Compressed Air System Audit

February 26th- March 5th 2021

Prepared by Air Handling Equipment, Inc.

AIR HANDLING EQUIPMENT, INC.

Compressed Air Challenge / Department of Energy
Compressor Control Comparison
% Of Full Load BHP Versus % Of Full Load Capacity

% of Compressor Capacity	Modulation (Inlet Valve) % FL BHP	Variable Displacement % FL BHP	On-Line / Off-Line				Variable Speed Drive % FL BHP
			1 Gal/CFM % FL BHP	3 Gal/CFM % FL BHP	5 Gal/CFM % FL BHP	10 Gal/CFM % FL BHP	
100	100.00	100.00	100.00	100.00	100.00	100.00	100.00
95	98.50	96.00	101.51	100.49	99.95	99.34	95.20
90	97.00	92.00	100.44	98.36	97.28	96.11	90.40
85	**95.50**	**88.20**	**99.28**	**96.11**	**94.51**	**92.80**	**85.60**
80	**94.00**	**84.70**	**98.02**	**93.71**	**91.61**	**89.43**	**80.80**
75	**92.50**	**81.50**	**96.64**	**91.17**	**88.59**	**85.98**	**76.00**
70	91.00	78.30	95.12	88.46	85.43	82.45	71.20
65	89.50	75.40	93.45	85.57	82.10	78.85	66.40
60	88.00	73.00	91.58	82.49	78.63	75.18	61.60
55	**86.50**	**70.80**	**89.49**	**79.19**	**75.02**	**71.43**	**56.80**
50	**85.00**	**69.00**	**87.13**	**75.67**	**71.25**	**67.60**	**52.00**
45	**83.50**	**64.60**	**84.44**	**71.89**	**67.34**	**63.70**	**47.20**
40	82.00	60.20	81.35	67.80	63.28	59.72	42.40
35	80.50	55.80	77.76	63.41	59.06	55.66	37.60
30	79.00	51.40	73.53	58.76	54.69	51.52	32.80
25	**77.50**	**47.00**	**68.51**	**53.84**	**50.15**	**47.30**	**28.00**
20	**76.00**	**42.60**	**62.48**	**48.65**	**45.46**	**43.01**	**23.20**
15	**74.50**	**38.20**	**55.19**	**43.17**	**40.60**	**38.63**	**18.40**
10	73.00	33.80	46.26	37.41	35.57	34.17	13.60
5	71.50	29.40	36.19	31.36	30.37	29.63	8.80
0	70.00	25.00	27.33	26.30	26.09	25.93	4.00

Notes: All values taken from the Compressed Air Challenge Workshop 1999
Sponsored by the U.S. Department of Energy
www.knowpressure.org

Compressed Air System Components

Compressors:

#1 – Gardner Denver 100HP Variable Speed
Model L75RS 434cfm
31,000 Hrs

#2 – CompAir 100HP
Model L75 441cfm
45,000 Hrs

#3 – Atlas Copco 75HP
Model GA55 310cfm
70,000 Hrs

#4 – CompAir 100HP
Model L75 441cfm
22,000 Hrs

Total CFM Available : 1626

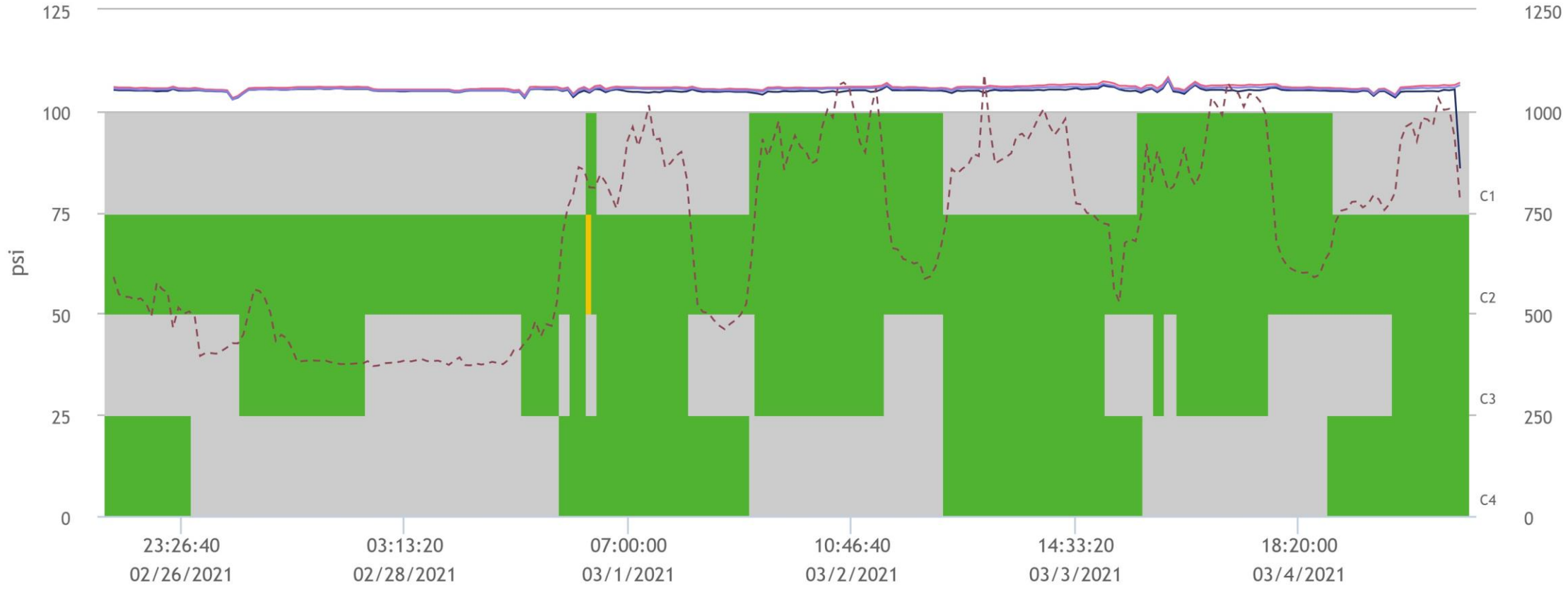
Dryer: ZEKS 2000HSF A408N
2000 CFM CYCLING REFRIDGERATED AIR DRYER

Compressed Air Tanks:
2560 GALLON
SILVAN TANK COMPANY
BUILT : 1995

Compressed Air System Audit
February 26th – March 5th 2020

Weekly/Yearly Results

Total System Seven Day Run Data 2-26-21 thru 3-5-21
Average Compressor Status, Pressure, Flow



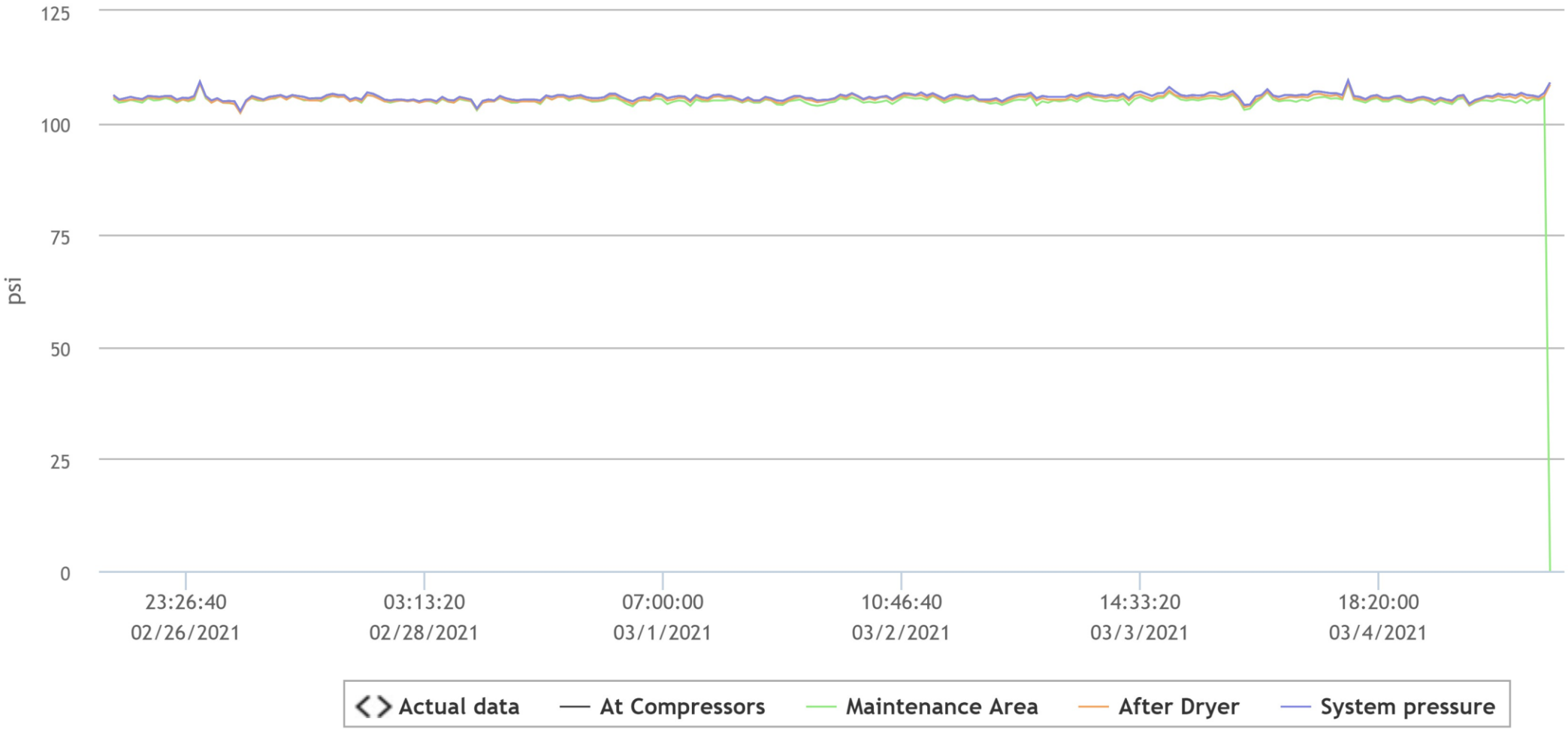
COMPAIR L75 #4

GD L75RS #1

ATLAS COPCO GA55 #3

COMPAIR L75 #2

Total System Seven Day Run Data 2-26-21 thru 3-5-21
Average Plant Pressures
No significant pressure drop was seen, Green line was the pressure transducer all the way across the plant in the maintenance area. Plant Pressure was maintained in a very tight band at 105psi by the sequencer.



Total System Seven Day Run Data 2-26-21 thru 3-5-21

System Utilization

Air compressor nickname	Air compressor brand ID	Air compressor model ID	Loaded hrs	Loaded %	Offload hrs	Offload %	Stopped hrs	Stopped %
4	CompAir	L75-100-9	2d 1h 37m	29.54	0d 0h 19m	0.20	4d 22h 2m	70.26
1	Gardner Denver	L75RS-125#-AC-60HZ	6d 22h 51m	99.32	0d 1h 9m	0.68	0d 0h 0m	0.00
3	Atlas Copco	GA 55	3d 17h 59m	53.57	0d 0h 36m	0.36	3d 5h 23m	46.07
2	CompAir	L75-100-9	3d 3h 7m	44.71	0d 0h 31m	0.31	3d 20h 21m	54.98
System utilisation			**7d 0h 0m**	**100**	**0d 0h 0m**	**0**	**0d 0h 0m**	**0**

Annual Cost at .07 cents per kWh

					Annual			
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Total energy kWh	Total cost $	Annual energy kWh	Annual cost non-productive $	Annual cost productive $	Annual cost total $
4	CompAir	L75-100-9	4545.8	318.20	237031	36.85	16555.17	16592.02
1	Gardner Denver	L75RS-125#-AC-60HZ	7821.1	547.48	407814.5	16.56	28530.51	28547.07
3	Atlas Copco	GA 55	5946.3	416.24	310057.1	39.50	21664.62	21704.12
2	CompAir	L75-100-9	5768.4	403.79	300780.9	53.17	21001.54	21054.72
System			**24081.6**	**1685.71**	**1255683.4**	**146.08**	**87751.85**	**87897.93**

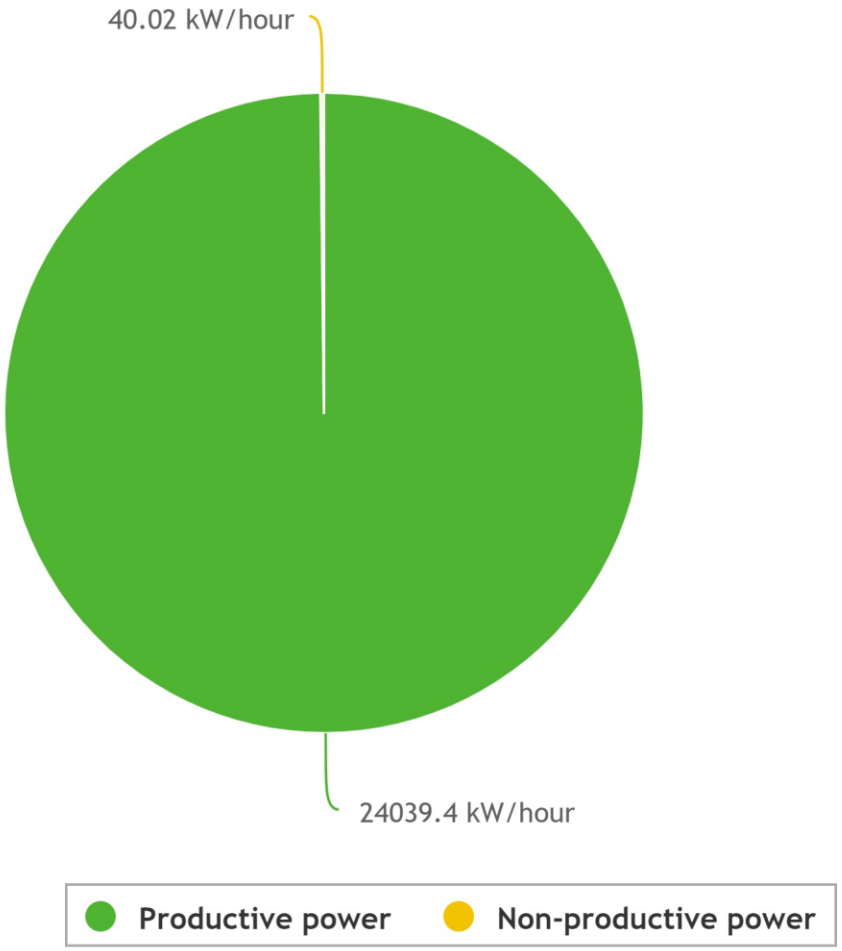
Total System Seven Day Run Data 2-26-21 thru 3-5-21
Equipment Power Analysis
Shows system output cfm broken down by 10% increments over time. Shows cfm output between 344 – 1147 a majority of time.

Output %	Output cfm	Time	Time %	Total kWh	Total cost $
0 %	0	0d 0h 0m	0.00	0.00	0.00
1 - 10%	16.4 - 163.9	0d 0h 2m	0.02	2.00	0.14
11 - 20%	180.2 - 327.7	0d 4h 5m	2.43	241.50	16.91
21 - 30%	344.1 - 491.6	1d 18h 37m	25.37	3615.60	253.09
31 - 40%	508.0 - 655.4	1d 5h 47m	17.73	3515.40	246.08
41 - 50%	671.8 - 819.3	1d 8h 23m	19.28	5124.30	358.70
51 - 60%	835.7 - 983.2	1d 15h 25m	23.46	7398.30	517.88
61 - 65%	999.5 - 1065.1	0d 13h 50m	8.23	2872.30	201.06
66 - 70%	1081.5 - 1147.0	0d 5h 11m	3.09	1158.70	81.11
71 - 75%	1163.4 - 1229.0	0d 0h 36m	0.36	144.90	10.14
76 - 80%	1245.3 - 1310.9	0d 0h 1m	0.01	5.40	0.38
81 - 85%	1327.3 - 1392.8	0d 0h 0m 10s	0.00	0.80	0.06
86 - 90%	1409.2 - 1474.7	0d 0h 0m 9s	0.00	0.80	0.05
91 - 95%	1491.1 - 1556.7	0d 0h 0m 4s	0.00	0.30	0.02
96%	1573.1	0d 0h 0m 2s	0.00	0.20	0.01
97%	1589.4	0d 0h 0m 10s	0.00	0.90	0.06
98%	1605.8	0d 0h 0m 2s	0.00	0.20	0.01
99%	1622.2	0d 0h 0m	0.00	0.00	0.00
100%	1638.6	0d 0h 0m	0.00	0.00	0.00

Total System Seven Day Run Data 2-26-21 thru 3-5-21

Productive Power VS. Non-productive Power

This pie chart shows that the sequencer is managing the compressors at an optimal level. Very little enengy is wasted on compressors running unloaded.



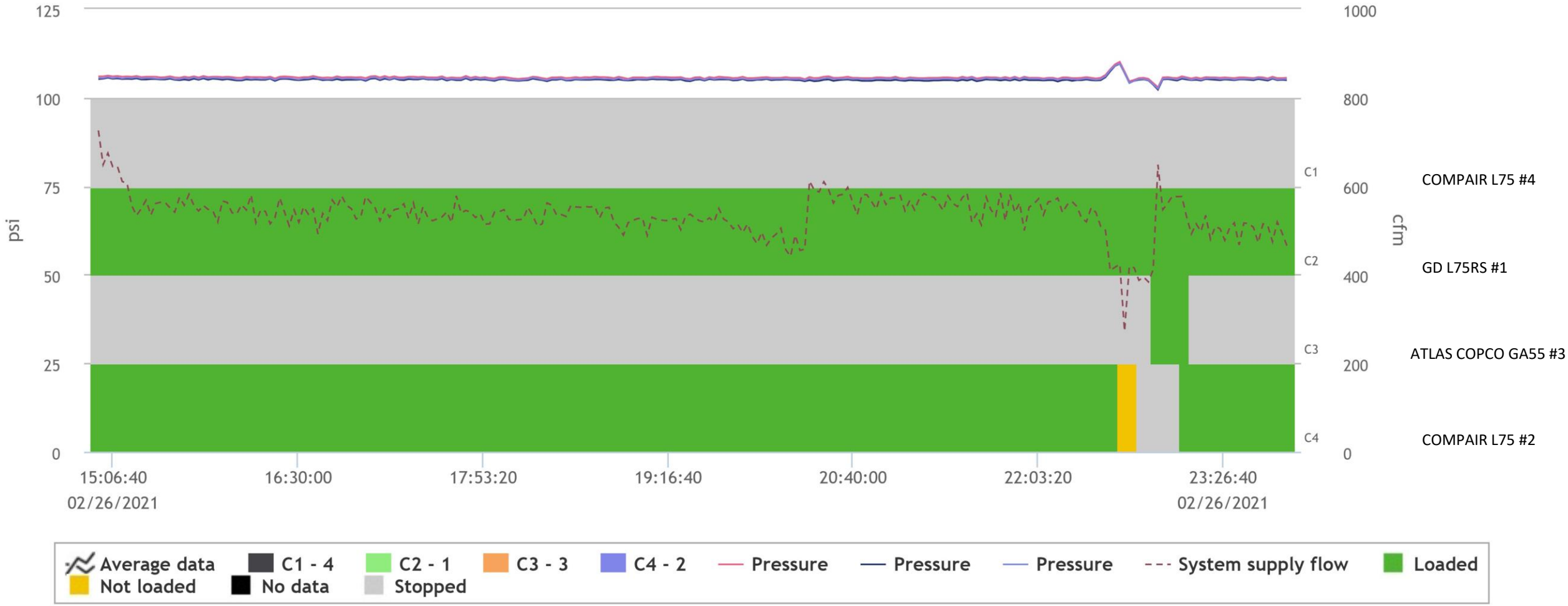
Compressed Air System Audit
2-26-21 Thru 3-5-21

DAILY RESULTS

Daily Average CFM

Friday 2-26-21	535.4	
Saturday 2-27-21	423.8	AVERAGE
Sunday 2-28-21	415.8	693.9
Monday 3-1-21	751.1	
Tuesday 3-2-21	847.6	
Wednesday 3-3-21	843.9	
Thursday 3-4-21	830.1	
Friday 3-5-21	870.9	

Friday 2-26-21
Average Status, Flow, Pressure

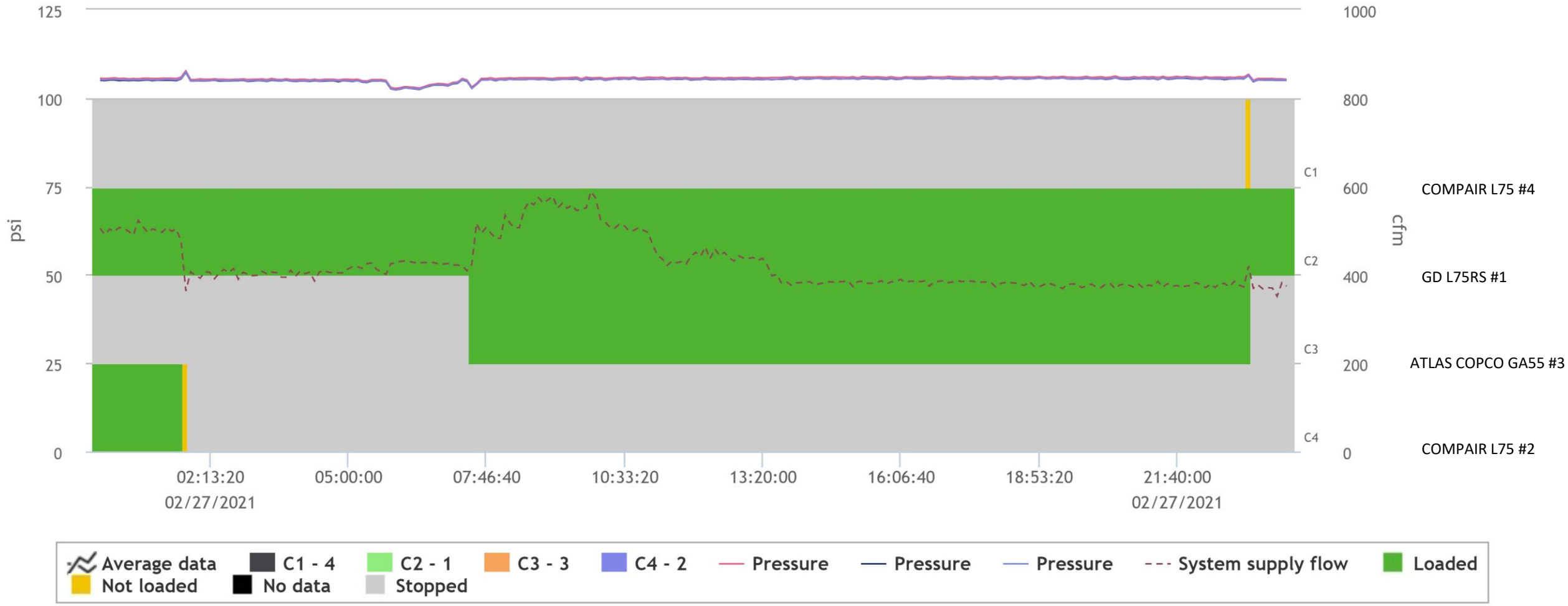


Friday
2-26-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	N/A	N/A	N/A	N/A	N/A	N/A
1	Gardner Denver	L75RS-125#-AC-60HZ	13.6	84.7	37.6	44.6	431.0	190.6
3	Atlas Copco	GA 55	13.7	68.3	49.8	15.6	310.8	212.3
2	CompAir	L75-100-9	18.6	165.2	75.1	13.6	441.4	349.6
System			49.3	261.1	111.8	51.7	968.4	535.4
						Audit system power & supply side output		

Saturday 2-27-21
Average Status, Flow, Pressure

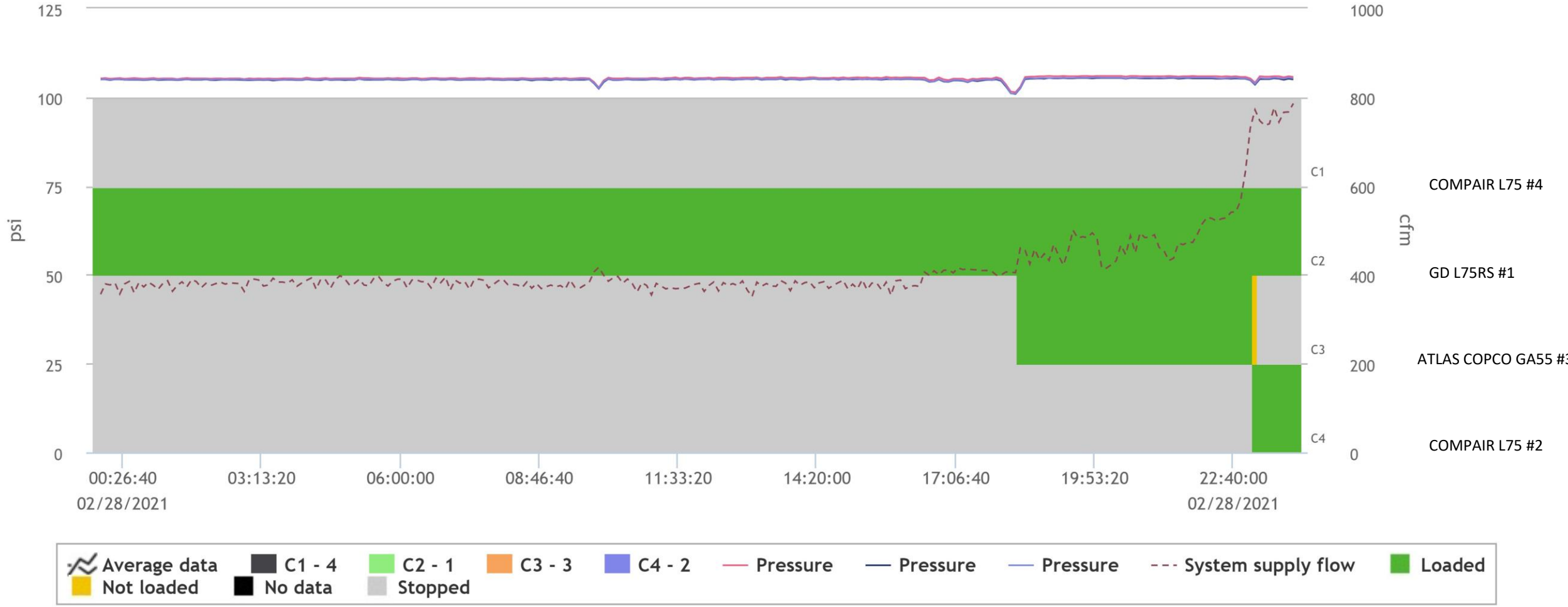


Saturday
2-27-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	29.6	112.7	48.0	7.1	441.4	116.8
1	Gardner Denver	L75RS-125#-AC-60HZ	13.0	93.5	40.0	41.8	434.4	194.8
3	Atlas Copco	GA 55	14.4	69.0	66.4	17.6	310.8	308.9
2	CompAir	L75-100-9	25.1	78.3	73.1	15.5	376.3	335.6
System			48.0	182.6	89.4	54.1	810.6	423.8
						Audit system power & supply side output		

Sunday 2-28-21
Average Status, Flow, Pressure

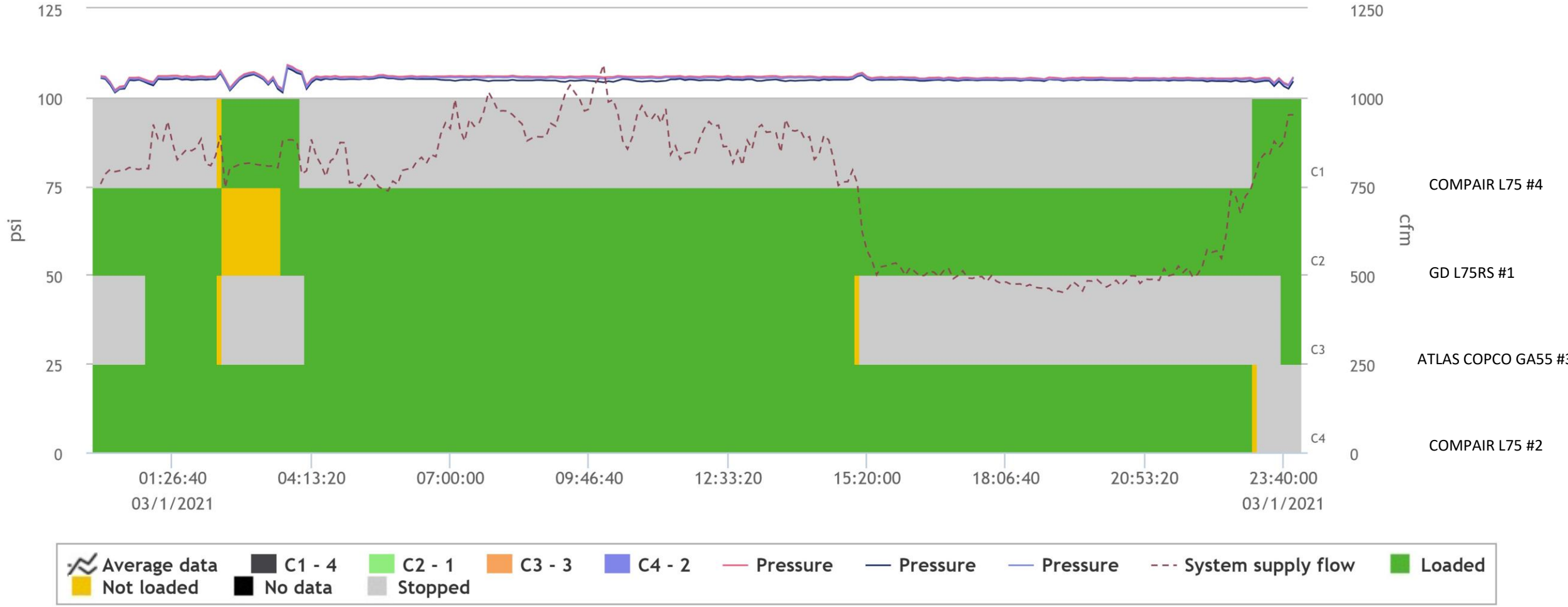


Sunday
2-28-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	N/A	N/A	N/A	N/A	N/A	N/A
1	Gardner Denver	L75RS-125#-AC-60HZ	13.5	94.7	66.0	44.1	434.4	342.0
3	Atlas Copco	GA 55	15.5	75.8	64.3	28.7	310.8	304.3
2	CompAir	L75-100-9	21.3	159.3	77.2	324.7	441.4	367.0
System			49.1	292.7	81.6	262.3	1106.7	415.8
						Audit system power & supply side output		

Monday 3-1-21
Average Status, Flow, Pressure

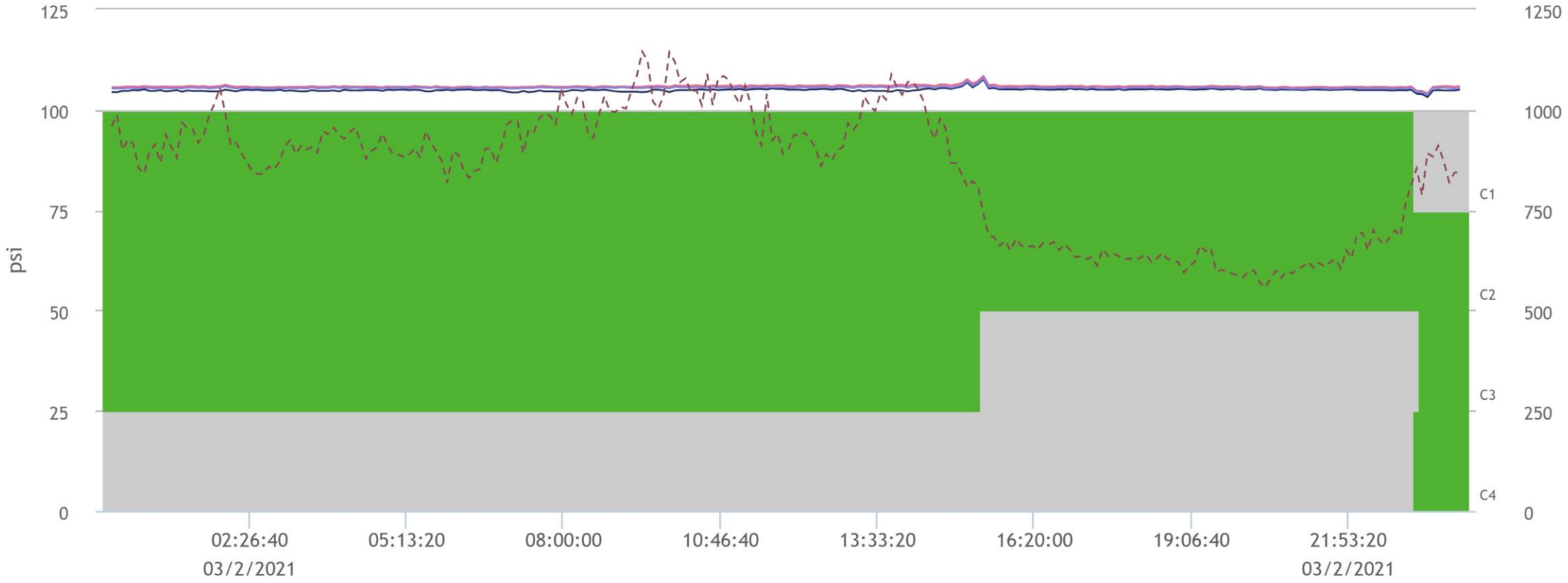


Monday
3-1-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	18.3	124.6	86.5	6.3	441.4	415.8
1	Gardner Denver	L75RS-125#-AC-60HZ	3.5	107.4	39.0	5.2	434.4	193.5
3	Atlas Copco	GA 55	10.8	70.6	65.0	39.3	310.8	305.9
2	CompAir	L75-100-9	25.5	81.6	76.5	5.4	403.8	361.1
System			88.6	332.2	157.1	351.7	1590.4	751.1
						Audit system power & supply side output		

Tuesday 3-2-21
Average Status, Flow, Pressure

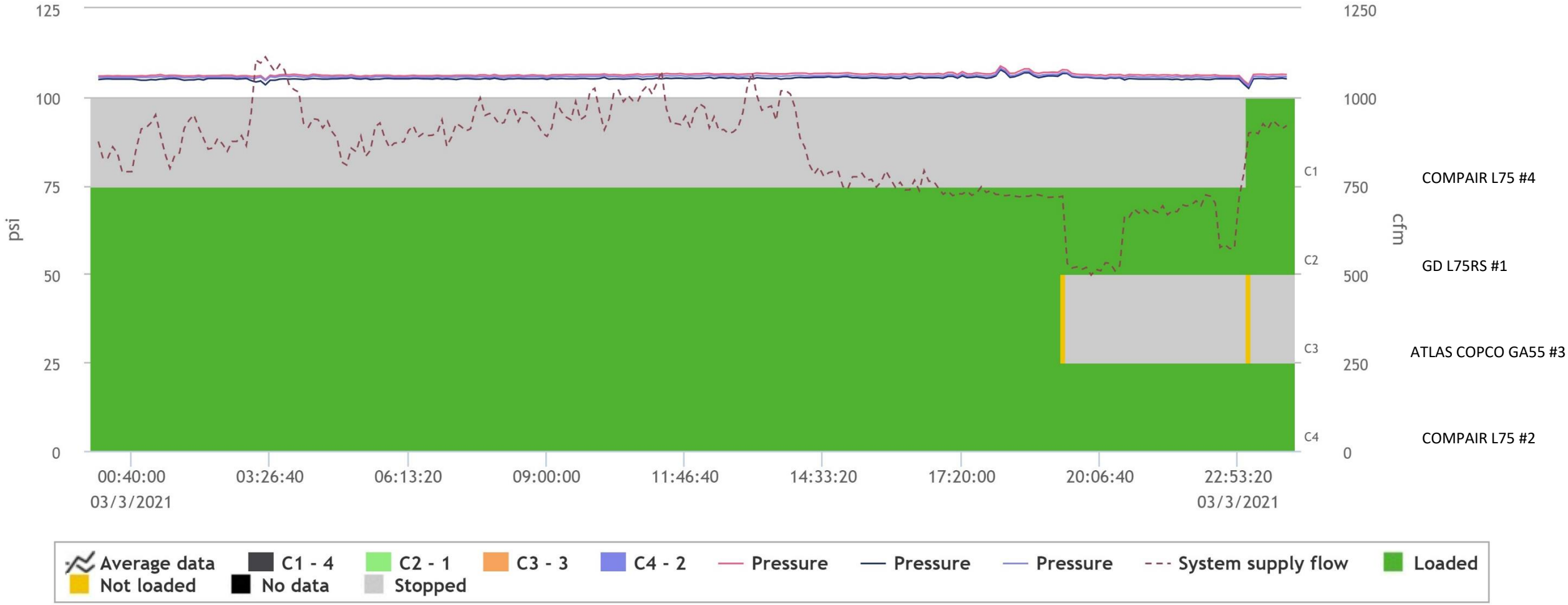


Tuesday
3-2-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	29.0	96.0	91.7	11.9	441.4	439.9
1	Gardner Denver	L75RS-125#-AC-60HZ	14.1	97.2	39.2	47.3	434.4	199.3
3	Atlas Copco	GA 55	13.8	69.7	66.8	23.0	310.8	309.0
2	CompAir	L75-100-9	23.3	147.5	77.3	169.6	441.4	367.4
System			107.8	316.7	176.1	488.7	1283.0	847.6
						Audit system power & supply side output		

Wednesday 3-3-21
Average Status, Flow, Pressure

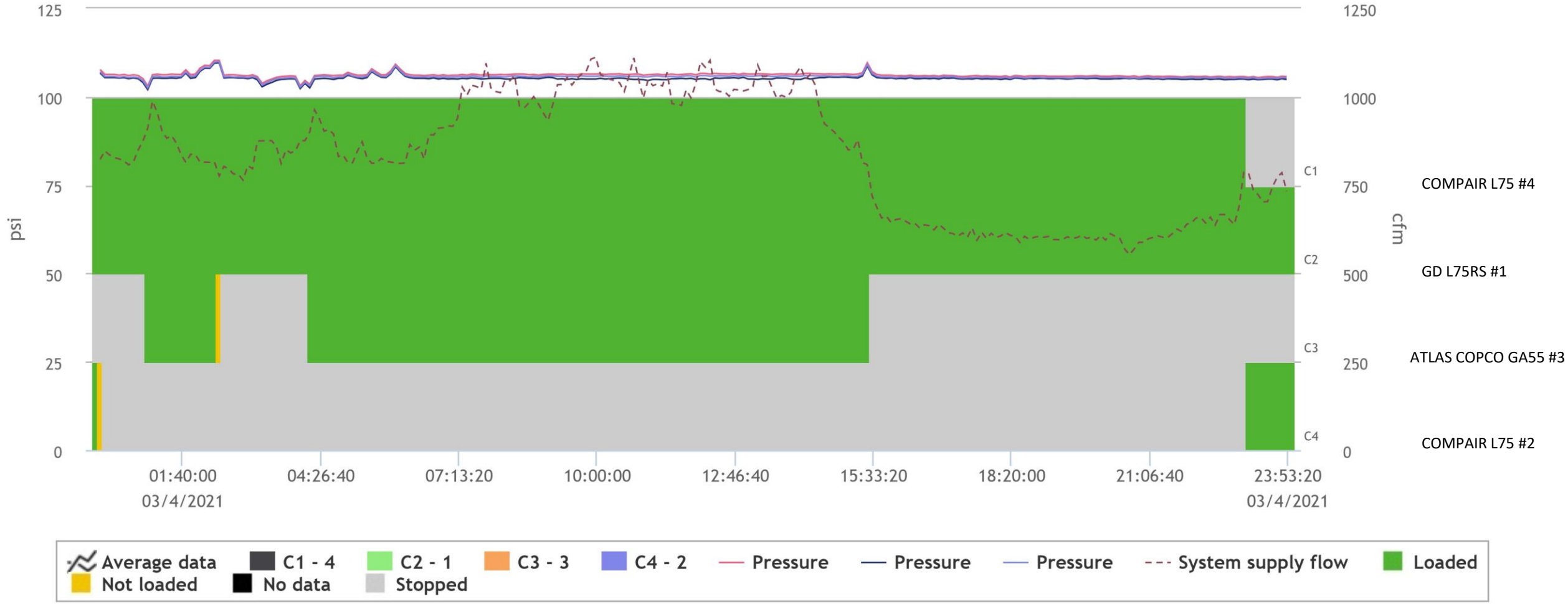


Wednesday
3-3-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	18.0	108.9	88.7	6.1	441.4	440.1
1	Gardner Denver	L75RS-125#-AC-60HZ	13.9	97.7	42.2	46.2	434.4	214.4
3	Atlas Copco	GA 55	11.8	67.8	64.8	28.1	310.8	307.7
2	CompAir	L75-100-9	73.9	79.5	76.6	338.8	386.4	361.8
System			94.1	312.5	175.0	394.7	1430.3	843.9
						Audit system power & supply side output		

Thursday 3-4-21
Average Status, Flow, Pressure

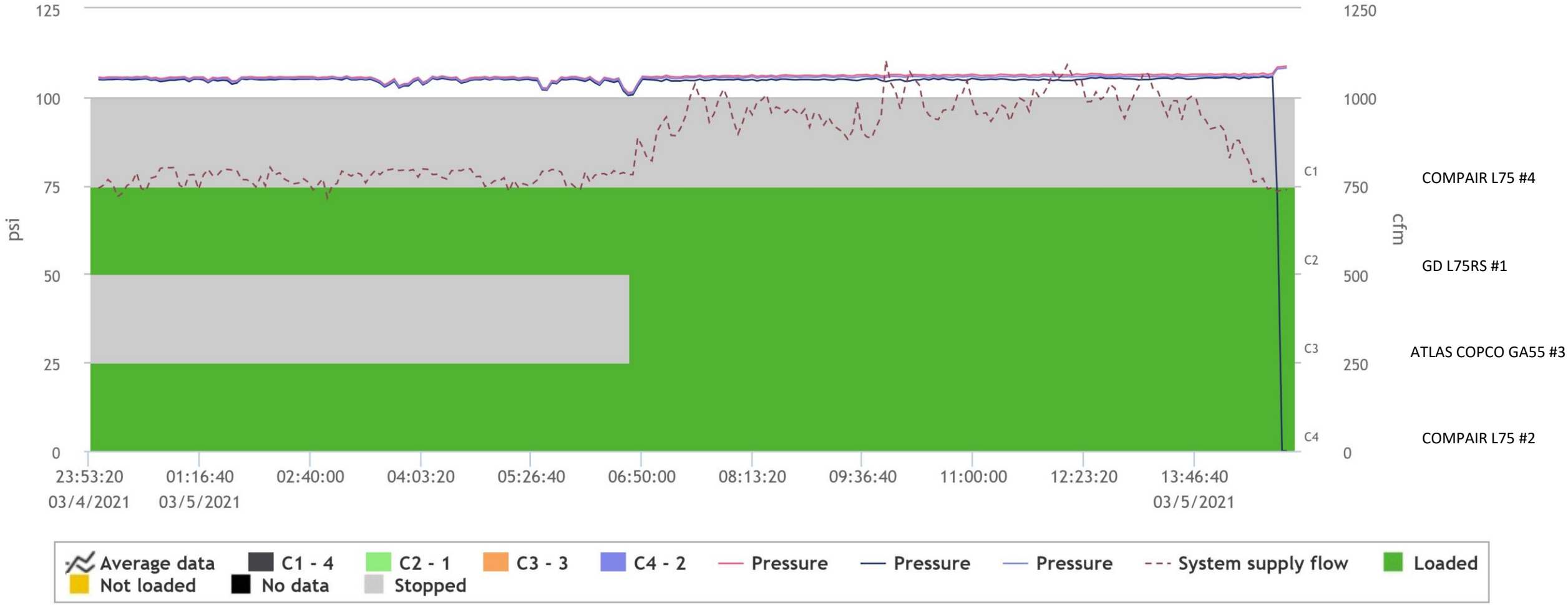


Thursday
3-4-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	29.6	96.4	91.0	10.1	441.4	439.9
1	Gardner Denver	L75RS-125#-AC-60HZ	13.2	99.3	44.5	43.0	434.4	226.2
3	Atlas Copco	GA 55	11.0	69.3	65.3	24.7	310.8	306.2
2	CompAir	L75-100-9	23.7	129.8	70.7	35.4	441.4	317.0
System			108.2	297.9	170.7	484.4	1277.3	830.1
						Audit system power & supply side output		

Friday 3-5-21
Average Status, Flow, Pressure



Friday
3-5-21

System Power and Output

			Excludes starting peak kW					
Air compressor nickname	Air compressor brand ID	Air compressor model ID	Min kW (Run state)	Max kW	Avg kW	Min output cfm (Run state)	Max output cfm	Avg output cfm
4	CompAir	L75-100-9	N/A	N/A	N/A	N/A	N/A	N/A
1	Gardner Denver	L75RS-125#-AC-60HZ	14.6	98.4	65.4	49.8	434.4	338.7
3	Atlas Copco	GA 55	16.2	72.0	66.7	167.8	310.8	310.7
2	CompAir	L75-100-9	73.9	79.0	76.7	338.9	382.3	362.4
System			129.9	238.4	178.6	648.1	1121.8	870.9
						Audit system power & supply side output		

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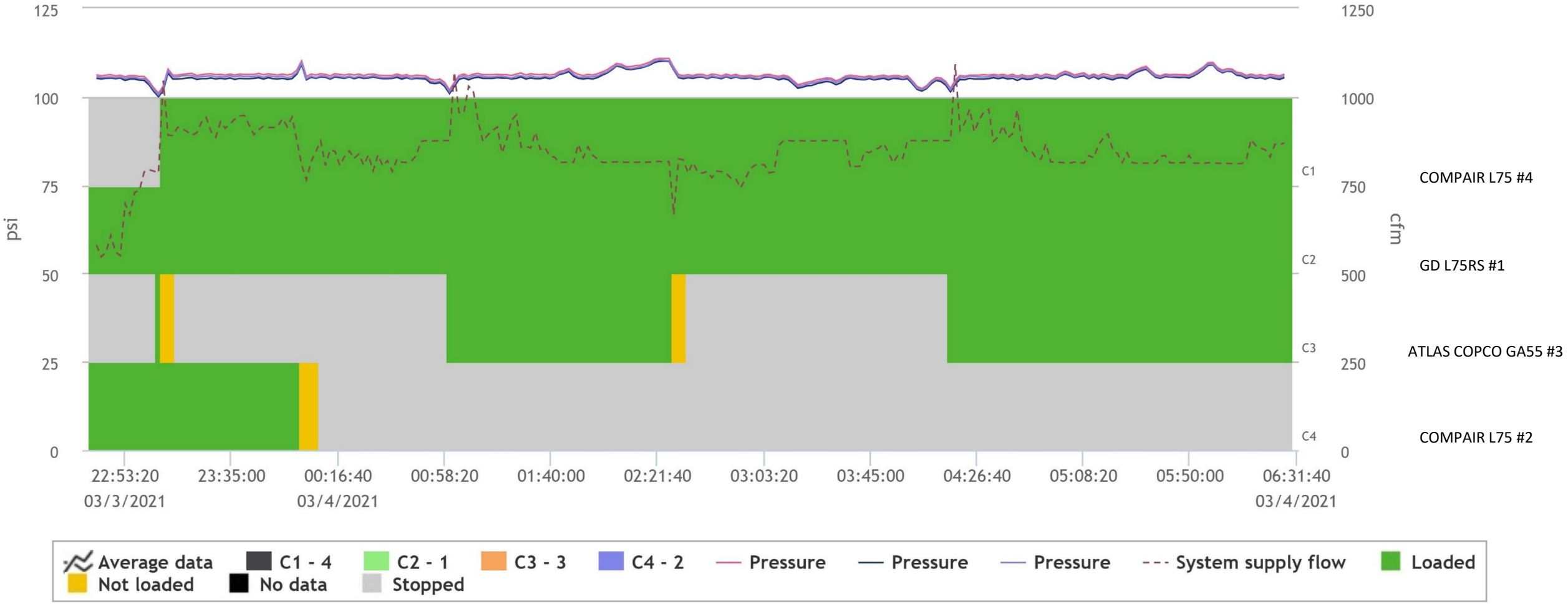
Short Compressor Run Example

Short Compressor Run Example 3/3/21

At approx. 11pm, plant pressure dropped enough for the sequencer to briefly turn on all four compressors. If we can cover this short time with additional system storage and manage our plant air by adding a plant regulator (flow controller) we could keep this fourth compressor from turning on for brief times.



SYSTEM FINDINGS AND RECOMMENDATIONS

The Compressed Air System is operating at a very efficient level, the use of a stand alone Energair Sequencer is optimizing the system.

The overall sizing of the compressors is adequate for the system demands, only rarely does the fourth compressor turn on and is for very brief times of heavy air use. This provides system redundancy for one compressor if one were to fail. I would recommend that when the time comes to replace the smaller 75hp Atlas Copco (70K hours), that its replacement be upsized to the 100hp size of the other three units for full redundancy.

The compressor room is hot, not optimal for the air dryer or the air compressors. I would recommend either full ducting of the exhaust air from each compressor or adding additional exhaust fans and controls to the compressor room to control the temp better.

I would focus attention on additional storage and regulating the compressed air to the plant thru an entire plant Flow Controller to store addition air in the compressor room at our current pressure (105 to 110psi) and potentially reduce the air delivered to the plant to 90-95psi. This is provide additional compressed air efficiency by lowering all the leaks in the plant, providing a constant air pressure to all equipment. This will also provide a buffer for the brief times the plant demand might call for the fourth compressor and keep that compressor off because of the additional storage and lower plant pressure.

While adding storage and regulation I would recommend removing the old AirCel Dryer and cleaning up the pipe work from dryer to tanks, flow controller etc.