Loy Yang B Power Station
Determination of 90th Percentile PM_{10} and $PM_{2.5}$ Emissions

March 2022

Loy Yang B Power Station

Powering alintaenergy

Contents

1. INTRODUCTION

1.1 Scope of work

Loy Yang B Power Station (LYB) operates under licence 3987 issued by the Victorian Environment Protection Authority (EPA). The most recent amendment of this licence was issued on 5 May 2021 and included a new condition, LI_DA4.3, which states that LYB:

> *… must establish and implement a program for a 12-month period to monitor the discharge to air, at discharge point(s) 1 to 4, of fine particles $PM_{2.5}$ and coarse particles PM_{10} to establish the 90th percentile annual frequency distribution. The results of this program must be made available to EPA on request and must be published to the publicly accessible website required by condition LI_DA4.3 by 31 March 2022.*

Further to this, EPA issued supporting information at the time which stated in relation to this condition:

> *EPA expects licence holder to engage with EPA when establishing program. EPA acknowledges technological changes for direct monitoring PM_{10} and $PM_{2.5}$ in real time. As such, EPA supports use of surrogate methods together with an appropriate number of stack tests. You are encouraged to engage with EPA when establishing the program.*
>
> *(Refer to EPA publications 440 & 1322.9).*

Following discussions with EPA, a proposed emissions monitoring program to facilitate compliance with this condition was submitted to EPA on 12 May 2021. On 31 May 2021, LYB was advised by EPA that the scope of the proposed program was appropriate.

2. BACKGROUND

2.1 Particle production

The combustion of lignite (brown coal) in a power station boiler, results in the production of a range of combustion by-products including gasses and solids. The solid material produced is referred to as ash and contains non-combustible materials such as mineral particles and refractory compounds along with some incompletely combusted organic matter referred to as char. Long-term lignite produced from the Loy Yang mine typically contains around 2.5% ash (dry basis), but this figure can vary significantly over shorter timeframes, depending on coal composition. The particle size distribution of the ash produced by the power station is also dependent on coal composition along with operation of plant systems.

2.2 Particle emissions

Ash particles produced from burning coal within the boiler are removed from the combustion gases through two mechanisms prior to discharging to air, the boiler hearth and the Electrostatic Dust Precipitators (EDPs). Heavier ash particles produced in the boiler fall to the boiler hearth where they are mixed with water and pumped to the ash ponds. Ash disposed of via the hearth is known as bottom ash. Lighter ash particles produced, known as fly ash, are entrained in the boiler combustion gas flow and then pass through the EDPs where most of these particles are removed. EDPs are the principal dust collection equipment which control pollution by imparting a negative charge on dust particles then removing them from the gas flow using large positively charged collector plates to which the particles adhere. The collector plates are periodically rapped to remove accumulated dust, which falls to a hopper and is then combined with water and pumped to the ash ponds. EDPs at LYB have a design collection efficiency of 99.5%. There are six EDPs on each Unit at LYB (three suppling each flue). After passing through the EDPs, the combustion gasses are then discharged to air via the chimney, with any entrained particles. These are referred to as particle emissions and are composed of Total Particulate Matter (all particles) containing size fractions of smaller particulate matter PM_{10} and $PM_{2.5}$.

2.3 Particle size

The size of the particles from an emission source is significant, as finer particles have a greater potential to adversely affect human health.

Particle emissions can be characterised in several ways depending on the proportion of particles of various sizes within the emissions. The licence issued to LYB from EPA Victoria refers to particles using three conventions:

- Particles – To avoid ambiguity, this document will refer to this as Total Particulate Matter (TPM).
- PM_{10} – Particles less than or equal to 10µm in diameter.
- $PM_{2.5}$ – Particles less than or equal to 2.5µm in diameter.

Note that $PM_{2.5}$ is a subset of PM_{10}, and both $PM_{2.5}$ and PM_{10} are subsets of TPM.

2.4 Monitoring particle emissions

There are two key methods available for monitoring particle emissions in power station discharges to air. These include methods based on discrete sampling events, and Continuous Emissions Monitoring Systems (CEMS).

Discrete sampling events typically involve drawing a sample from inside the chimney flue through a manual sampling system containing a particle collection device and a gas volume measurement device. The particles collected are later weighed in a laboratory, and by using this weight in conjunction with the gas volume sampled a particle weight/volume concentration is calculated. Typically, results are expressed as milligrams per cubic meter or mg/m^3. These methods can only provide a single result for the time when the sampling was performed. Using appropriate size-selective sampling heads, the determination of TPM, PM_{10} and $PM_{2.5}$ can be achieved from a single sampling event.

CEMS are based on devices which continuously monitor a parameter which can be used to determine particle concentration. At LYB, the CEMS is based on a light absorption measurement known as ‘optical density’ which has been correlated with TPM concentration results obtained by discrete extractive sampling methods. Using this method allows continuous real-time monitoring of TPM emissions. There are currently no commercially available systems which can continuously monitor PM_{10} and $PM_{2.5}$ in coal-fired power stations emissions.

EPA Victoria *Publication 440.1 A GUIDE TO THE SAMPLING AND ANALYSIS OF AIR EMISSIONS AND AIR QUALITY* specifies the use of *Australian Standard 4323.2 Determination of Total Particulate Matter – Isokinetic manual sampling – Gravimetric method* for determination of TPM in emission sources. EPA Publication 440.1 does not specify a method to determine PM_{10} or $PM_{2.5}$ from emissions sources. US EPA Test Method 201A was used for PM_{10} and $PM_{2.5}$ analysis.

2.5 Historical testing

Since commissioning of the power station (Unit 1 in1993, Unit 2 in1996), TPM emissions have been required to be continuously monitored as part of LYB’s EPA licence and have been subject to a maximum discharge limit. Prior to the most recently issued EPA licence in 2021, there had not been a requirement to monitor PM_{10} and $PM_{2.5}$. However, LYB has conducted testing annually for PM_{10} and $PM_{2.5}$ to ensure accurate reporting for the National Pollutant Inventory (NPI).

Although TPM tests were often conducted as part of the same annual test program which performed the PM_{10} and $PM_{2.5}$ test, they were performed as a separate test (not sampled concurrently) to the PM_{10} and $PM_{2.5}$ tests. As a result, while these historic results are valid for use in NPI reporting they are of limited use for assessing the relationships between the concentrations of both PM_{10} and $PM_{2.5}$ and TPM.

3. CONDITION LI_DA4.3 EMISSIONS MONITORING PROGRAM

This emissions monitoring program was developed to determine the relationship between the concentrations of both PM_{10} and $PM_{2.5}$ and the concentration of TPM in LYB stack emission (Discharge points 1 and 2). From these relationships, factors would be determined that could then be applied to TPM emissions data from the CEMS, thereby enabling surrogate continuous monitoring of PM_{10} and $PM_{2.5}$. The PM_{10} and $PM_{2.5}$ data could then be used to calculate annual 90^{th} percentile values for these parameters. Discharge points 3 and 4 (coal handling plant wet scrubbers) have been found to make no significant contribution to station particle emissions and were not included in this program.

The program performed multiple tests for TPM, PM_{10} and $PM_{2.5}$ on each of the four boiler flues (two flues per Unit). In total, 60 sets of tests were performed on 15 days over a five-month period. Testing was performed under a range of typical plant operating conditions including different generation levels, two or three EDPs in service per flue (due to routine maintenance activities), and variations in coal quality. During the testing campaign, routine 12-hourly coal samples were collected allowing the effects of coal quality to be assessed.

A stack emissions testing specialist, Ektimo Pty Ltd, was engaged to perform the testing. The sampling performed for this program was carried out according to US EPA Method 201A. This method was chosen as it allows determination of TPM, PM_{10} and $PM_{2.5}$ concurrently from a single test using one sampling apparatus. Analysis was performed according to AS2343.2 for TPM, and US EPA Method 201A for PM_{10} and $PM_{2.5}$. Ektimo hold accreditation for these tests with The National Association of Testing Authorities (NATA).

A power industry specialist consultant, HRL Technology Group, was engaged to prepare a detailed report on the program results including analysis and interpretation of results.

4. MONITORING PROGRAM RESULTS

The results from the monitoring program for are shown in Table 1.

Table 1. Results of TPM, PM10 and PM2.5 monitoring

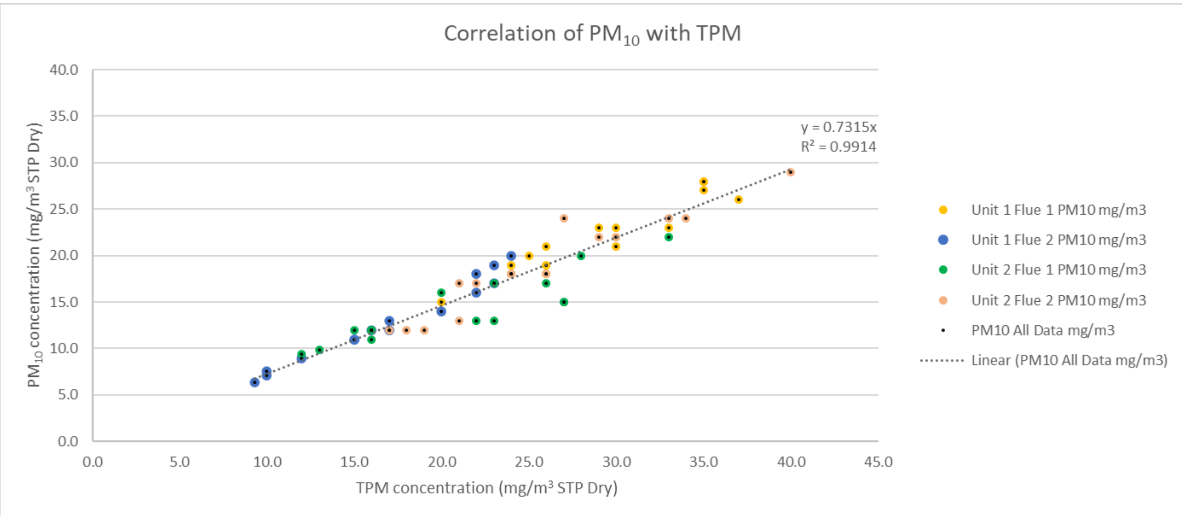
Date Sampled	Unit 1 Flue 1			Unit 1 Flue 2			Unit 2 Flue 1			Unit 2 Flue 2		
	TPM mg/m^3	PM_{10} mg/m^3	$PM_{2.5}$ mg/m^3	TPM mg/m^3	PM_{10} mg/m^3	$PM_{2.5}$ mg/m^3	TPM mg/m^3	PM_{10} mg/m^3	$PM_{2.5}$ mg/m^3	TPM mg/m^3	PM_{10} mg/m^3	$PM_{2.5}$ mg/m^3
3/08/2021	29	23	11	22	16	7.5						
3/08/2021	30	21	8.7	23	17	8.5						
4/08/2021	35	27	13	24	20	14						
4/08/2021	25	20	12	23	19	13						
4/08/2021	26	19	10	22	18	12						
5/08/2021							20	16	11	29	22	16
5/08/2021							33	22	13	33	24	17
5/08/2021							22	13	6.8	24	18	12
6/08/2021							13	10	5.1	22	17	10
6/08/2021							16	12	5	26	18	8
20/09/2021	26	21	8.9	15	11	3.7						
21/09/2021	19	15	6.8	17	12	4.8						
21/09/2021	24	18	7.2	15	11	4.1						
21/09/2021	35	28	10	10	7.6	3						
22/09/2021	20	15	6.1	16	12	5.1						
22/09/2021	35	28	10	12	8.9	4.6						
22/09/2021							16	11	4.4	27	24	10
23/09/2021							12	9.4	3.2	21	17	8.2
23/09/2021							15	12	5.5	40	27	12
23/09/2021							16	12	4.8	30	22	11
24/09/2021							23	17	7.2	34	24	10
26/10/2021	37	26	19	17	13	9.4						
27/10/2021	30	23	16	20	14	8.7						
27/10/2021							26	17	7.7	17	12	8.9
28/10/2021							28	20	12	24	18	13
13/12/2021	26	18	8	9	6	4						
13/12/2021	33	23	11	10	7	3						
14/12/2021							27	15	6	18	12	8
14/12/2021							27	15	6	21	13	6
16/12/2021							23	13	5	19	12	6

5. ANALYSIS OF RESULTS

5.1 Relationship between PM_{10} and TPM

Results for PM_{10} were plotted against the corresponding TPM results obtained from testing. Figure 1 illustrates the correlation for all 60 samples across both Units 1 and 2. Individual flue results from all four flues are also shown in this figure.

Figure 1: Correlation of PM_{10} to TPM – all test data



Assessment of data performed by HRL indicated that there was no clear difference between test results for a specific Unit and/or flue, so all test results were combined for determining the correlation between PM_{10} and TPM.

The least squares correlation coefficient for the linear trendline was 0.99, indicating a good correlation.

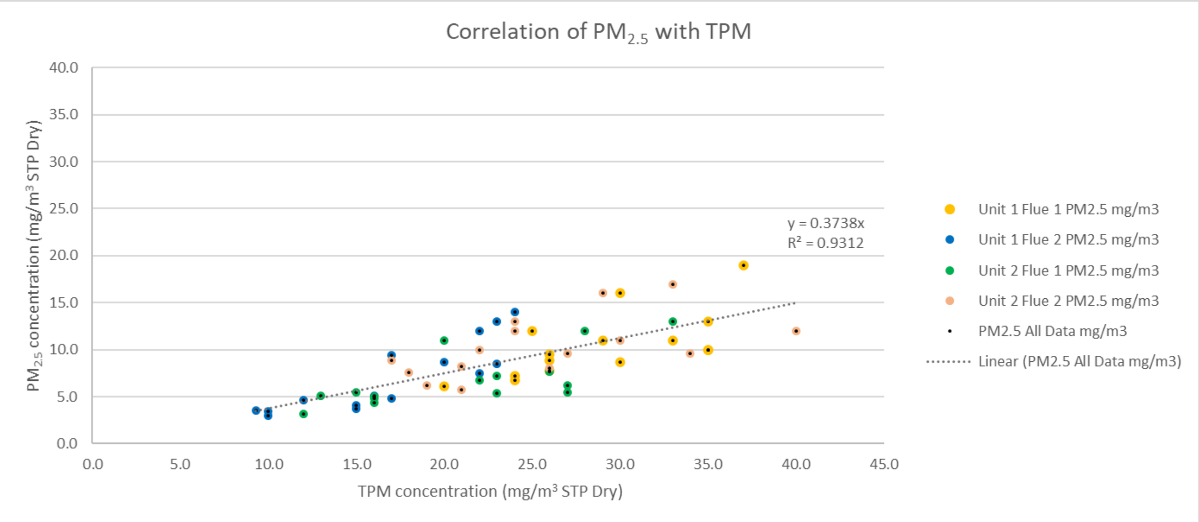
The linear trendline of these data indicate TPM emissions contain 73% PM_{10} on average.

HRL also analysed the effects of several variables on this correlation including coal quality parameters, EDP flow pairs operating, and Unit generation. None of the variables investigated produced consistent effects on the relationship between PM_{10} and TPM

5.2 Relationship between $PM_{2.5}$ and TPM

Results for $PM_{2.5}$ were plotted against the corresponding TPM results obtained from testing. Figure 2 illustrates the correlation for all 60 samples across both Units 1 and 2. Individual flue results from all four flues are also shown in this figure.

Figure 2: Correlation of PM2.5 to TPM – all test data



The $PM_{2.5}$ data were found to be more scattered compared with the PM_{10} data displayed in Table 1. HRL concluded that this could be expected due to the low concentrations of $PM_{2.5}$ present and lower/more variable EDP collection efficiency for $PM_{2.5}$.

Based on their assessment of the data performed, HRL have recommended that combining all data for determining the correlation between $PM_{2.5}$ and TPM is appropriate.

The least squares correlation coefficient for the linear trendline was 0.93, still indicating a good correlation.

The linear trendline of these data indicate TPM emissions contain 37% $PM_{2.5}$ on average.

6. CONCLUSIONS

As per new licence condition LI_DA4.3 LYB established and implemented a program to allow the determination of 90th percentile values for PM_{10} and $PM_{2.5}$.

A monitoring plan was developed and subsequently approved by EPA. Sampling occurred on fifteen days over 5 months and included normal operational variations at the power station in terms of generation output, coal quality and EDP availability.

Relationships between the concentrations of both PM_{10} and $PM_{2.5}$ and the concentration of TPM in LYB power station stack emissions were determined. From these relationships, factors were calculated which can be multiplied by CEMS TPM results to allow surrogate continuous monitoring of PM_{10} and $PM_{2.5}$, and from these data annual 90^{th} percentile values for PM_{10} and $PM_{2.5}$ could be calculated.

The factors were found to be 0.73 for PM_{10} and 0.37 for $PM_{2.5}$.