Conclusions

Performance during commissioning and under test conditions has identified no issues relating to start up, shut down and stability under a range of normal and simulated abnormal operating conditions.

The Unit 9 LNBo has passed the Stable Export Limit (SEL) test at a new proposed limit of 290MWgen and RWE has established a safety case for this limit, compared with the current minimum SEL of 395MWgen. Stability has been demonstrated under normal, ramp up and trip conditions. Further tests are due to be carried out on biomass co-firing.

RWE will continue to monitor performance under different environmental conditions and on different fuel compositions as part of the continuing fine-tuning of the boiler operations.

RWE intends to make an application to NRW for a permit variation to reduce the SEL (MSUL/MSDL) of Unit 9, in line with the results achieved in these tests (Permit Table S1.5 Minimum Start -up and Shut-down Thresholds) once the new SEL has been formally included within the RWE "PF Code of Practice".

9. Slagging

9.1 Anticipated and Potential Impacts

RWE believes that the LNBo conversion should be achieved without any inherent increase in slagging, based upon experience of other plants that have deployed the same technology.

Changes to the combustion temperatures and process, in order to control NOx formation, are inherent in the LNBo conversion. Changes to boiler design and platen metal temperatures have the potential to increase the rate of boiler slagging, when semi molten ash cools, solidifies and sticks to the boiler surfaces. Slagging can rapidly lead to fouling of radiant heat transfer surfaces, affecting boiler performance, reducing thermal efficiency, NOx performance and emission levels.

The composition of coal (particularly the iron content) is known to be a major factor in slagging rates and therefore the performance tests were designed to test the boiler under the range of coals likely to be burnt at Aberthaw.

It was anticipated that slagging could be an issue that could occur during the optimisation process, until operating procedures were 'fine-tuned' under all conditions.

9.2 Monitoring Data

Observations were made of higher than normal slagging levels, particularly when operating on 'neat' Ffos-y-Fran coal. Slag was observed to build up between the burner arch and the Over Fired Air (OFA) ports. Whilst this observation appeared to be linked to this particular coal, it was also considered that the problem could be improved by modifications to the boiler in the area where slag build up was observed.

RWE and the boiler conversion contractor identified design features which were likely to be affecting the slagging issue in this particular part of the boiler. A series of remedial works, involving modifications to the refractory surfaces around the OFA ports were undertaken during the planned shut-down, during May 2016.

Following the completion of operations on 100% Ffos-y-Fran coal, no heavy slagging was observed and it would appear that on other coals, slagging rates were normal, without the need for modifications.

The modifications are only likely to have any effect when the fuel diet contains a high proportion of coals of a very high iron content with other predisposing factors.

RWE and the boiler conversion contractor are continuing to investigate the root-cause of the slagging and long-term options for reducing the propensity for it to occur. This might be as simple as controlling fuel diet, two-shifting the unit or might involve further minor boiler modifications.

9.3 Conclusions

Slagging has been shown to be a potential problem, associated with particular coals, with a potential to affect boiler performance. Modifications have been carried out to address a design issue that was identified when operating on coal with an unusually high iron content. The issue was not observed on other coals.

Whilst modifications have been carried out in the particular area of the boiler where the slagging occurred, the coal composition is considered the major factor and the issue only

occurred when burning neat Ffos-y-Fran coal. This coal is not expected to be a significant part of the fuel diet in the future and it is unlikely that a unit will be operated on 100% of this fuel.

The boiler has not been tested on neat Ffos-y-Fran coal since the modifications. Whilst it is anticipated that the modifications will reduce the problem at the particular location where slag build up was observed, the inherent potential for slagging on this type of coal remains and slagging rates will continue to be monitored under different operating conditions and on different coals.

10. Thermal performance

10.1 Anticipated and Potential Impacts

RWE anticipated that the thermal performance of Unit 9 would not suffer as a result of the LNBo retrofit. RWE believed that there is a potential for a slight increase in performance, if an increase in 'burn out' rate can be achieved.

However, any changes to the configuration of the boiler could have the potential to reduce performance and the Performance Guarantee Testing program was designed to insure that thermal performance levels did not suffer.

10.2 Monitoring Data

RWE carried out boiler air ingress tests on full load on the 3rd and 4th of February 2016 and multiple plant measurements were made to calculate thermal efficiency. The test results showed a net thermal efficiency of 92.3%, an increase from the 91.9% measured during performance tests on the same unit in October 2014.

Boiler performance was further tested at the full generated load of 535MW and efficiency was measured in terms of the % gas loss, following the guidelines of EN 12952-15 & ASME PTC4.

In Test A (repeat) on 13/04/16, the boiler passed its efficiency test, recording a gas loss of 5.03% against a maximum target of 6.7%.

Thermal efficiency performance is constantly monitored during operation through a range of processes and performance measurements against targets. Thermal efficiency for each unit is calculated and reviewed on a weekly basis.

10.3 Conclusions

Unit 9 has comfortably passed its boiler efficiency test, in terms of gas loss and thermal efficiency tests have shown a higher net efficiency than previously recorded for this boiler.

Performance on different fuels and under different environmental conditions will be monitored and 'fine tuning' carried out, in order that efficiency can be maintained under all operating conditions.

None of the monitoring has indicated any loss of thermal performance.

11. Electrostatic precipitator performance

11.1 Anticipated and Potential Impacts

RWE does not expect that the LNBo modifications will result in any change to the performance of the electrostatic precipitators.

The LNBo project included increasing the ball loading of the PF mills in order to control PF fineness and it could be possible that this could result in a change to PF quality, which in turn could affect precipitator performance.

If the modifications had led to a reduction in the performance of the precipitators, this could have resulted in an increase in concentration of flue gas dust emissions to atmosphere, which is a continuously monitored parameter.

11.2 Monitoring Data

Continuous air quality monitoring is carried out at Aberthaw using MCERTs CEM technology (Continuous emission monitors), in order to ensure compliance with the Environmental Permit dust limit of 20mg/m^3 (monthly mean) and 35mg/m^3 (95%ile of daily mean).

Stack dust levels, recorded during the tests, were comfortably within the station environmental permit levels and are shown in Table 4 below -

Table 4 - Test Results for stack particulate emissions, measured in mg/Nm3.

Test	Date	Coal	Generation	Permit Limit (monthly)	Particulate concentration
A*	13/04/16	Ffos-y-Fran	535MW (MEL)	20mg/Nm^3	10.1mg/Nm^3
B	21/03/16	Ffos-y-fran	395MW (SEL)	20mg/Nm^3	8.4 mg/Nm^3
C	01/04/16	Tower	290MW (new SEL)	20mg/Nm^3	4.5 mg/Nm^3

*Test A Repeat

The figure of 10.1mg/Nm^3 (Test A repeat) on full load is within the normal range of performance expected at Aberthaw.

Separate tests were carried out on PF quality as a result of the increased loading of the PF mills. The mill load was set at 41"WG, the dynamic classifier speed was 110r.p.m. and the cyclone vent valves were set at 30% open.

The results of the PF quality tests are given in Table 5 below demonstrating the mills met the project target of 95% through 75microns:-

Table 5 - PF Quality results at 110rpm DC Speed

	Percentage of fraction retained on sieve (%)						
Sieve size (µm)	9A Mill	9B Mill	9C Mill	9D Mill	9E Mill	9F Mill	Avg.
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0
212	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150	0.1	0.1	0.1	0.1	0.1	0.0	0.1
106	0.8	0.7	0.6	0.8	0.8	0.5	0.7
75	4.6	4.4	4.4	4.4	4.4	3.7	4.3
<75	**94.6**	**94.8**	**94.9**	**94.7**	**94.7**	**95.7**	**94.9**
Total (%)	100	100	100	100	100	100	100

11.3 Conclusions

Monitoring of dust emissions during commissioning and performance testing has not indicated that the LNBo conversion, and the changes to PF fineness, has had any negative impact upon precipitator performance and emission levels remain comfortably within permit limits and are consistent with normal site levels.

12. NOx emissions

12.1 Anticipated and Potential Impacts

The object of the Unit 9 LNBo project was to reduce NOx emissions to atmosphere whilst maintaining other performance parameters. The permit application stated that the expectation was that unit would achieve emissions in the range of 450-600mg/Nm^3 following the conversion.

RWE was confident that the LNBo conversion could potentially reduce NOx levels to below 450mg/Nm^3, under optimal conditions, and this was set as the performance guarantee test level for Ffos-y-Fran coal. For Tower coal, the guarantee level was 550mg/Nm^3.

12.2 Monitoring Data

The guarantee tests covered operations on the two main coal types and at both the existing Maximum Export Limit of 535MW_{gen} and the existing Stable Export Limit of 395MW_{gen} (380$MW_{s/o}$) and at the proposed new SEL of 290MW_{gen}. NOx was measured by extraction at the FGD booster fan outlet. The results, for NOx tests are summarised in Table 6 below:

Table 6 - Test Results for NOx, measured in mg/Nm^3, extracted at the booster fan.

Test	Date	Coal	Generation	Test Limit	Performance
A*	13/04/16	Ffos-y-Fran	535MW (MEL)	<450 mg/Nm^3	429 mg/Nm^3
B	21/03/16	Ffos-y-Fran	395MW (SEL)	<450 mg/Nm^3	384.9 mg/Nm^3
C	01/04/16	Tower	290MW (new SEL)	<550 mg/Nm^3	412.3 mg/Nm^3

*Test A Repeat

12.3 Conclusions

In the commissioning tests, Unit 9 has met or exceeded the anticipated level of NOx abatement described in the permit variation application. These tests, whilst showing the potential performance under test conditions does not necessarily reflect the normal performance of the unit. Data extracted from CEMs monitoring, covering several months of operations is discussed in Section 14 and gives a more balanced view of the actual performance.

The performance test cannot include all potential operating conditions. RWE will continue to monitor the operation of the boiler under different conditions in order to fine tune its performance and insure that the abatement levels can be maintained under all normal operating conditions.

13. Other – SOx

13.1 Anticipated and Potential Impacts

RWE anticipated that the LNBo technology would not have any impact upon emissions of SOx. Aberthaw has a permit limit on emissions of SOx of 350mg/Nm^3 (monthly mean) and 440mg/Nm^3 (95%ile of daily mean) .

Monitoring was carried out, during the commissioning tests, in order to confirm this assumption.

13.2 Monitoring Data

SOx levels were monitored during the commissioning tests and the sulphur content of the coal (See PGTRS Table 14). The Ffos-y-Fran coal used in the tests averaged 1.22% sulphur. The monitoring results are summarised in Table 8 below -

Table 8 - Test Results for stack SOx, measured in mg/Nm3

Test	Date	Coal	Generation	Test Limit	Permit limit	Performance
A*	13/04/16	Ffos-y-Fran	535MW (MEL)	n/a	350 mg/Nm^3	157.9mg/Nm^3
B	21/03/16	Ffos-y-fran	380MW (SEL)	n/a	350 mg/Nm^3	174 mg/Nm^3
C	01/04/16	Tower	290MW (new SEL)	n/a	350 mg/Nm^3	138.5mg/Nm^3

13.3 Conclusions

The data gathered demonstrated that the LNBo has not had a negative impact upon SOx emissions and performance is comfortably within the site's permit limits and in the normal range expected.

14. BAT Discussion

14.1 Anticipated and Potential Impacts

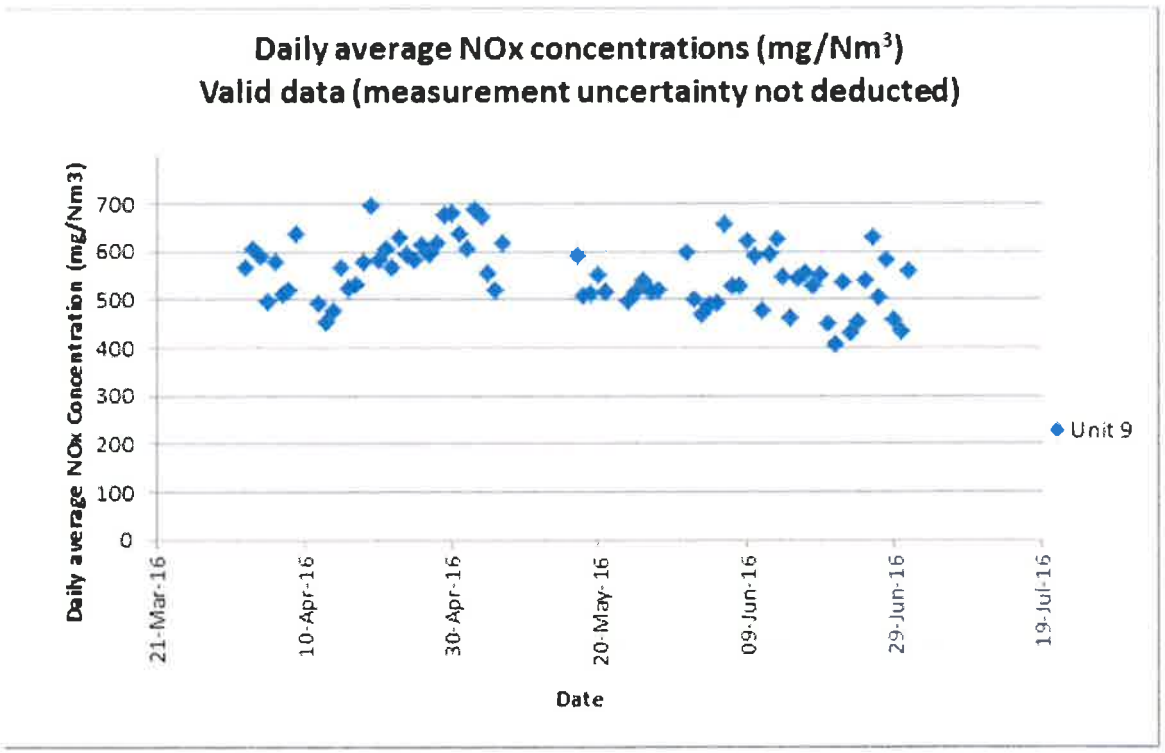
The improvement condition also asked RWE to consider the ongoing BAT implications as a result of the installation of the Low NOx Boiler technology.

"The report should include a justification of the Best Available Techniques Associated Emission Limits (BAT ELV's) to be adopted upon full implementation of all low NOx boilers."

14.2 Monitoring Data

The performance tests detailed in Section 12.2 indicate that the NOx concentrations under the conditions of the tests met expectations for the technology. These are essentially snapshots under specific test conditions and cannot cover the wide combination of fuel and operational characteristics which occur during ongoing normal operation over a year. However recent concentration data aligns with expectations taking into account the expected variability, illustrated in Figure 2 below which shows daily average concentrations (valid data with no deduction for measurement uncertainty) over the time period April to June 2016. As noted in Section 1 further optimisation and refinement is ongoing over the next year.

Figure 2 – Daily valid average NOx concentrations



14.3 Conclusions

There is currently insufficient data to robustly determine the monthly and daily average BAT Associated Emission Limits for the Low NOx Boiler Technology. The developing dataset of NOx performance will continue to be evaluated and form part of the assessment of overall station NOx performance in the context of the wider strategic picture of NOx reduction measures at Aberthaw - however RWE propose no changes to the current station ELVs at the present time.

15. Compliance Assessment Report Response

15.1 Anticipated and Potential Impacts

Following the submission of the Commissioning Plan, NRW raised an action in the Compliance Assessment Report (CAR, Report Ref. CAR_NRW_0022709) requesting the following information –

The commissioning plan has been reviewed. The only point of query relates to the possibility of consequential effects associated with the mill ball charge increase. In particular whether changes in PF particle size distribution will result in changes in EP performance and balance of trace pollutants in seawater discharge.

ACTION: RWE to confirm whether or not these effects have been considered and if any assessment has been undertaken as part of the commissioning programme.

RWE anticipated that the LNBo conversion of Unit 9, in particular the reduction in PF size would not lead to the any change in the performance of the Electrostatic Precipitators. If this were the case, there would be the potential for a change to the balance of trace elements which are divided between FBA, PFA, Emissions to atmosphere and the FGD seawater discharge.

15.2 Monitoring Data

The results of tests carried out on the performance of the EP is given in Section 11 and shows that the performance of the EPs is within the range expected at Aberthaw and this would not indicate any change, which could have a consequential effect upon trace element distribution.

15.3 Conclusions

The performance of the EPs remains within the normal range expected at Aberthaw and it is unlikely that any major change to trace element absorption by FGD seawater will have occurred.

16. Controls Required

16.1 Anticipated and Potential Impacts

RWE anticipated that the LNBo conversion of Unit 9 would not lead to the need for changes to additional controls or new controls.

It was anticipated that a period of fine tuning would be required to understand the performance of the boiler under all conditions and that this could lead to modifications to operating procedures.

16.2 Monitoring Data

The monitoring and testing process reported in this document has not identified any serious issues that require specific controls, other than through normal or minor modifications to operating procedures.

The two operational issues that were encountered during commissioning are –

- The suspected potential for slagging when burning 100% Ffos-y-Fran coal
- The known effect upon CIA levels if PF particle quality falls

16.3 Conclusions

No issues requiring specific controls were encountered during commissioning, however, operating procedures will be reviewed during the 'fine tuning' period in order to ensure that optimal performance can be maintained under all operating conditions.

17. Conclusions

17.1 Anticipated and Potential Impacts

RWE has completed the retrofitting of Unit 9 with Low NOx Boiler technology and the unit has been successfully returned to service and passed its performance guarantee tests.

The unit has achieved the anticipated reduction of NOx, under test conditions, whilst other performance parameters have been maintained. No major changes to performance have been observed and the unit's thermal efficiency, stability and reliability have not deteriorated.

A period of 'fine tuning' is planned, lasting at least 12 months, when the unit will be operated on different fuels and under a range of operating conditions. During this period, experience will be gained in order to ensure that the plant can maintain optimal performance levels under all conditions.

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