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1 Overview

This report summarizes the testing and presents the results of emissions tests carried out for verification testing for catalyst destruction efficiencies for diesel nitrogen oxides (NO_x) to satisfy the requirements of EGLE Permit to Install 327-98G. Testing was carried out on a General Motors (GM) Diesel Duramax 6.6 litre diesel engine.

The test cell set up comprised of a well-used representative diesel aftertreatment system. This system comprising of a Close Coupled Diesel Oxidizing Catalyst (CCDOC), a Selective Catalytic Reduction (SCR) and finally a combined Diesel Oxidizing Catalyst II (DOCII) and Diesel Particulate Filter (DPF) unit as fitted to a vehicle.

The diesel efficiency was found, as expected to have a zero Nitrogen Oxide (NO_x) conversion efficiency, over the 24 hour test the engine and test consumed 117.4 gallons (444.4 liters) of Ultra Low Sulfur Diesel (ULSD) and produced 16.2 lbs. (7,348 grams) of Diesel Nitrogen Oxide (NO_x) at the rate of 0.675 lbs. per hour (306.17 grams per hour) for the duration of the test.

2 Testing Description

2.1 Background

The test consisted of running a diesel engine in a test cell over a twenty-four (24) hour period, utilizing a typical diesel test cycle and vehicle aftertreatment system and establishing the conversion efficiency of NO_x and fuel consumption over the duration of the test. The system was tested without the effects of urea or Diesel Exhaust Fluid (DEF) making the testing a worst case.

This was achieved by sampling the emissions upstream and downstream of the aftertreatment system each hour. From these results a diesel NO_x emission conversion efficiency was calculated.

The analyzers used were Horiba Mexa 7500D calculated with NIST traceable gases. The calibration gases are also A2LA ISO17025 certified for use. All analyzers were zeroed and spanned with their relevant calibration gases prior to use.

NO_x Analyzers Specification:

Horiba CLA 520

Range 0 to 5,000 ppm Accuracy +/-1% of FSD. (+/-50 ppm)

2.2 Test Cycles

2.2.1 Diesel Nitrogen Oxides (NO_x) Conversion Efficiency Test

The test was to demonstrate that the NO_x produced during the catalyst ageing test cycle is measured and recorded. The catalyst conversion efficiency is calculated and recorded over the duration of the test. The total mass of NO_x produced, and fuel consumed to be reported.

The test used a sensors EFMS flow meter directly in the exhaust flow to calculate the exhaust mass flow directly.

The test was run over a twenty-four-hour period with emissions samples on an hourly basis. The engine and catalyst system data being recorded electronically every second (1 hertz) and secondary handwritten data collected every hour directly by a shift technician, this also promotes human interface with the test at least every hour.

The NO_x emissions were measured and recorded at pre and post locations on the aftertreatment system using a Horiba Mexa CLA-720D NO_x analyzer. The analyzer was

calibrated prior to testing with NIST traceable gases as required. Results were then calculated to establish the NOx mass emissions produced and the overall conversion efficiency.

The twenty-four-hour test was started on Tuesday October 27th on Procat Test Cell number 19 and completed during the evening of Wednesday October 28th. The test was run at an engine speed of 2,000 rpm with a load of 230 lb/ft torque and controlled to a CCDOC inlet temperature of 350 deg C and ran at these conditions steady for the test duration a representative ageing test.

2.3 Test Equipment

All testing was carried out within ProCat Test Cell number 19 for the Diesel NOx Emission testing. The test set up was typical of all diesel aftertreatment testing carried out within the facility at ProCat.

3 Results Summary

3.1 Results of 24-Hour NOx Efficiency Test

24 Hour NOx Efficiency Test

Lag Date	Log Time	Time into Test	Exhaust Flow	Exhaust Flow	Speed	Torque	Throttle Position	Power	Fuel Flow	Fuel Flow	NOx Emitted	NOx Emitted	CO	HC	NOx	CO	HC	NOx	CO	THC	NOx
	HH:MM:SS	HH:MM:SS	kg/hr	lb/hr	rpm	lb/ft	%	HP	lb/hr	gal/hr	lb/hr	g/hr	%	ppm	ppm	%	ppm	ppm	%	%	%
													In		Out		Efficiency				
10/28/2020	2:38:00	0:00:00	528	1.164	2000	238	41.2	90.6	29.1	4.90	0.68	306.66	0.02	246.00	509.00	0.00	63.00	1.00	100.00	74.39	0.00
10/28/2020	3:35:00	1:00:00	532	1.173	2000	230	41.2	87.6	28.8	4.85	0.67	303.49	0.01	150.00	499.00	0.00	39.00	1.00	100.00	74.00	0.00
10/28/2020	4:35:00	2:00:00	532	1.173	2003	226	41.8	86.2	27.3	4.60	0.63	287.69	0.01	72.00	517.00	0.00	20.00	1.00	100.00	72.22	0.00
10/28/2020	5:35:00	3:00:00	513	1.131	2001	242	40.8	92.2	28	4.71	0.65	295.06	0.01	26.00	526.00	0.00	7.00	1.00	100.00	73.08	0.00
10/28/2020	6:35:00	4:00:00	528	1.164	2000	235	40.7	89.5	27.5	4.63	0.64	289.80	0.01	36.00	530.00	0.00	10.00	1.00	100.00	72.22	0.00
10/28/2020	7:35:00	5:00:00	535	1.179	2002	237	41.5	90.3	27.9	4.70	0.65	294.01	0.01	37.00	477.00	0.00	10.00	1.00	100.00	72.97	0.00
10/28/2020	8:35:00	6:00:00	530	1.168	2000	231	41.5	88.0	27.8	4.68	0.65	292.96	0.01	45.00	467.00	0.00	13.00	473.00	100.00	71.11	0.00
10/28/2020	9:34:00	7:00:00	542	1.195	2002	245	40.4	93.4	28.3	4.76	0.66	298.23	0.01	49.00	465.00	0.00	12.00	477.00	100.00	75.51	0.00
10/28/2020	10:35:00	8:00:00	531	1.171	2001	235	41.4	89.5	29.1	4.90	0.68	306.66	0.02	33.00	421.00	0.00	9.00	470.00	100.00	72.73	0.00
10/28/2020	11:35:00	9:00:00	539	1.188	2003	239	41.4	91.1	26.8	4.51	0.62	282.42	0.01	40.00	477.00	0.00	8.00	482.00	100.00	80.00	0.00
10/28/2020	12:35:00	10:00:00	539	1.188	2001	238	41.2	90.7	27.4	4.61	0.64	288.74	0.01	35.00	496.00	0.00	10.00	51.00	100.00	71.43	0.00
10/28/2020	13:35:00	11:00:00	534	1.177	2000	239	42.1	91.0	27.3	4.60	0.63	287.69	0.01	27.00	494.00	0.00	8.00	496.00	100.00	70.37	0.00
10/28/2020	14:34:00	12:00:00	539	1.188	2000	232	41.5	88.3	27.5	4.63	0.64	289.80	0.01	30.00	450.00	0.00	9.00	494.00	100.00	70.00	0.00
10/28/2020	15:28:00	13:00:00	532	1.173	2000	225	42.2	85.7	27.7	4.66	0.64	291.90	0.01	72.00	538.00	0.00	21.00	501.00	100.00	70.83	0.00
10/28/2020	16:35:00	14:00:00	536	1.182	1999	225	41.4	85.6	27.1	4.56	0.63	285.58	0.01	45.00	506.00	0.00	7.00	516.00	100.00	84.44	0.00
10/28/2020	17:35:00	15:00:00	538	1.186	2001	223	42.2	85.0	27.9	4.70	0.65	294.01	0.01	38.00	510.00	0.00	8.00	521.00	100.00	78.95	0.00
10/28/2020	18:35:00	16:00:00	542	1.195	2000	222	42.2	84.5	28.4	4.78	0.66	299.28	0.01	36.00	505.00	0.00	8.00	515.00	100.00	77.78	0.00
10/28/2020	19:35:00	17:00:00	529	1.166	2000	248	40.9	94.4	27.7	4.66	0.64	291.90	0.01	35.00	506.00	0.00	7.00	519.00	100.00	80.00	0.00
10/28/2020	20:35:00	18:00:00	532	1.173	2000	240	41.6	91.4	27	4.55	0.63	284.53	0.01	40.00	501.00	0.00	9.00	521.00	100.00	77.50	0.00
10/28/2020	21:35:00	19:00:00	535	1.179	2000	227	41	86.4	28.5	4.80	0.66	300.33	0.01	37.00	515.00	0.00	8.00	524.00	100.00	78.38	0.00
10/28/2020	22:35:00	20:00:00	535	1.179	2000	238	41.4	90.6	28	4.71	0.65	295.06	0.01	38.00	504.00	0.00	9.00	508.00	100.00	76.32	0.00
10/28/2020	23:28:00	21:00:00	538	1.186	2001	232	41.9	88.4	28.3	4.76	0.66	298.23	0.01	55.00	549.00	0.00	14.00	510.00	100.00	74.55	0.00
10/29/2020	0:35:00	22:00:00	542	1.195	2001	236	40.9	89.9	28.1	4.73	0.65	296.12	0.01	22.00	527.00	0.00	6.00	528.00	100.00	72.73	0.00
10/29/2020	1:35:00	23:00:00	538	1.186	2000	220	42.2	83.8	27.9	4.70	0.65	294.01	0.01	28.00	507.00	0.00	7.00	520.00	100.00	75.00	0.00
10/29/2020	2:35:00	24:00:00	538	1.186	2000	247	40.9	94.1	28	4.71	0.65	295.06	0.02	37.00	511.00	0.00	9.00	524.00	100.00	75.68	0.00
10/29/2020	3:35:00	25:00:00	535	1.179	2000	241	40.9	91.8	28	4.71	0.65	295.06	0.01	33.00	508.00	0.00	7.00	519.00	100.00	78.79	0.00

Ave. over 24 hrs 4.70 0.65 294.01
 Total over 24 hours 117.4 gallons 16.2 lbs 7,348 grams



Prepared by Phil Moss

Approved by


P. H. Moss 12⁸20



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4 List of Appendix

Appendix 4.1 ProCat 24 Test Set Up Documentation and Performance Sheets

Appendix 4.2 Hourly Emission Data & Efficiency Sheets

Appendix 4.3 Procat Ageing Report & Histograms

Appendix 4.4 Diesel Fuel Specification Sheet

Appendix 4.5 Horiba Analyzer Span Gas Certificates of Analysis

Appendix 4.6 ProCat Sample Test Cell Summaries October 28th & 29th



Appendix 4.1

Procat 24 Hour NOx Emission Test Set Up Documentation and Performance Sheets

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Test Information

Hours	25
Description	NOx Efficiency
Date	October 29, 2020
Job Number	2762-56s1
Title	25 hr NOx Efficiency

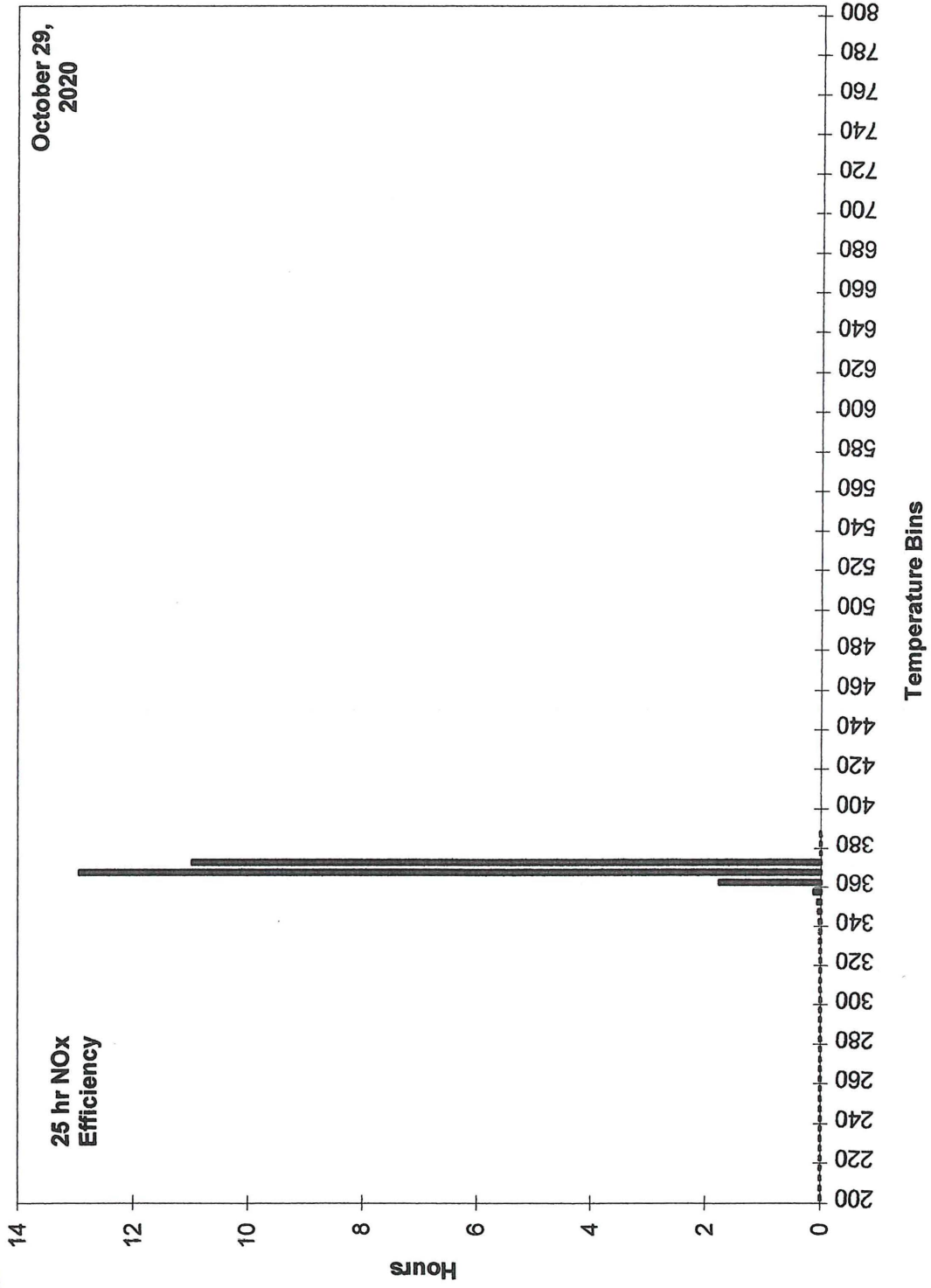
Get File

Graph No	Catalyst Description and Part No
1	Turbo Out Temp
2	DOC 1 (CC26832) Inlet Temp
3	DOC 1 (CC26832) Outlet Temp
4	SCR (CC26808) Outlet Temp
5	DPF (CC27836/26823) Outlet Temp
6	
7	
8	
9	
10	

COPY



Turbo Out Temp

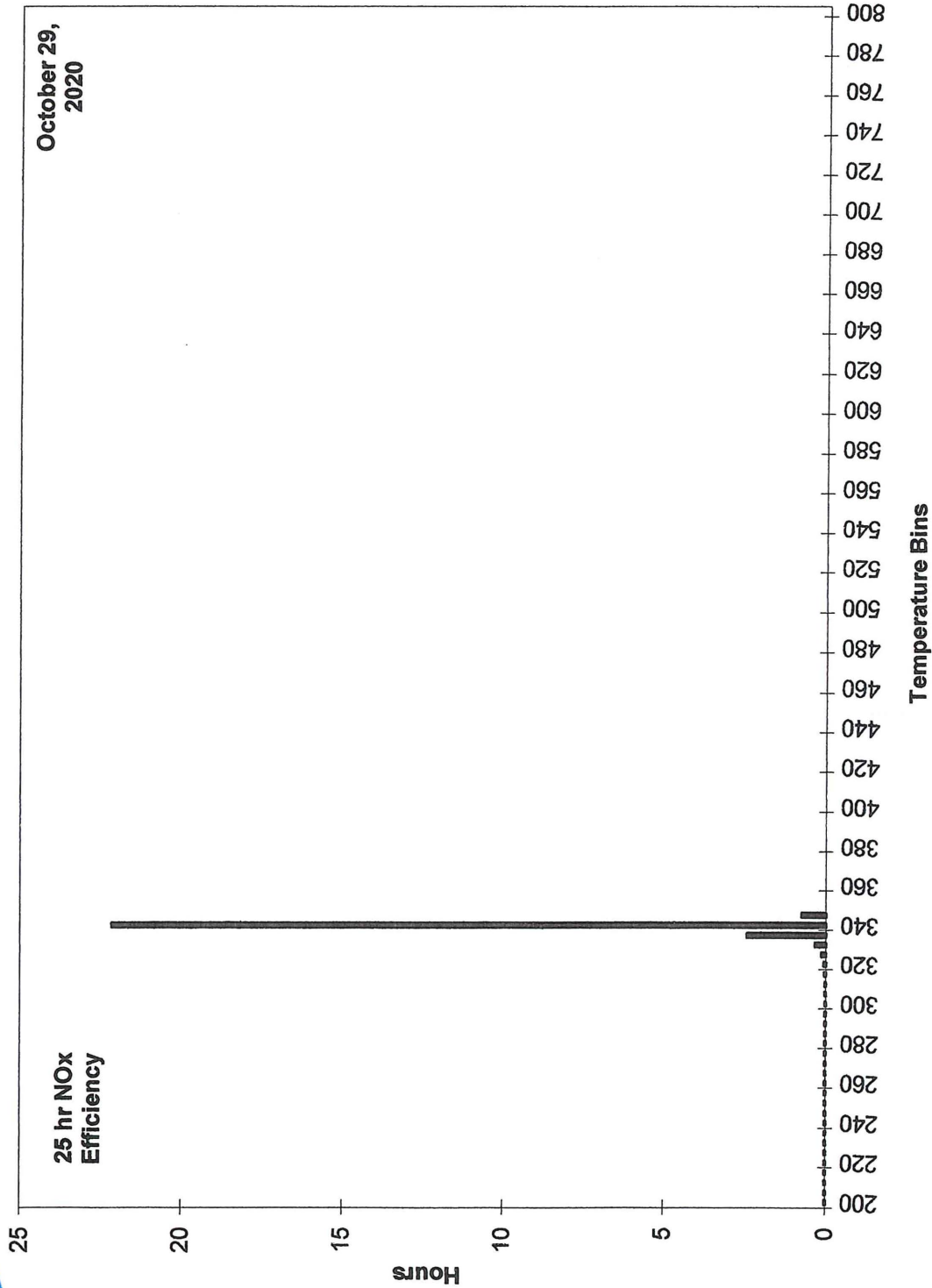




DOC 1 (CC26832) Inlet Temp

October 29,
2020

25 hr NOx
Efficiency



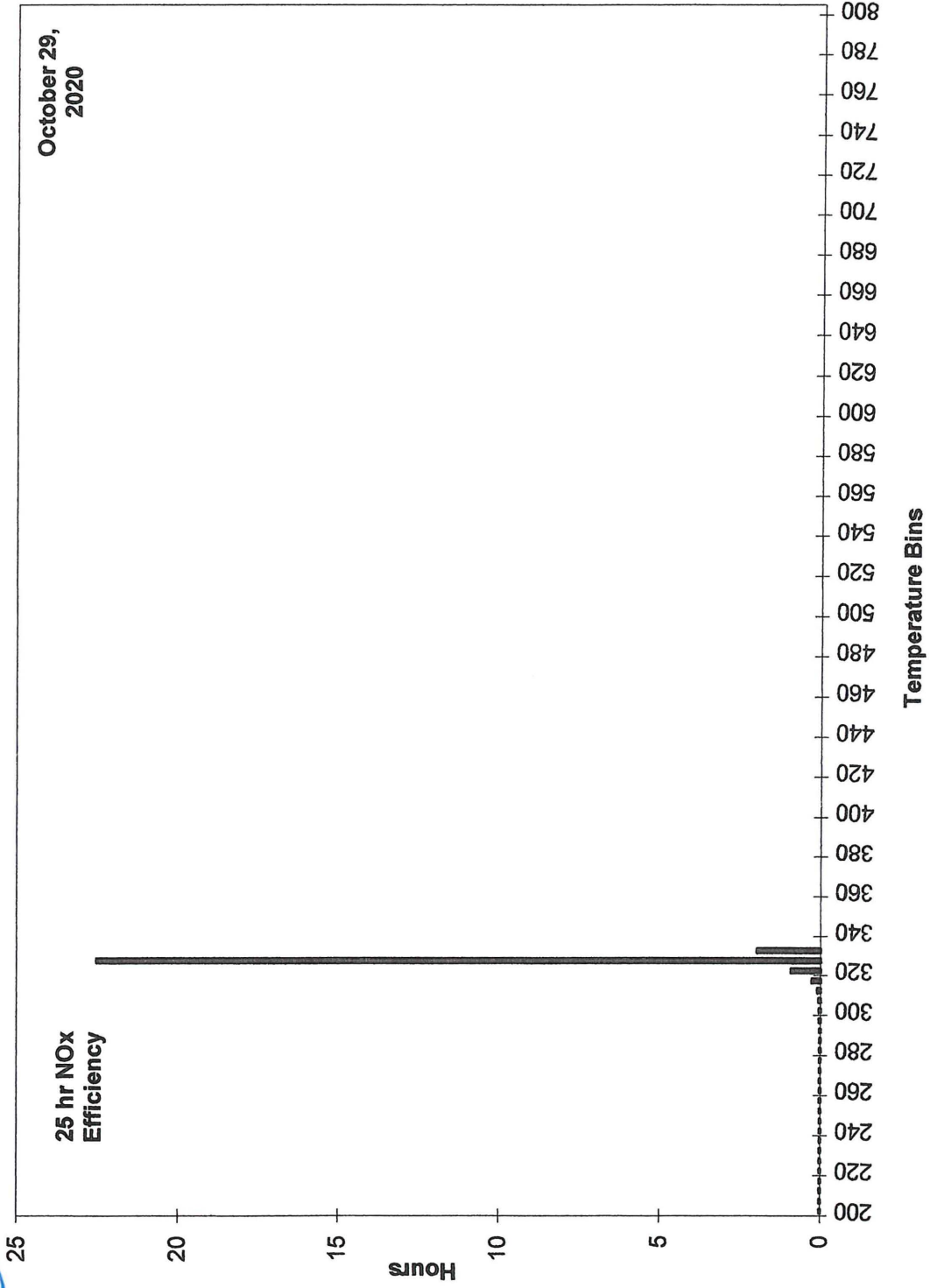
Series2

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COPY



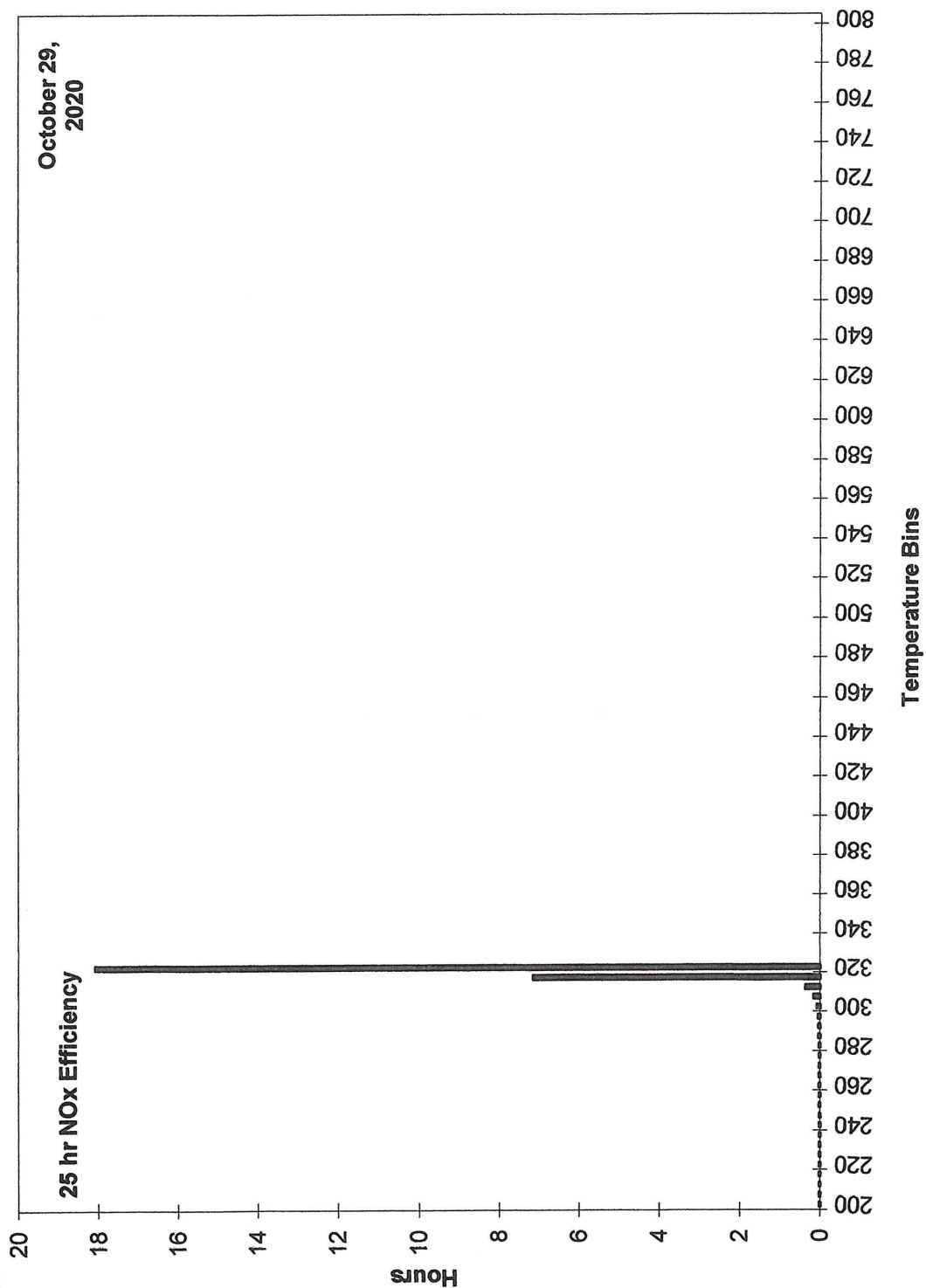
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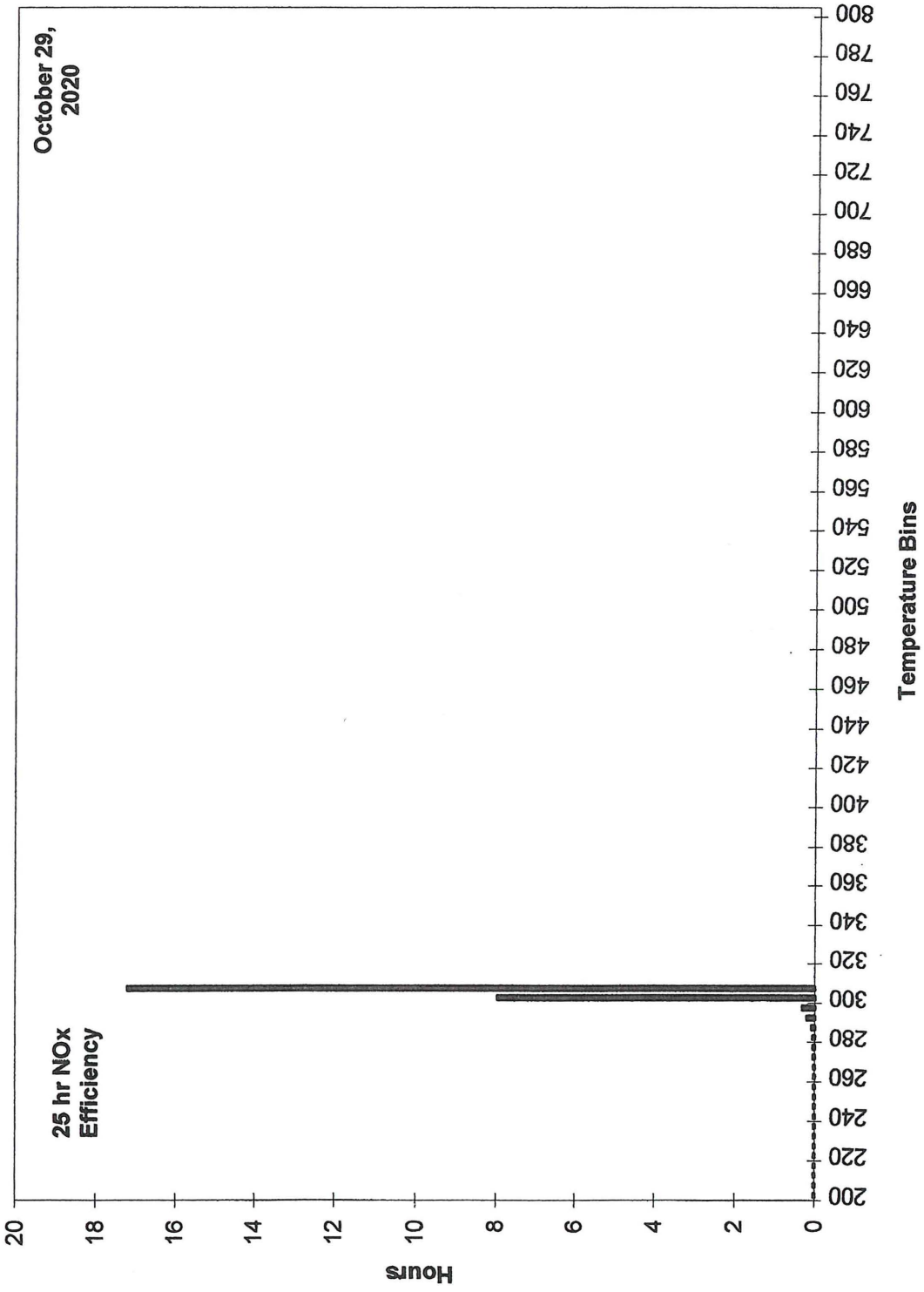


SCR (CC26808) Outlet Temp



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DPF (CC27836/26823) Outlet Temp



Series2