BARRY COGENERATION PLANT

The Environmental Permitting (England & Wales) Regulations 2016

Permit No: EPR/JP3632ZH

IMPROVEMENT PROGRAMME

Reference IC7

Following the commissioning of dry low NOx (DLN) conversion of the CHP gas turbines and a period of operation for optimisation, the Operator shall submit a written post-commissioning report to Natural Resources Wales for approval. The report shall confirm the commissioning completion date for each gas turbine conversion to DLN firing. The report shall also state the emission reductions achieved and relevant performance parameters under the full range of operating scenarios, including, but not limited to:

- *noise levels associated with commissioning activities and routine start up and operation*
- *start up, shut down thresholds and effective DLN threshold.*
- *thermal performance*
- *CEMs performance*
- *NOx emissions, including NO:NO2 ratio*
- *CO emissions*

The report shall include confirmation of the Best Available Techniques Associated Emission Levels (BAT AELs) to be adopted upon full optimisation of the units, including a date from which the BAT AELs will be complied with.

Required Submission Date: 31st August 2021

Written October 2021 by [redacted]

Background

Improvement condition IC7 relates to the operation and emissions from two Gas Turbines (A & B) at the Dow Silicones Cogeneration Plant (CHP). The Large Combustion Directive (LCPD) and Industrial Emissions Directive (IED) introduced lower allowable emissions of NOx (nitrogen oxides). These lower emission limits were introduced into the CHP permit on 30th June 2020.

Schedule 3(a) of the CHP permit provided new NOx limits of 75mg/m³ (monthly), 82.5mg/m³ (daily) and 125mg/m³ (95th percentile) applicable from 1st July 2020.

Schedule 3(b) – Emissions and monitoring - Table S3.1(a) is effective from the date approved by NRW upon completion of this improvement condition IC7. New NOx limits will then apply as follows: 55mg/m³ (annual mean), 75mg/m³ (monthly), 80 mg/m³ (daily) and 125mg/m³ (95th percentile).

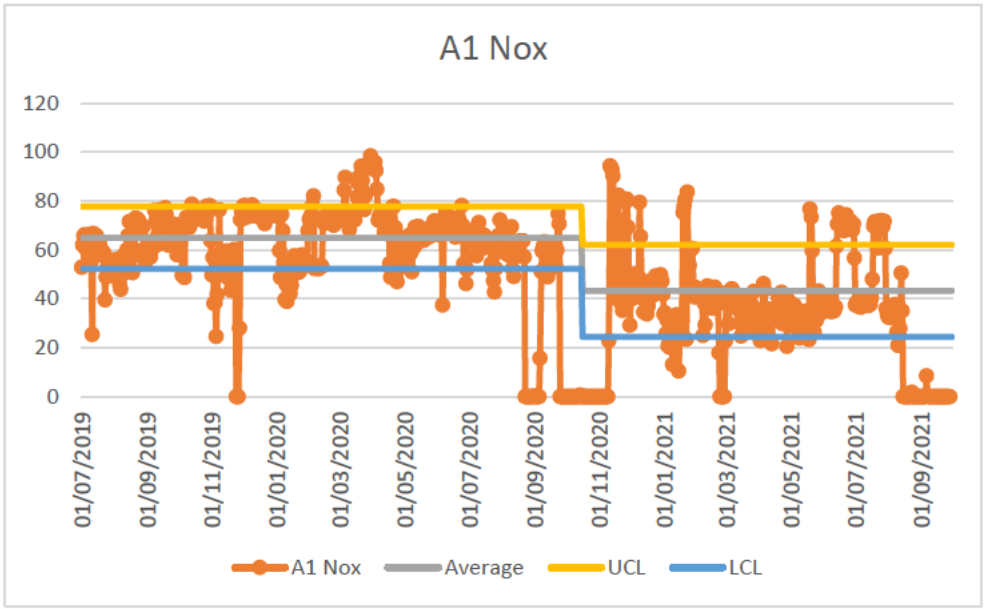
To meet the lower NOx permit requirements involved upgrading the two gas turbine machines using dry low NOx (DLN) technology via a multi-million dollar project.

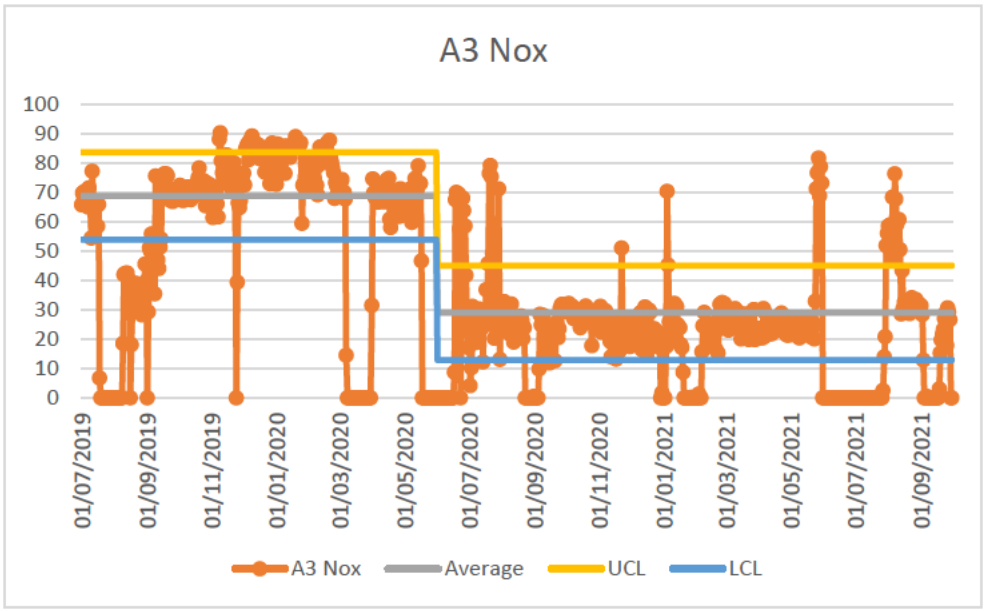
Gas turbine A was upgraded and fully commissioned, online and handed over to operations on 28th June 2020. Gas Turbine B was handed over on 15th November 2020. Some delays were incurred during the project due to Covid19 and resource availability.

The following sections provide details of the commissioning and subsequent operational performance post upgrade.

Emission Reduction Levels Achieved

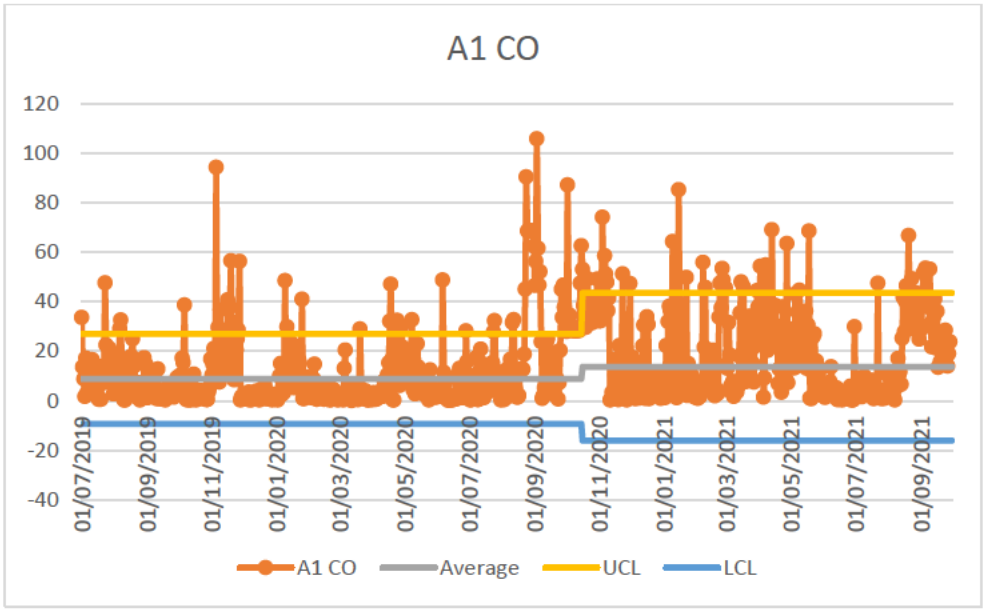
The following graphs show emission levels of NOx and CO before and after for both gas turbines. Emission results from both gas turbines post DLN installation have consistently been below both LCPD and IED schedule 3(a) and 3(b) permit emission values.

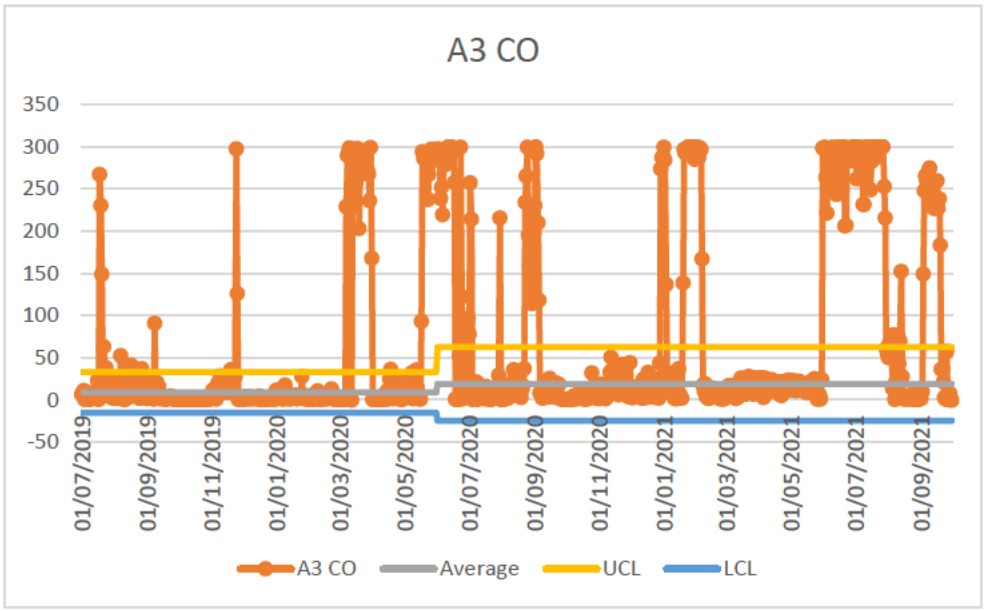




		NOx mg/m3 Dry*		
		SPC average	SPC UCL	SPC LCL
A1 (GTA)	Before	65.00	77.77	52.22
	After	43.27	62.11	24.43
	Reduction	33.4%		
A3 (GTB)	Before	68.88	83.76	53.99
	After	29.02	45.12	12.91
	Reduction	57.9%		

*Corrected to 15% O2.





		CO mg/m3 Dry*		
		SPC average	SPC UCL	SPC LCL
A1 (GTA)	Before	8.86	26.99	-9.27
	After	13.72	43.50	-16.06
A3 (GTB)	Before	8.90	33.10	-15.30
	After	18.91	62.49	-24.67

*Corrected to 15% O2.

Analysis of NOx performance showed that NOx levels from GT-A are slightly higher than GT-B. A Root Cause Investigation was carried out earlier this year to try to understand why there was a difference. The investigation concluded that that the difference could be due to fouled gas filters on GT-A. These have been replaced in the current outage of GT-A so we anticipate Improved performance in Q4 2021 and thereafter. Procedures have been updated to change gas filters on a periodic basis to ensure they are not capable of adversely impacting performance in future.

Table 1: NO:NO2 Emission Monitoring Results

The following table shows results for A1 and A3 emission points post commissioning.
All results expressed at Reference Conditions 273k, 101.3kPa & Dry Gas with no oxygen correction for this report as it is not for compliance purposes

Emission Point Reference	Substance to be Monitored	Periodic Monitoring Result	Units	Uncertainty (%)	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation Claimed for Test Result	Operating Status
A1	Nitrogen Monoxide (as NO)	60.62	mg/m³	3	Dry Gas	18/12/2020	09:30 - 12:30	BS EN 14792: 2017	UKAS / MCERTS	Normal
	Nitrogen Monoxide (as NO_2)	92.95	mg/m³	3					UKAS / MCERTS	

	Nitrogen Dioxide (as NO_2)	2.91	mg/m^3	3					UKAS / MCERTS	
	Total NOx (NO (as NO_2) + NO_2)	95.86	mg/m^3	3					UKAS / MCERTS	
	Calculated NO as % of Total NOx	95.96	%	N/A						
	Calculated NO_2 as % of Total NOx	3.04	%	N/A						

Emission Point Reference	Substance to be Monitored	Periodic Monitoring Result	Units	Uncertainty (%)	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation Claimed for Test Result	Operating Status
A3	Nitrogen Monoxide (as NO)	34.2	mg/m^3	3	Dry Gas	17/12/2020	13:00 - 16:30	BS EN 14792: 2017	UKAS / MCERTS	Normal
	Nitrogen Monoxide (as NO_2)	52.44	mg/m^3	3					UKAS / MCERTS	
	Nitrogen Dioxide (as NO_2)	3.7	mg/m^3	3					UKAS / MCERTS	
	Total NOx (NO (as NO_2) + NO_2)	56.14	mg/m^3	3					UKAS / MCERTS	
	Calculated NO as % of Total NOx	93.4	%	N/A						
	Calculated NO_2 as % of Total NOx	6.6	%	N/A						

Noise Levels during commissioning and routine start up and operation

Appendix 1 provides a noise report for start-up of GT-B (during which time the vent is discharged via a local start up bypass line (which can be used for a maximum of 2 hours). Local noise levels did increase by up to 10 dBA during this short period of operation (which should be very infrequent).

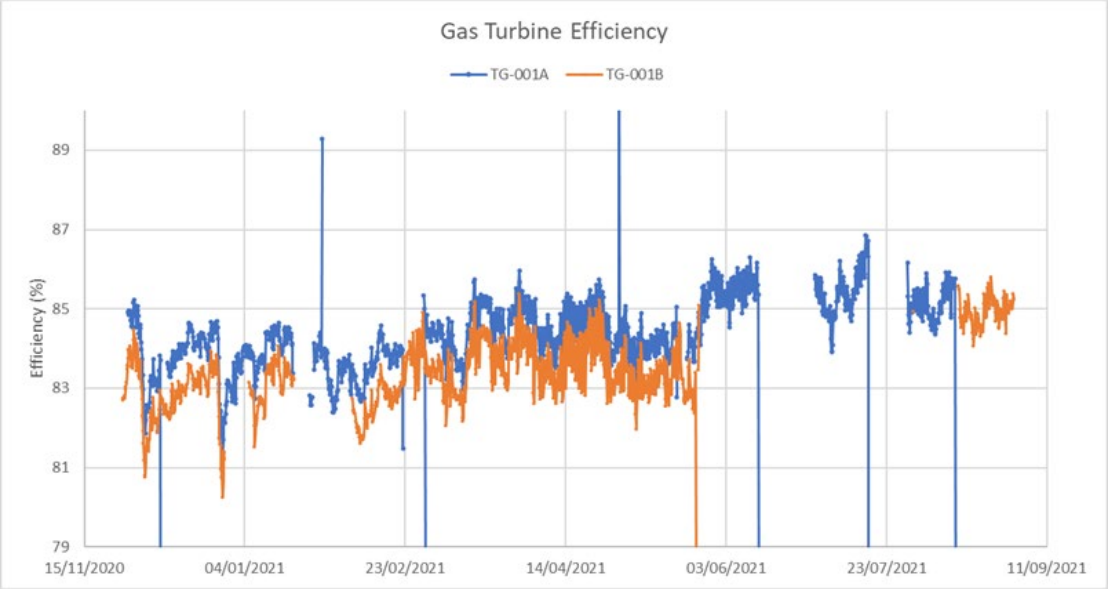
Start up, shut down thresholds and effective DLN threshold

As the units have 3 modes of operation and the GT's (which are the DLN equipment) either run ON or OFF it has not been feasible to create a load versus NOx DLN threshold chart to enable start up, and shutdown thresholds to be altered.

It is proposed to leave the start up and shut down thresholds in the permit as they are because the operational limits for these units were already been calculated as part of IC4. The operation modes of the CHP plant has not changed with the installation of the new gas turbines. IC4 was created before Dow was in Operational control and we have been unable to find a copy of this report to verify the methods used for these calculations.

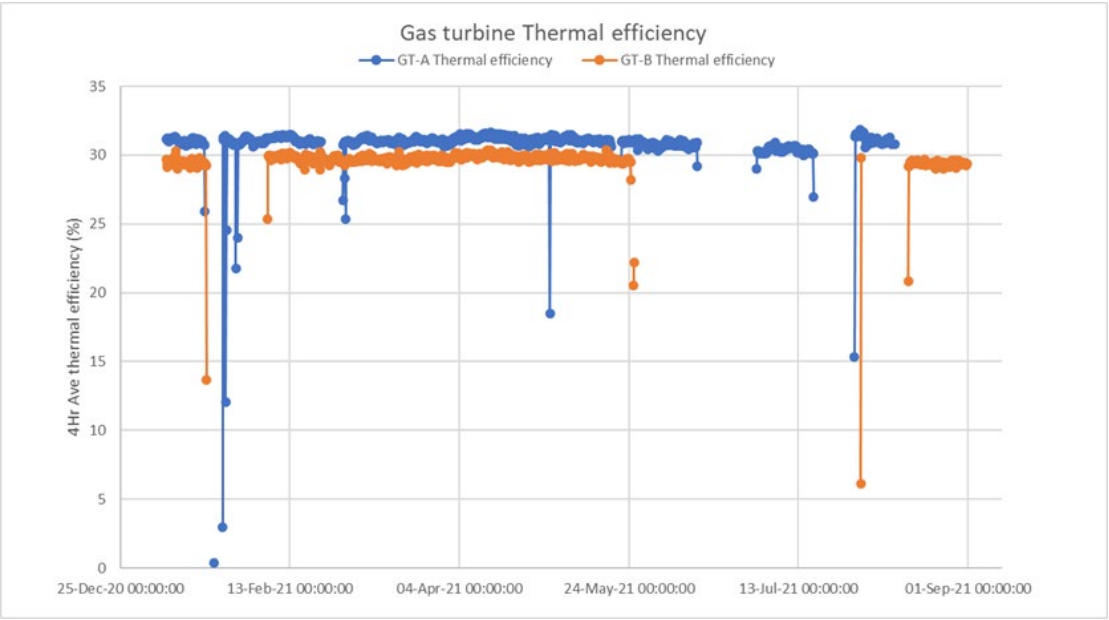
Gas Turbine Efficiency and Thermal performance

The graph below shows the isentropic compressor efficiency
Average efficiency values for the upgraded turbines are as follows:
GT-B = 84.35%
GT-B = 83.41%



The thermal efficiency can be calculated using the data below:
MW of Energy in (Nat Gas + Boiler Feed Water) = MW of Energy out (Steam + Electricity + losses).
Thermal efficiency (or "thermal performance") can be determined from this.

Using this calculation suggests that the turbines are around 30% thermal efficient (if you do not consider the amount of steam raised, which is significant). Other measures or calculations of efficiency could be reported depending on NRW requirements or needs.



CEMs performance

There were no changes to the CEMS monitors as part of the project. Work is ongoing to establish the suitable range for them now the NOx levels are lower. As yet we are unsure if we will be able to re-range the existing analysers or will need to order and install new.

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Summary and Proposals

The emission results confirm that the Best Available Techniques Associated Emission Levels (BAT AELs) (provided in Schedule 3(b) of the permit) can now be adopted as the units are fully optimised and the BAT AELS can be complied with.

APPENDIX 1

Noise Monitoring
GT-B Running through start up vent.

Environmental Noise Monitoring Results – Doug Richardson IH Delivery Specialist

Gas Turbine Upgrade Project

Noise Monitoring – GT-B Running through start up vent.

Survey Details

1) Monitoring carried out 10/7/2020 from approx. 12 noon to 4pm
2) Weather conditions clear with light breeze
3) All monitors mounted at head height – no measurements above this.
4) Locations as detailed in the map (fig 1)

Monitoring Equipment

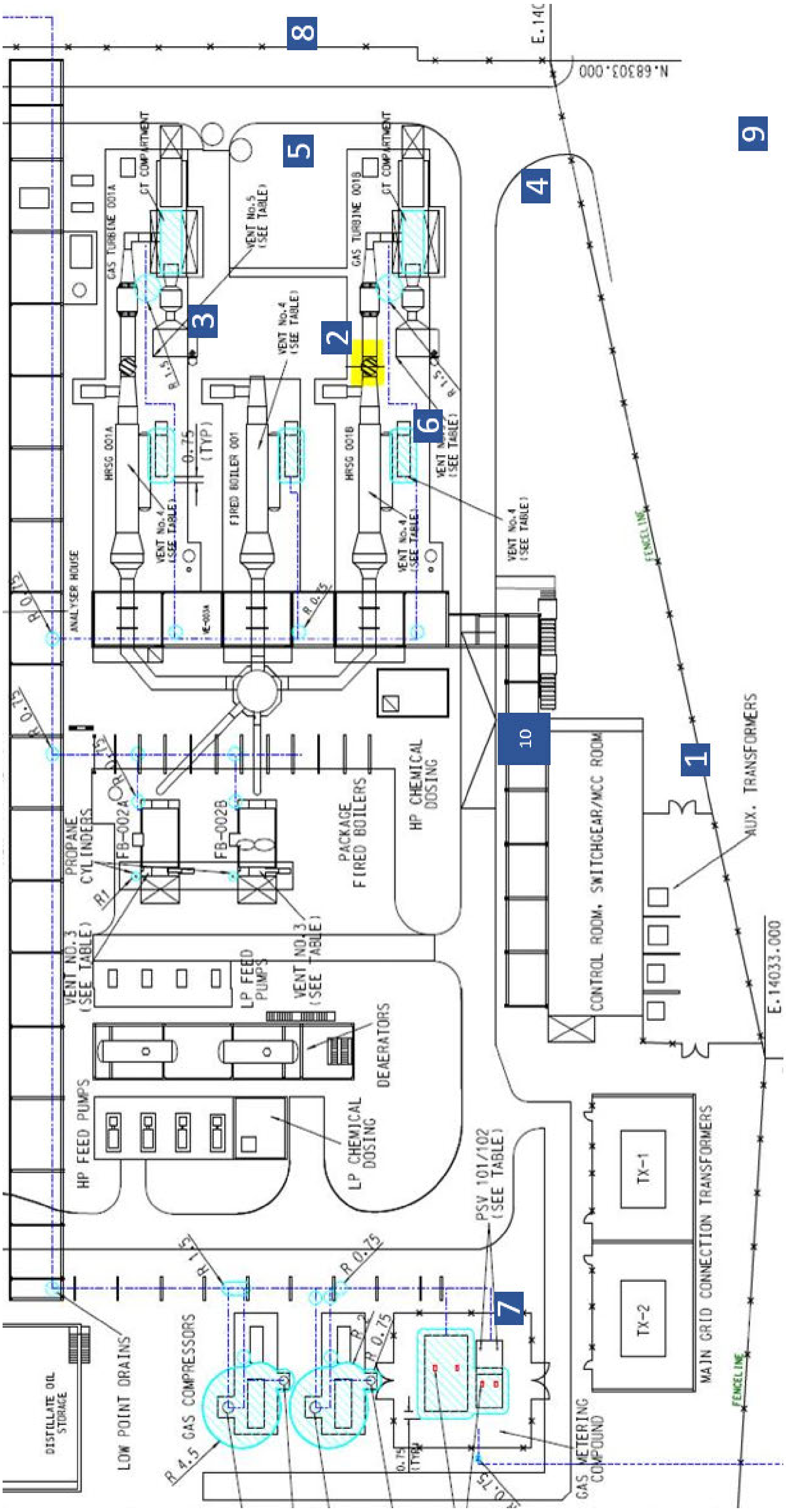
Cirrus CR110A noise badge – serial numbers CA8397, CA8398, CA8399, YA025, YA026, YC041, YC042, YC043, YC044, YB715 – Last serviced and main calibration Nov 2019.
All units calibrated on the day with RC:110A serial number 43949.
All monitors fitted with wind shields and placed facing the vent stack.
Monitors placed at the locations detailed on the map (figure 1)

1) Plant fence line below control room
2) Base of Stack RHS on barrier
3) GT A near base of stack
4) Fence-line (plant exit)
5) Valve head – edge of road
6) Base of stack LHS on plant
7) Gas unit – under shelter
8) Hydrant – far edge of plant
9) Site boundary on pipeline
10) Below control room stairs

Event Details

Plant running normally when monitors activated and post bypass
Plant put into bypass up vent stack at 13:33
Taken off bypass at 14:58

Figure 1



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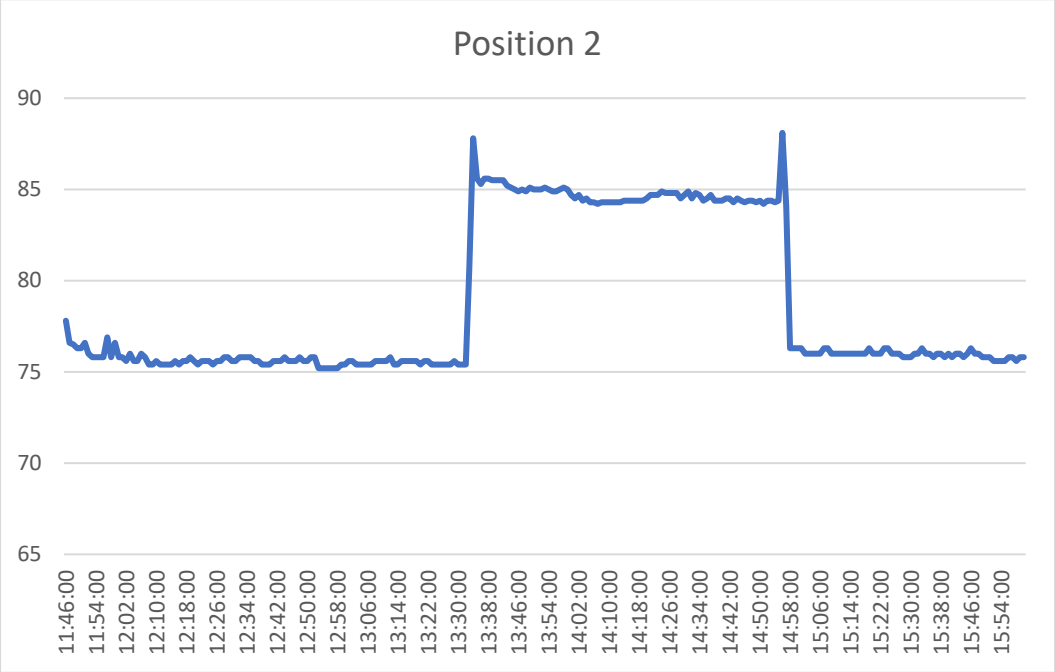
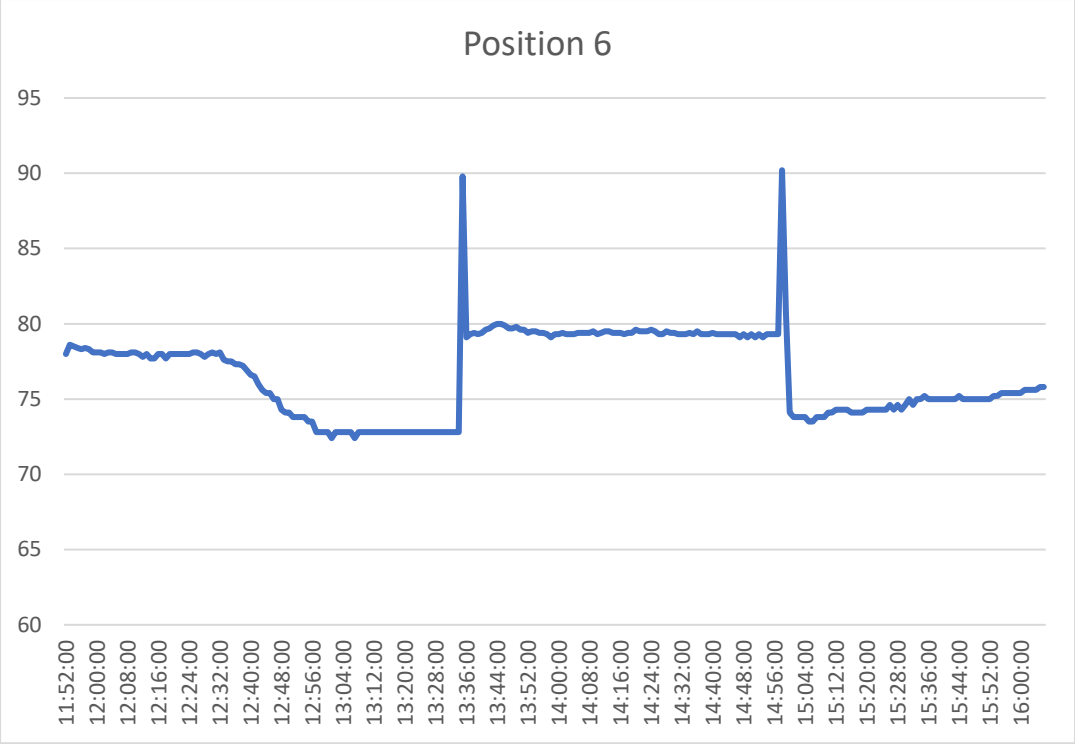
GAS TURBINE 001A
GAS TURBINE 001B
CT COMPARTMENT
HRSG 001A
FIRED BOILER 001
HRSG 001B
VENT No.4 (SEE TABLE)
VENT No.5 (SEE TABLE)
ANALYSER HOUSE
PROPANE CYLINDERS
FB-002A
FB-002B
PACKAGE FIRED BOILERS
HP CHEMICAL DOSING
VENT NO.3 (SEE TABLE)
LP FEED PUMPS
DEAERATORS
HP FEED PUMPS
LP CHEMICAL DOSING
PSV 101/102 (SEE TABLE)
CONTROL ROOM, SWITCHGEAR/MCC ROOM
AUX. TRANSFORMERS
E.14033.000
N.68303.000
TX-1
TX-2
MAIN GRID CONNECTION TRANSFORMERS
FENCELINE
GAS METERING COMPOUND
GAS COMPRESSORS
LOW POINT DRAINS
DISTILLATE OIL STORAGE

Results Summary
Position 2 and 6 (closest to the stack)
Position 2 saw an average 10dB increase in noise levels during bypass. Position 6 (shielded by plant) saw an average 7.5dB increase.
Position 3 and 4 (near field)
Both positions showed a 2-3dB increase in noise levels.
Position 5 and 8 (edge of plant)
Position 5 saw an increase of 1dB, position 8 at 0.5 dB (background noise from other part of plant)
Position 1 and 10 (control room area)
Both positions dominated by other background noises – no uptake in noise in position 1, and 1dB in position 10 (better line of sight of the stack)
Position 9 (Site Boundary)
No significant uptake in levels.
Position 7 (Gas compound)
No significant uptake in levels. Some evidence of tampering with monitor (spikes).

Graphs

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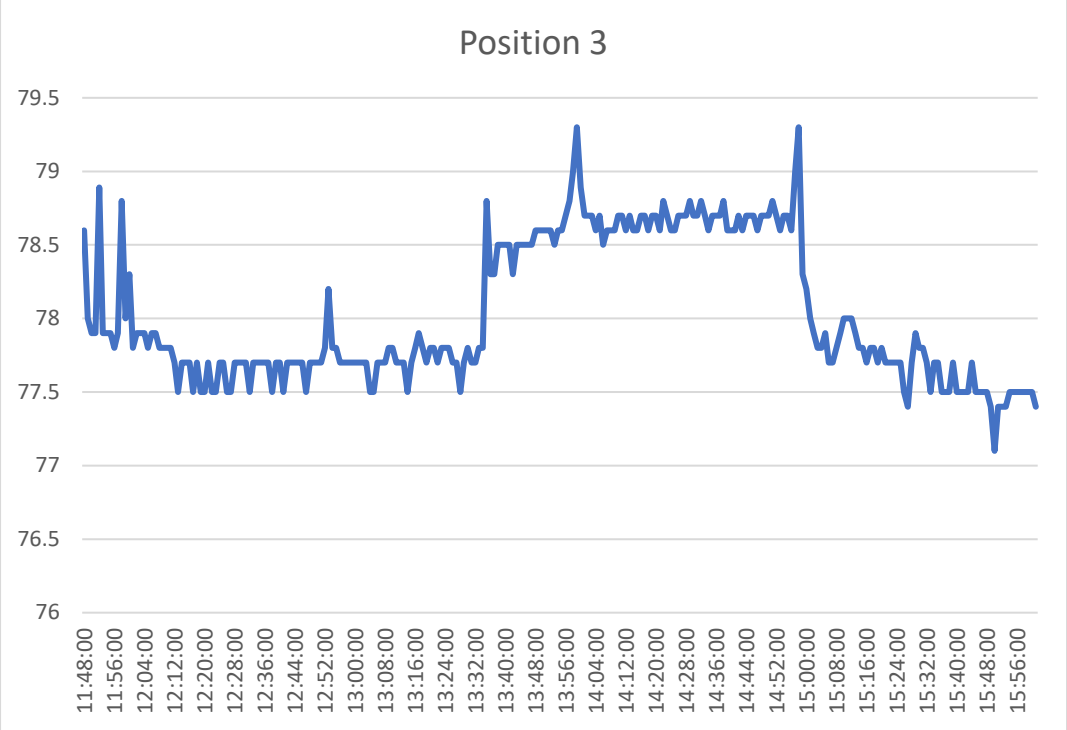
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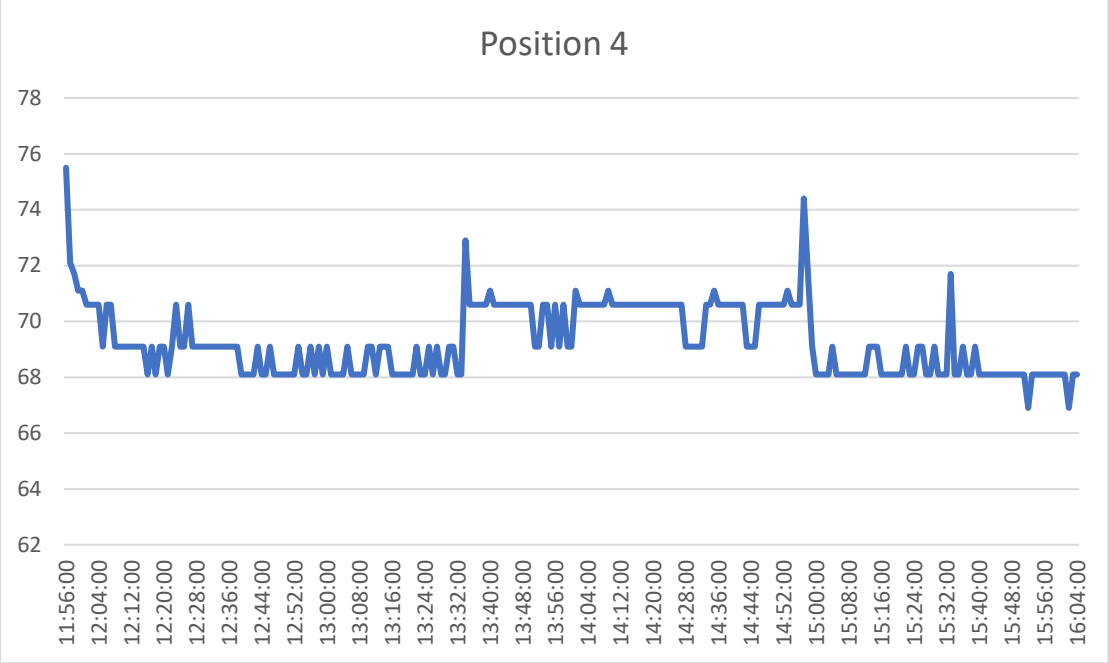
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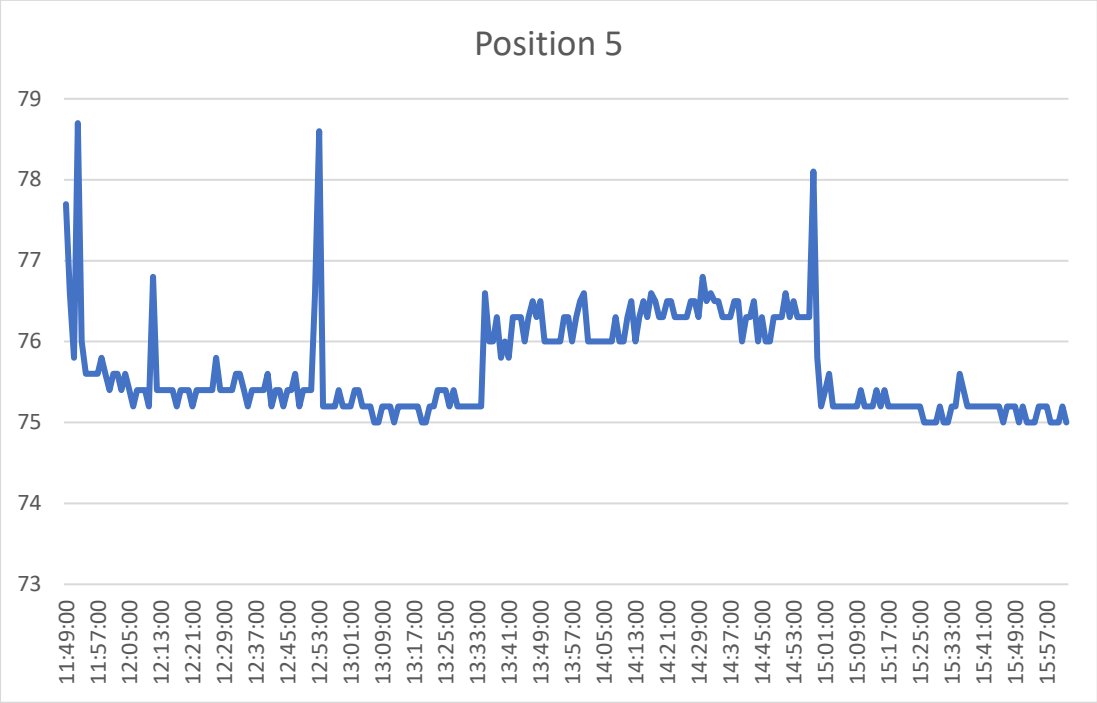
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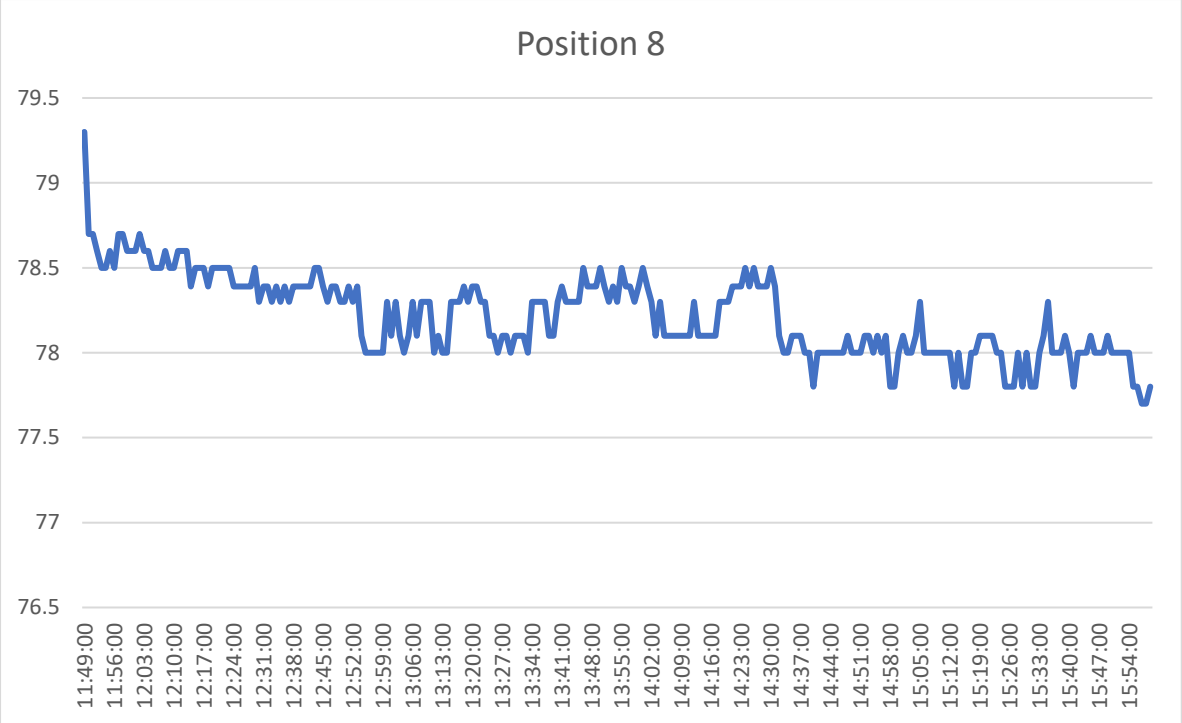
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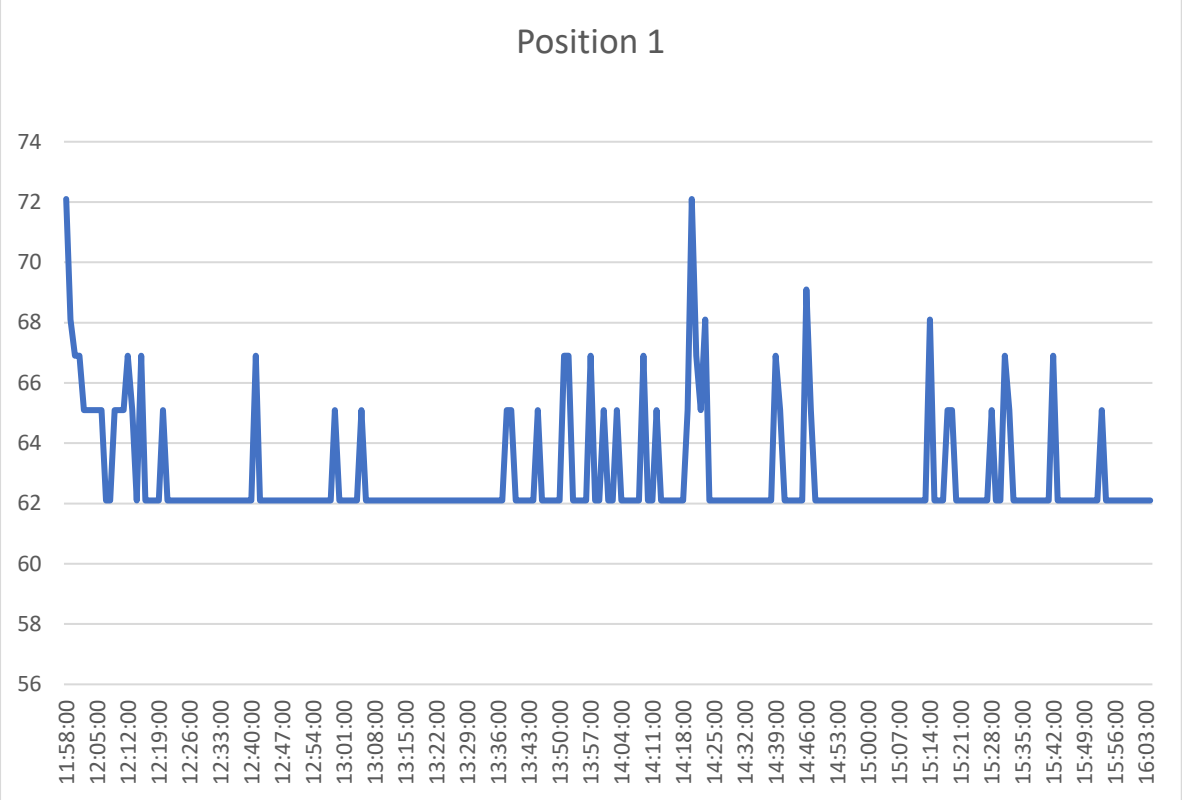
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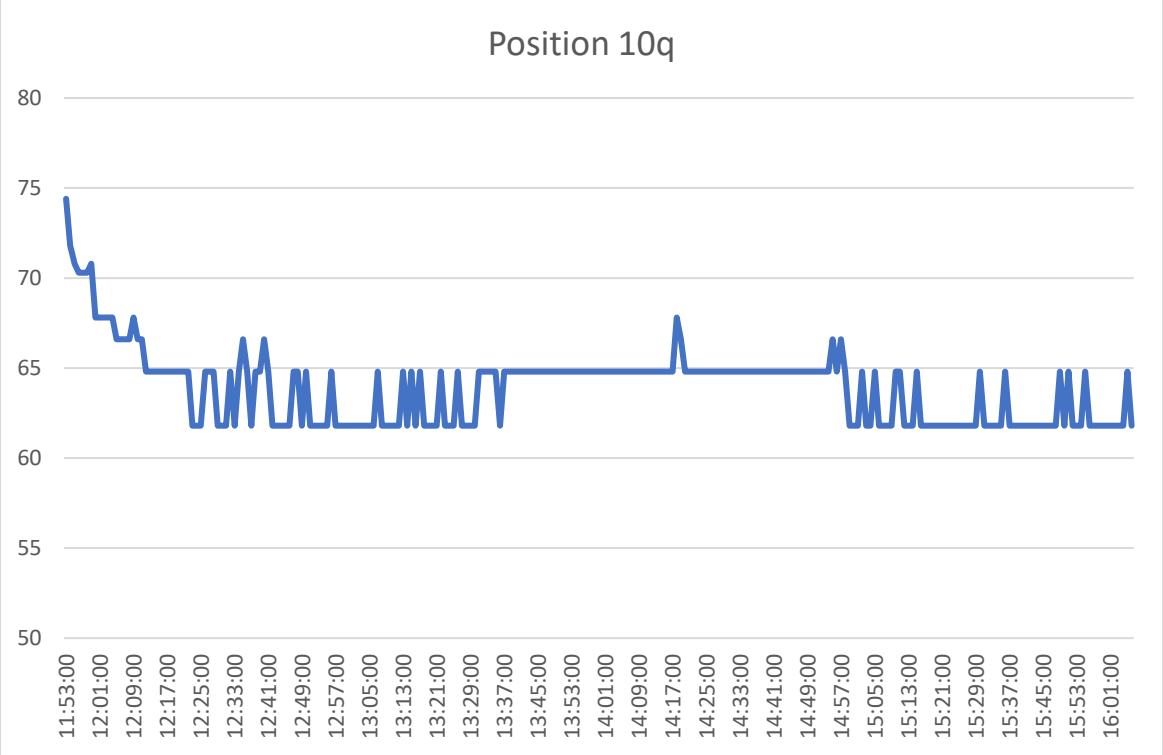
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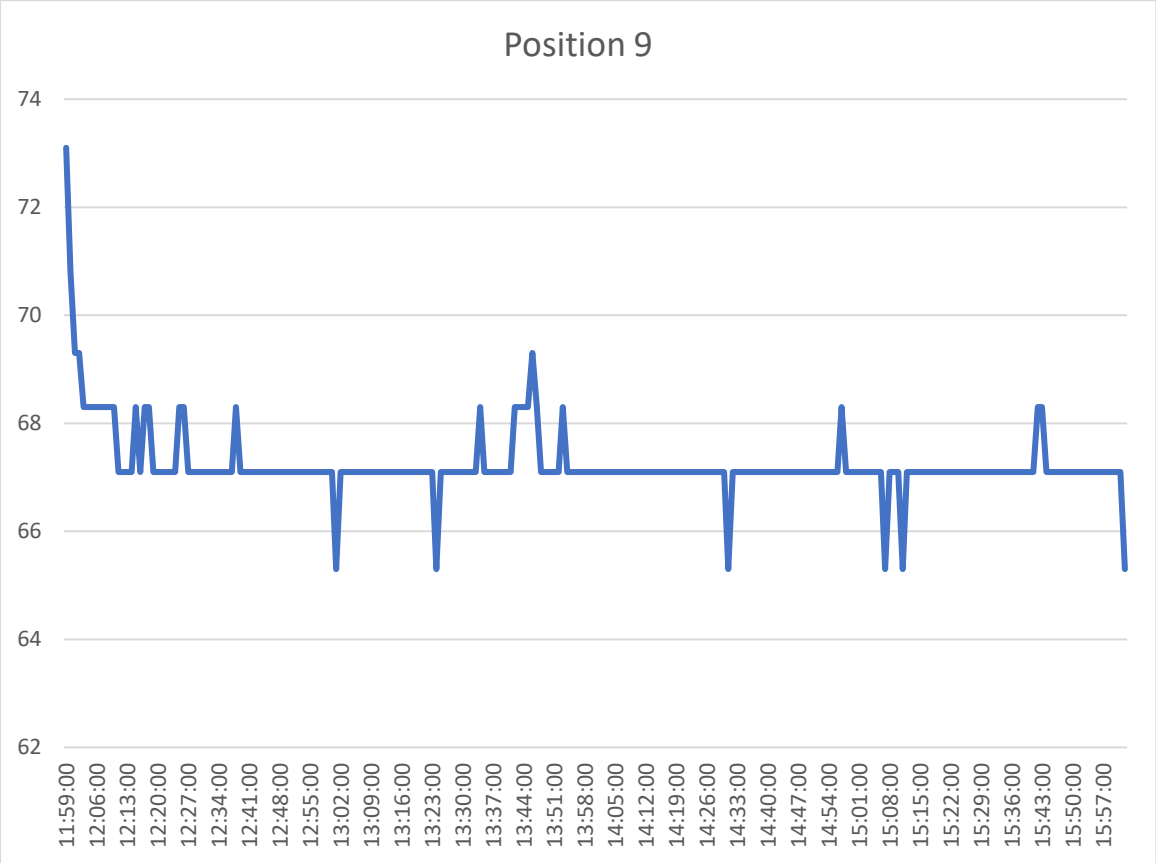
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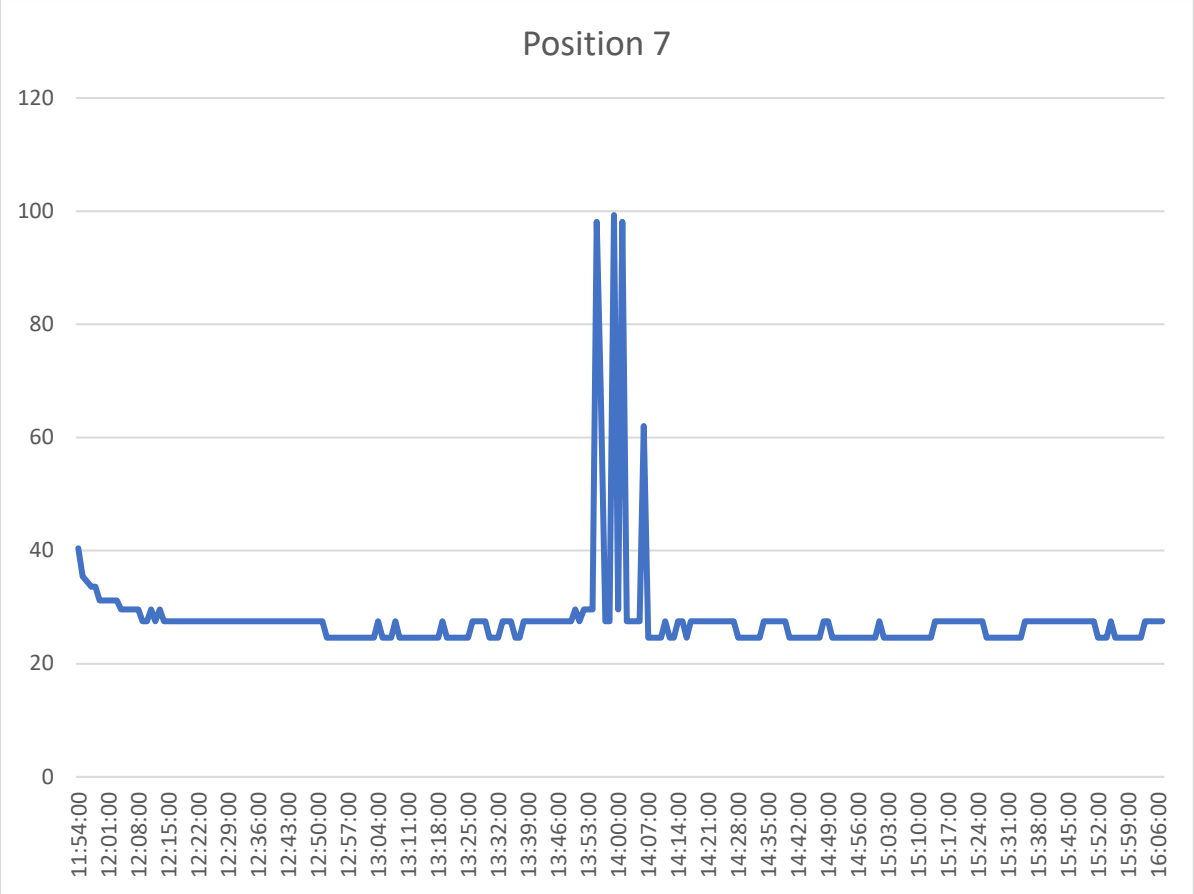
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