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APPENDIX M

CM TRACTION MOTORS

Typical nameplate data for the traction motors of a CM can be seen in Table M-1. The traction motors measured at section 21 was a 250 V, 37 kW DC motor with a full load current rating of 167 A. The traction motor at section 51 was a 250 V, 50 kW DC motor with a full load current rating of 226 A.

Table M-1: Nameplate data of traction motor on a CM.

CM Traction Motors					
Power	37 / 50	kW	Voltage	250	V
Duty	S2 - 60		Current	167 / 226	A
Ins class	H		RPM	1650 / 1500	

Table M-2: Production figures for shifts that the traction motors were investigated.

Date	Sect 21		Sect 61		Sect 51	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
17-May-2005	858	2145	-	-	-	-
18-May-2005	1320	2112	-	-	-	-
19-May-2005	1716	2013	-	-	-	-
23-May-2005	-	-	1740	2030	-	-
24-May-2005	-	-	1450	2320	-	-
25-May-2005	-	-	2320	1160	-	-
10-Jun-2005	1575	2695	-	-	-	-
13-Jun-2005	2310	2520	-	-	-	-
14-Jun-2005	1610	1750	-	-	-	-
29-Jun-2005	-	-	-	-	1305	2175
30-Jun-2005	-	-	-	-	1740	2320

M.1 LOAD PROFILE

The next section focuses on the load profiles of the traction motors. Each graph shows the line voltage and the voltage limits, the load current and full load current capacity of the traction motors. The morning shifts and afternoon shifts are separated as well as the measurements made at the different sections.

M.1.1 SECTION 21

M.1.1.1 Morning shifts

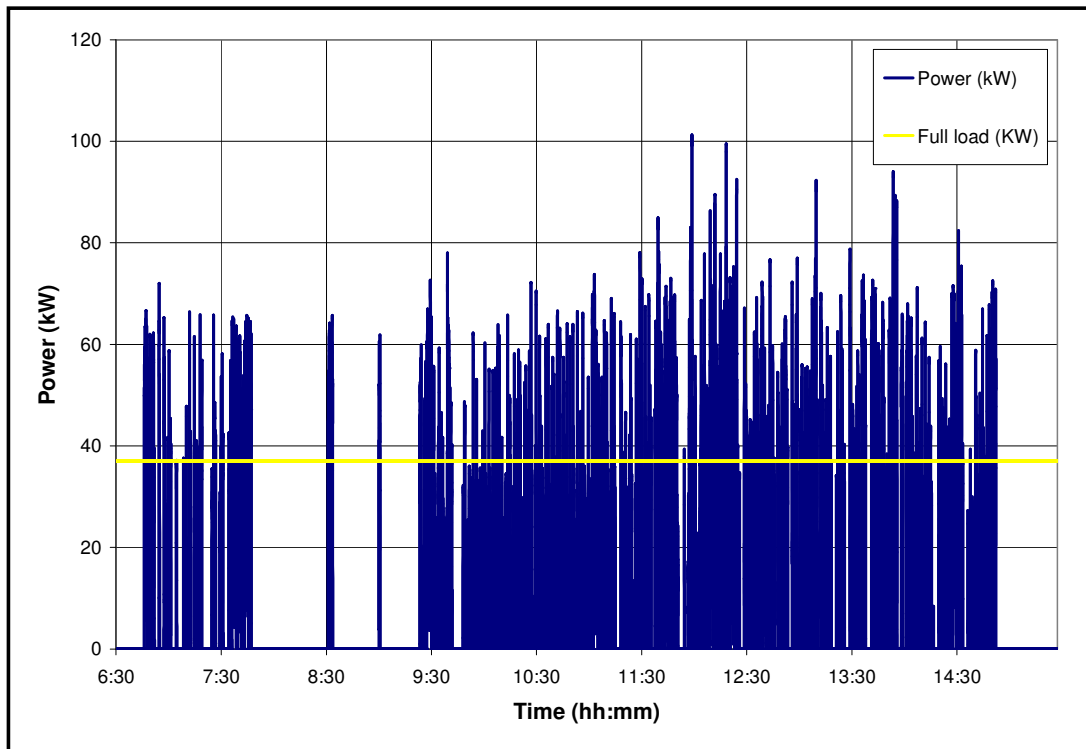
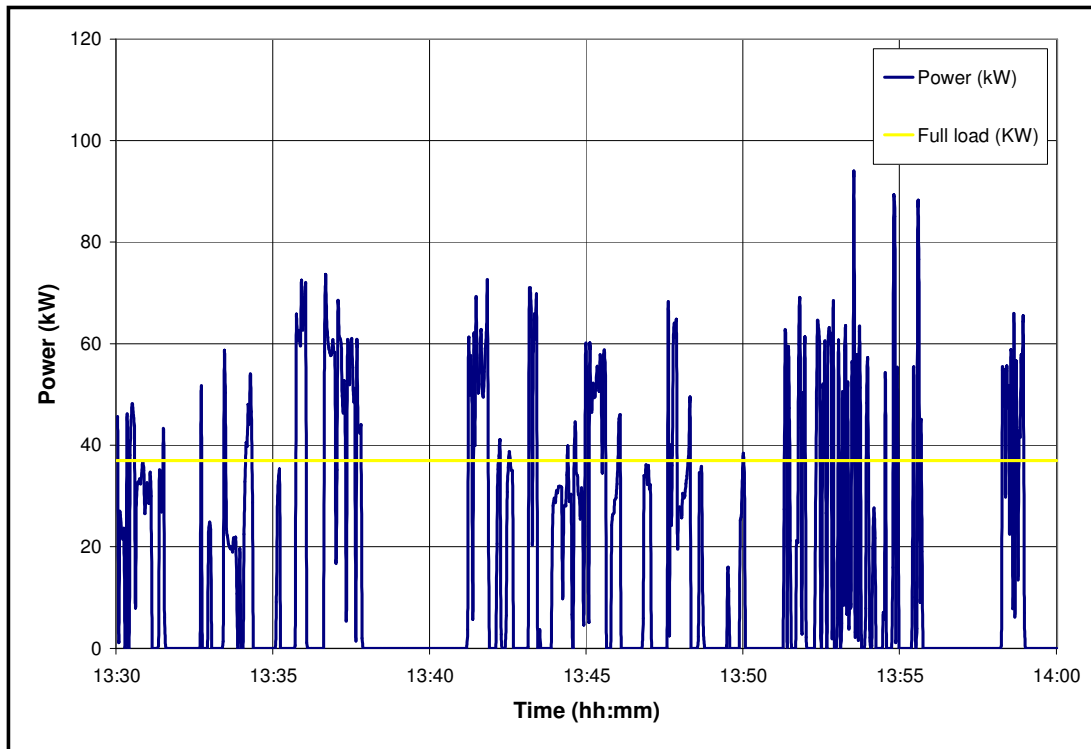


Figure M.1-1: Load power for a LH traction motor – 10 June 2005.



**Figure M.1-2: Load power for a LH traction motor
– 10 June 2005 (30 minute period).**

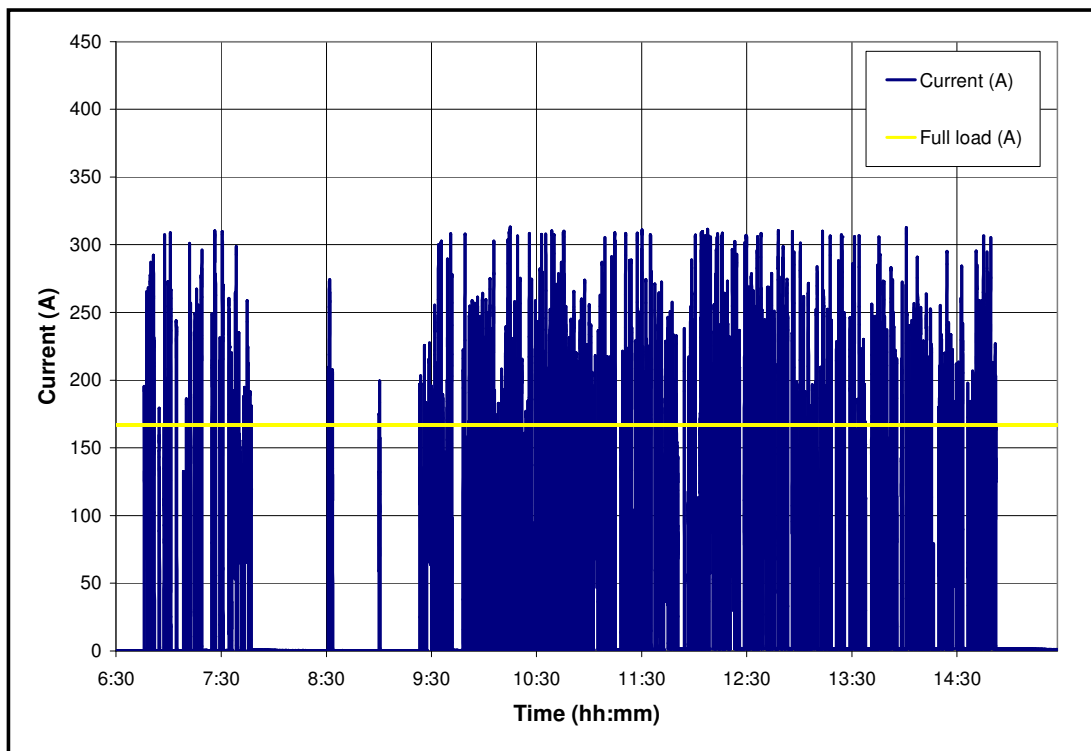
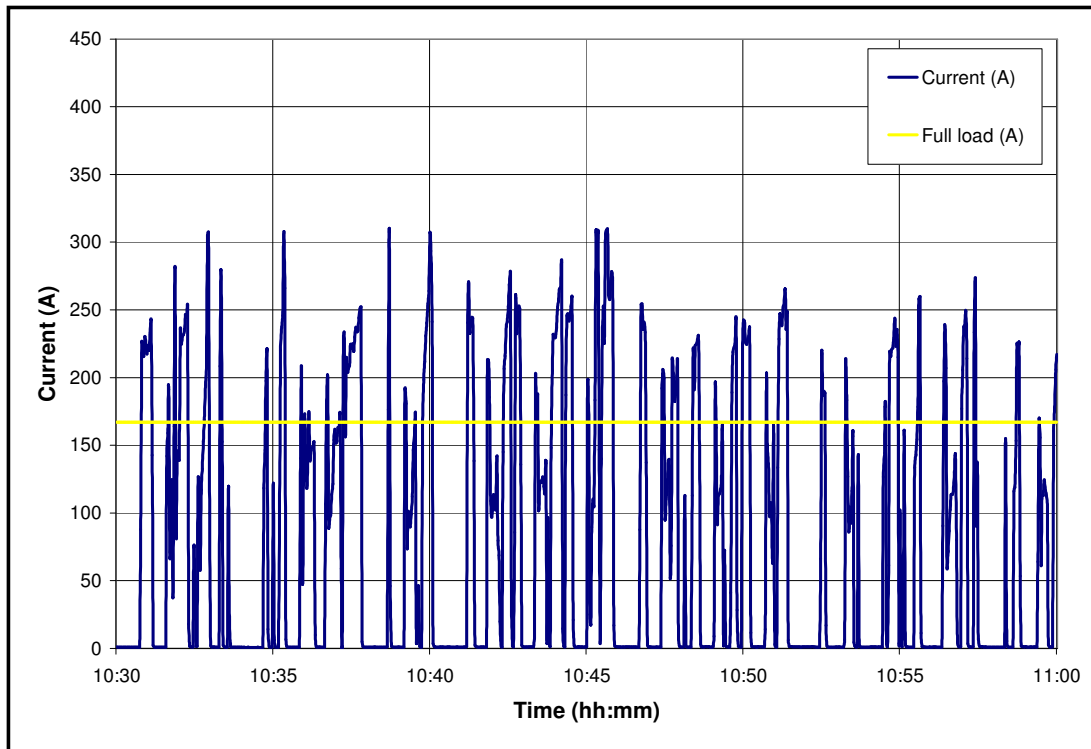


Figure M.1-3: Load current for a LH traction motor – 10 June 2005.



**Figure M.1-4: Load current for a LH traction motor
– 10 June 2005 (30 minute period).**

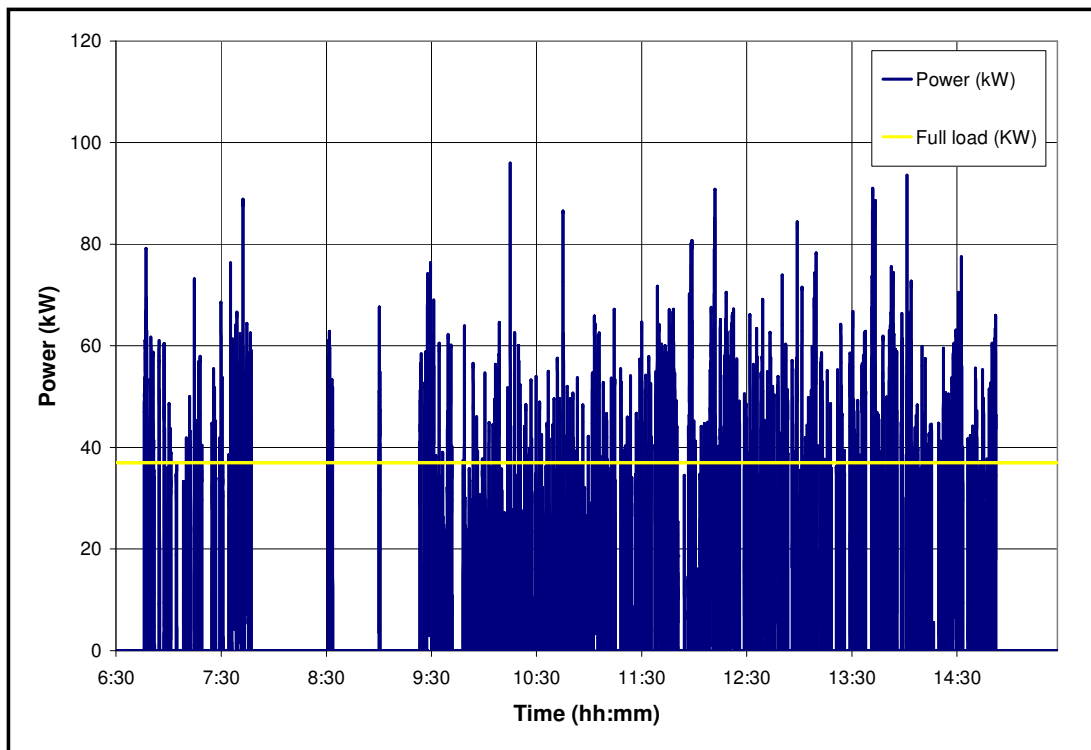
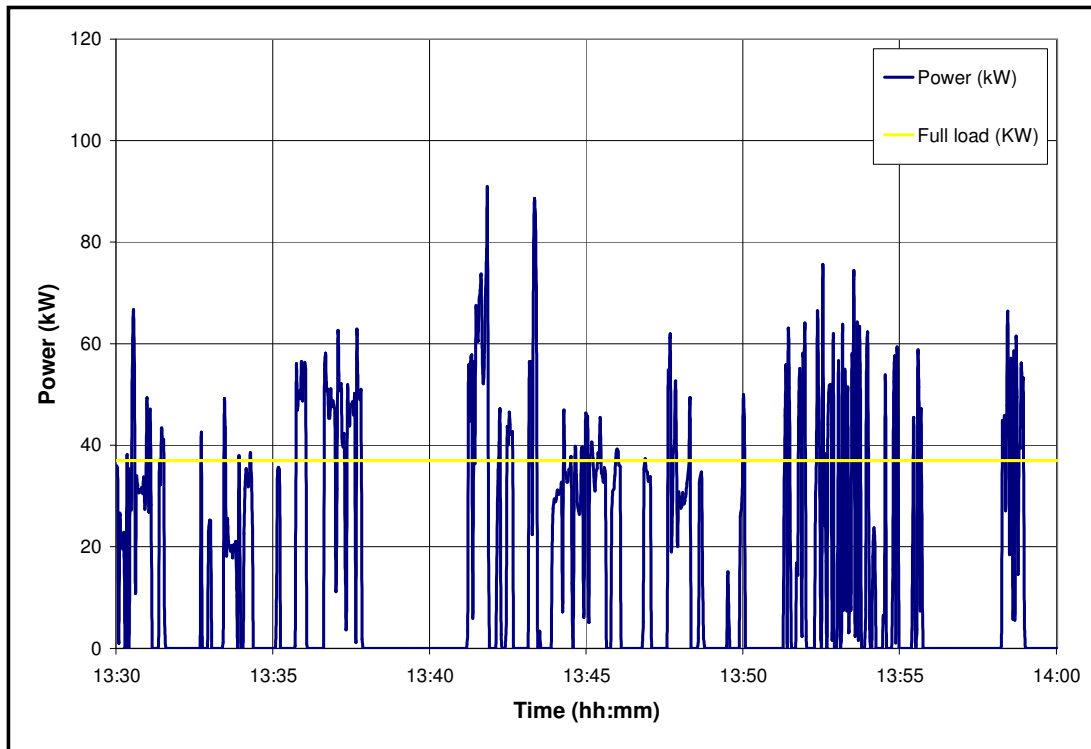


Figure M.1-5: Load power for a RH traction motor – 10 June 2005.



**Figure M.1-6: Load power for a RH traction motor
– 10 June 2005 (30 minute period).**

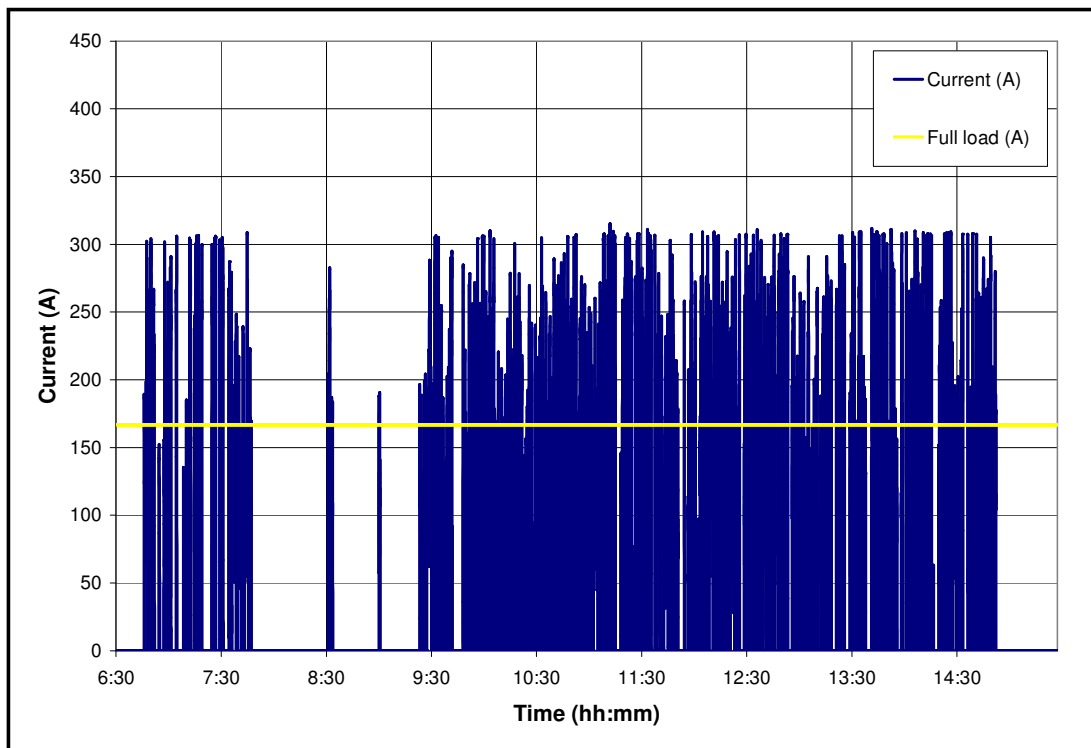
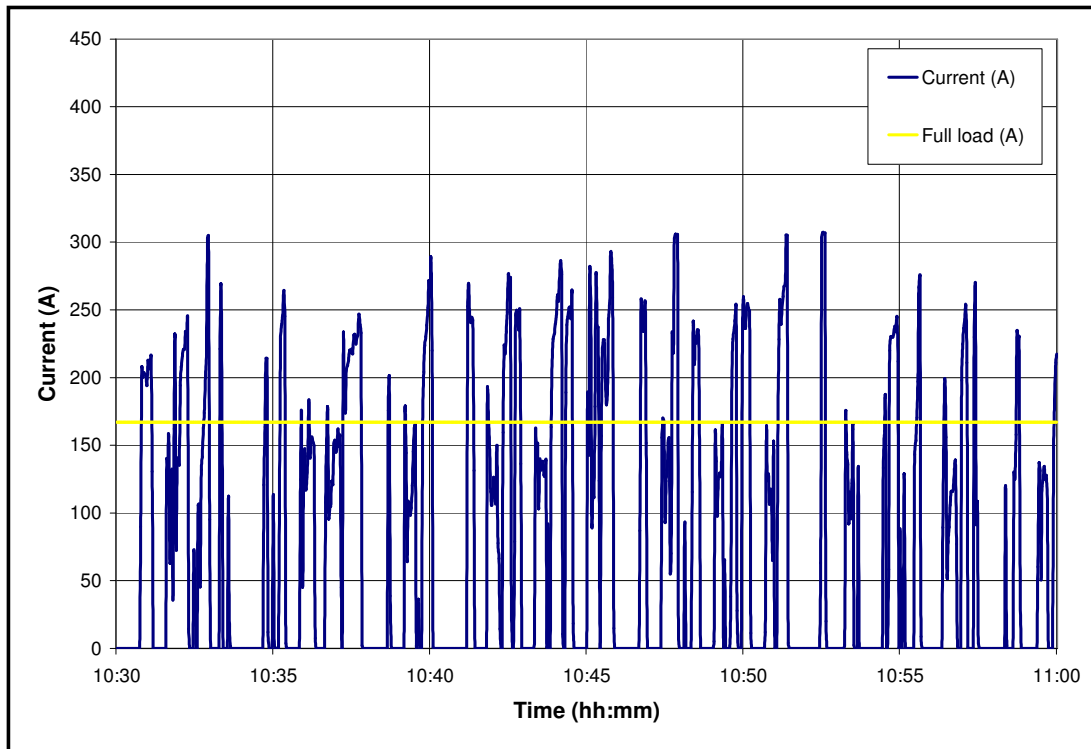


Figure M.1-7: Lo Load current for a RH traction motor – 10 June 2005.



**Figure M.1-8: Load current for a RH traction motor
– 10 June 2005 (30 minute period).**

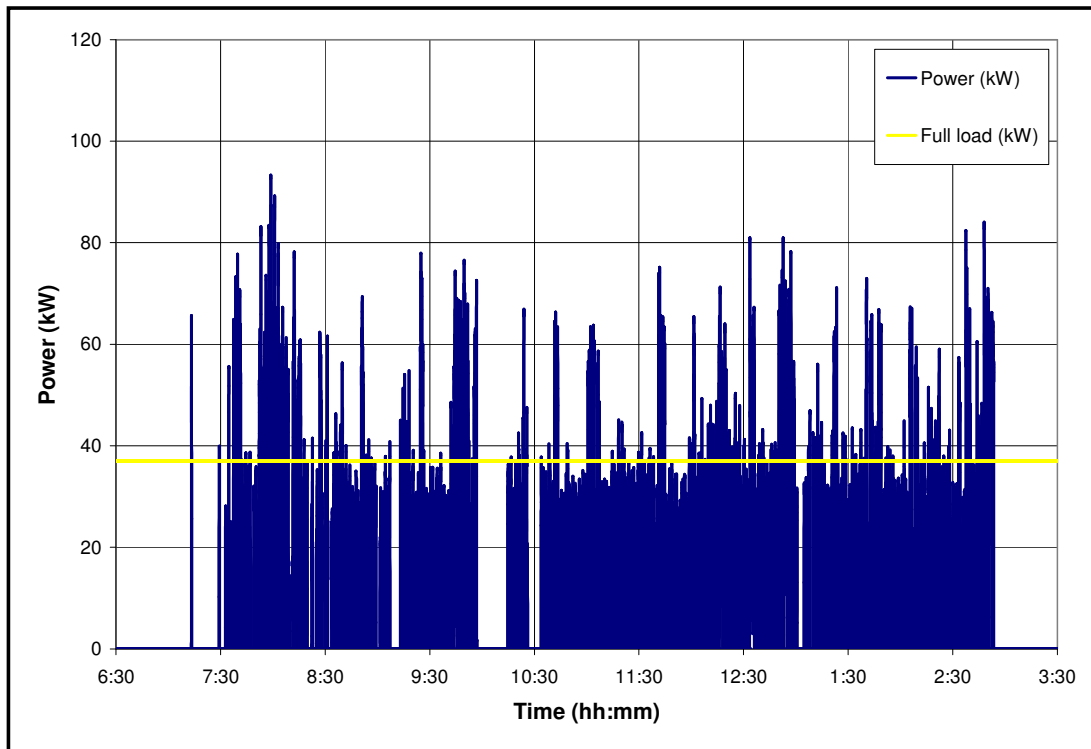
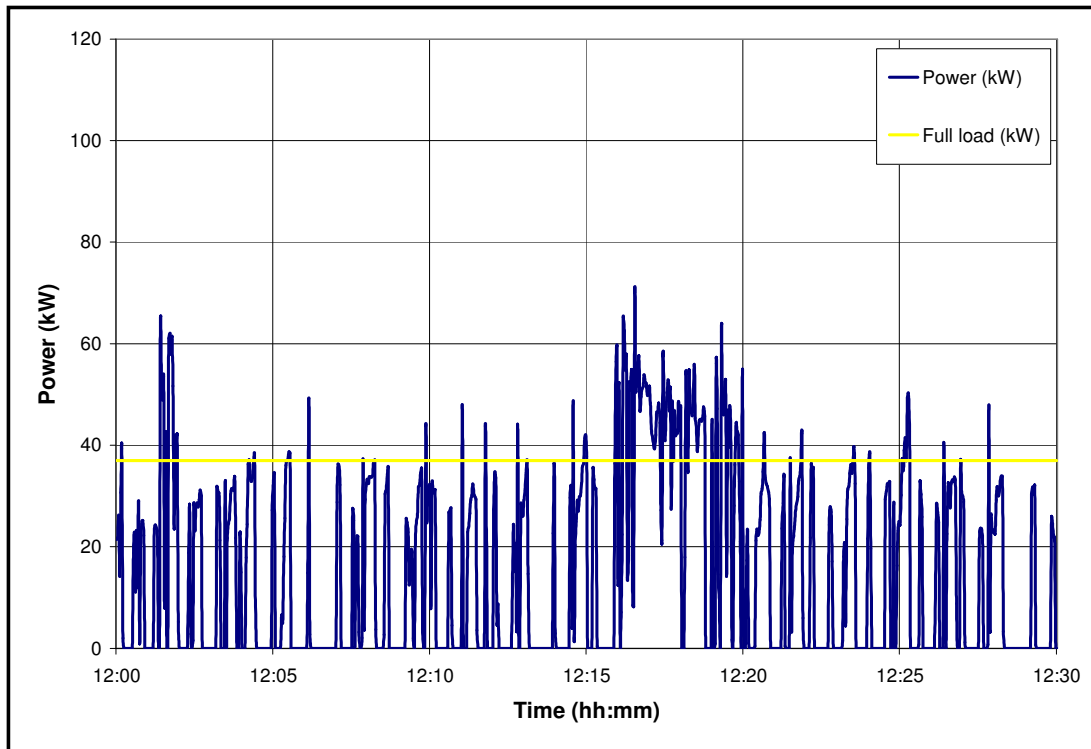


Figure M.1-9: Load power for a LH traction motor – 13 June 2005.



**Figure M.1-10: Load power for a LH traction motor
– 13 June 2005 (30 minute period).**

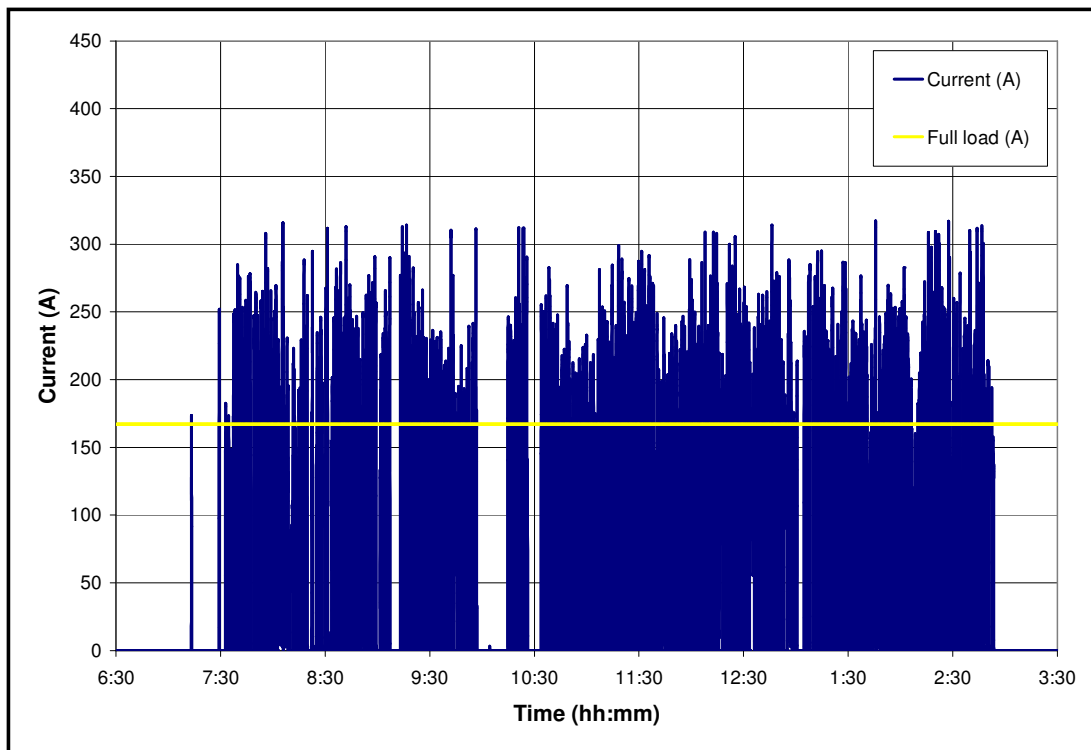
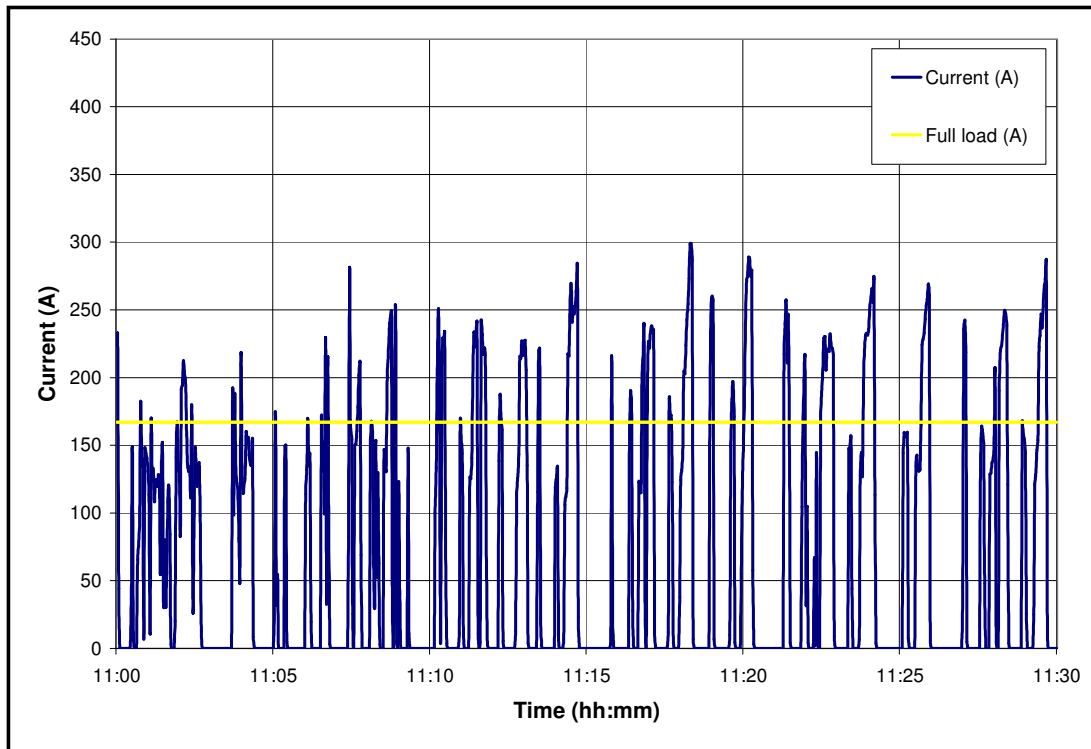


Figure M.1-11: Load current for a LH traction motor – 13 June 2005.



**Figure M.1-12: Load current for a LH traction motor
– 13 June 2005 (30 minute period).**

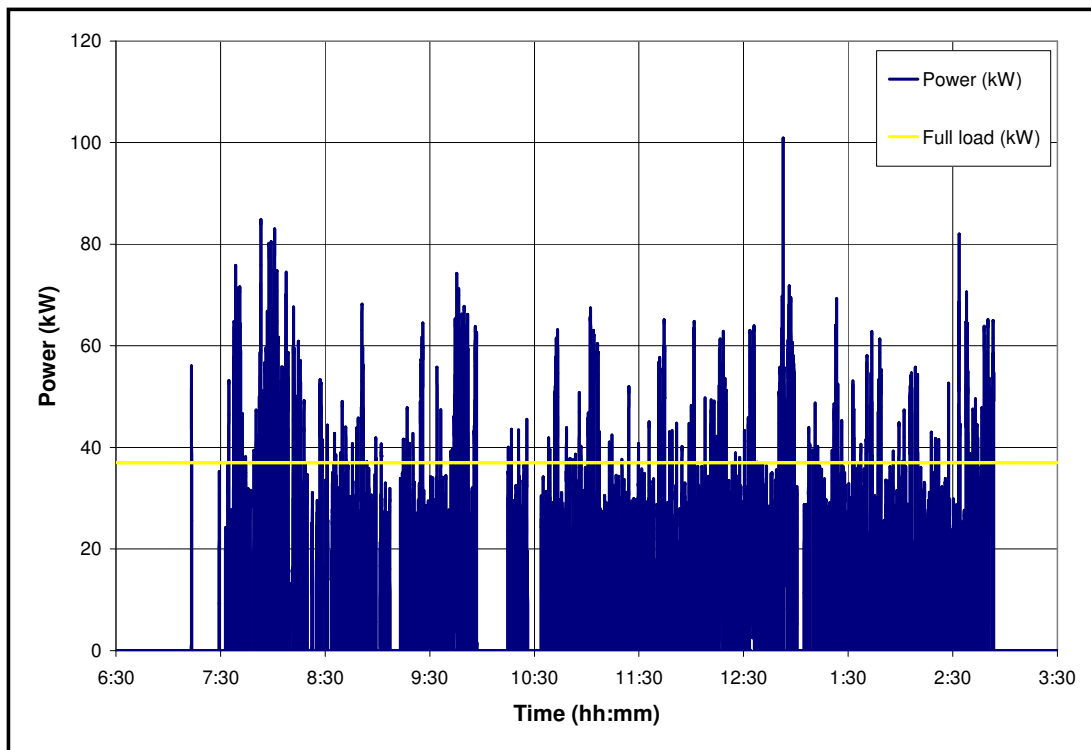
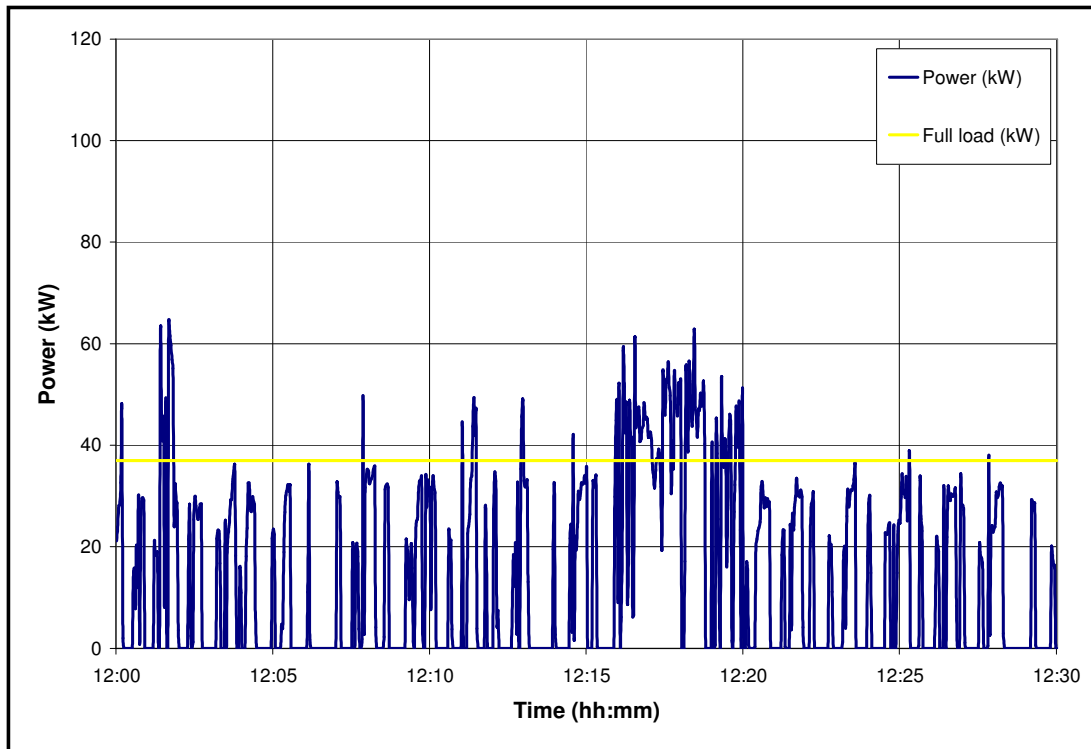


Figure M.1-13: Load power for a RH traction motor – 13 June 2005.



**Figure M.1-14: Load power for a RH traction motor
– 13 June 2005 (30 minute period).**

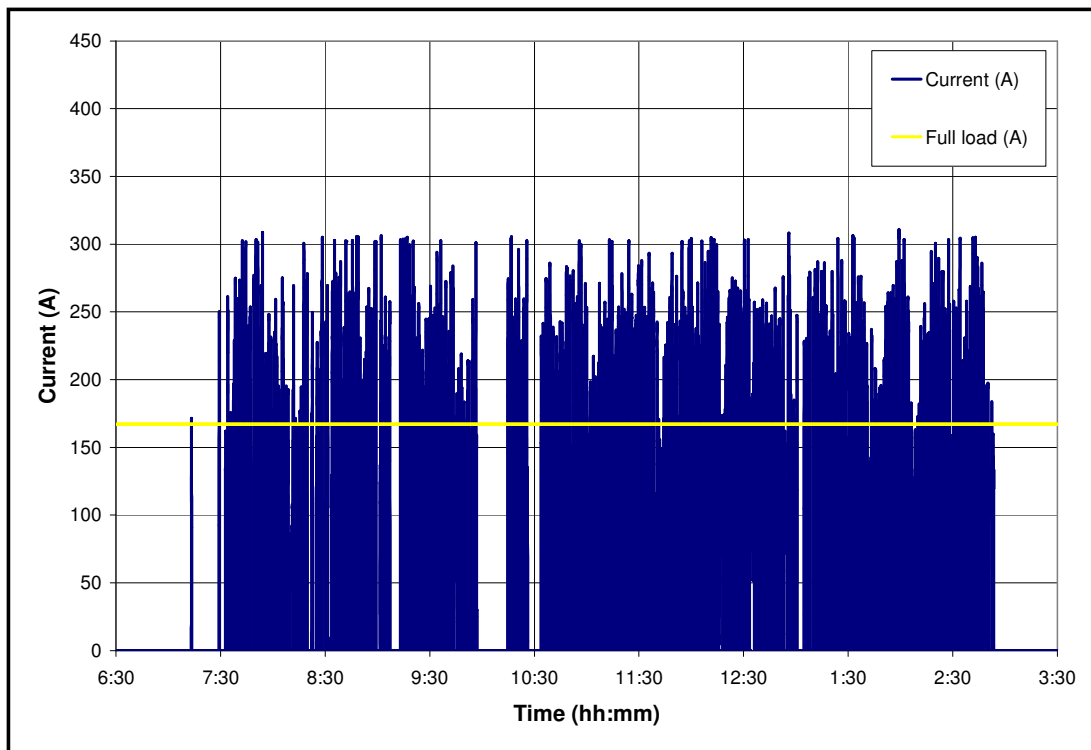
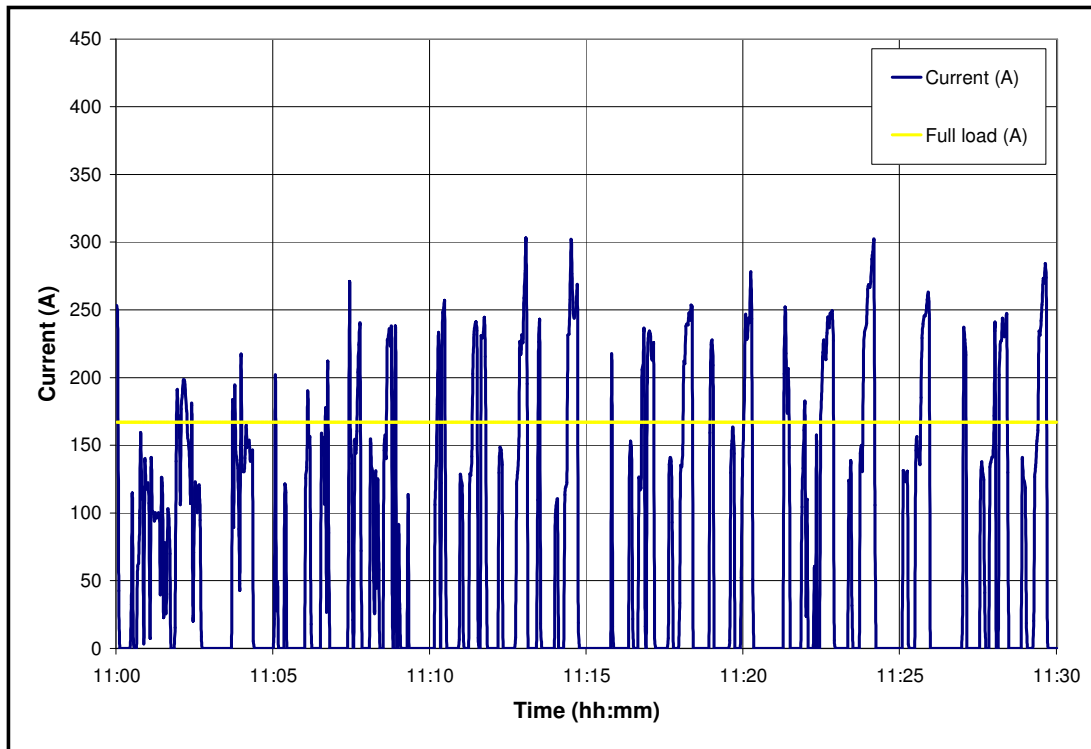


Figure M.1-15: Load current for a RH traction motor – 13 June 2005.



**Figure M.1-16: Load current for a RH traction motor
– 13 June 2005 (30 minute period).**

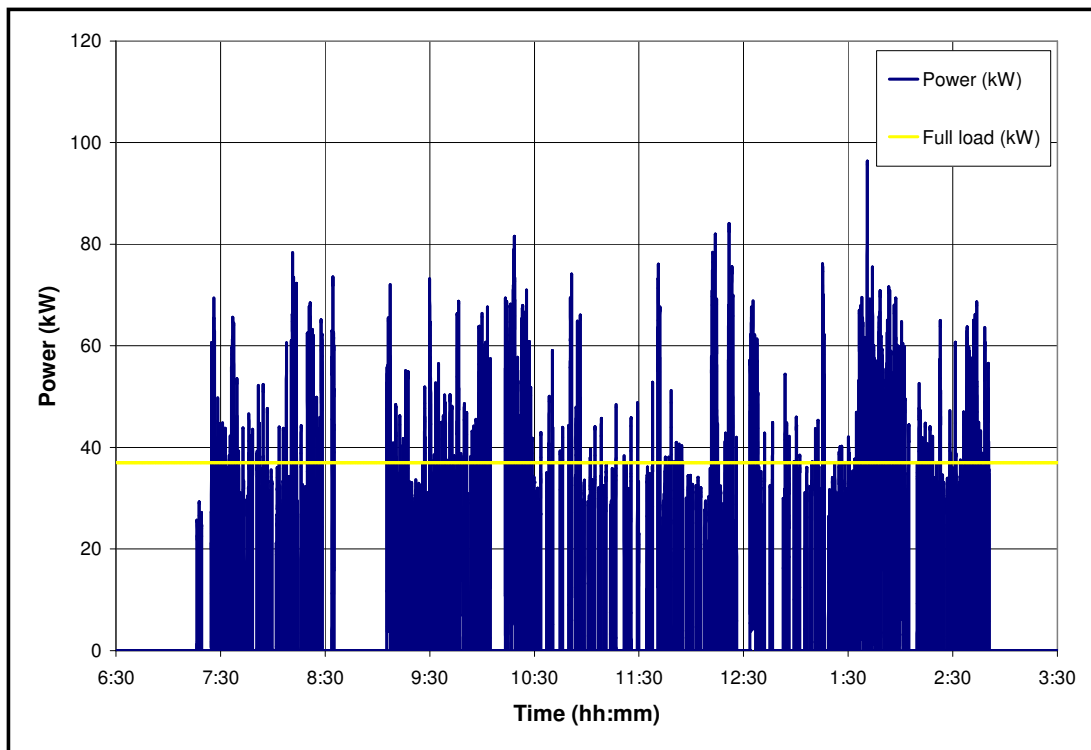
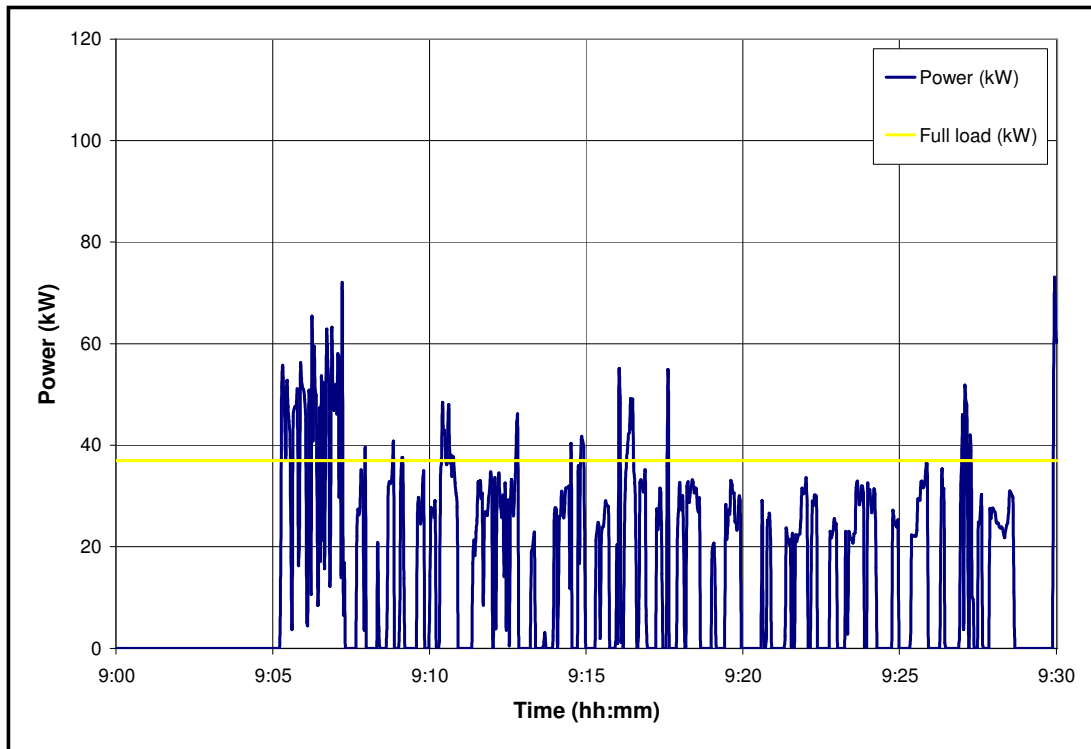


Figure M.1-17: Load power for a LH traction motor – 14 June 2005.



**Figure M.1-18: Load power for a LH traction motor
– 14 June 2005 (30 minute period).**

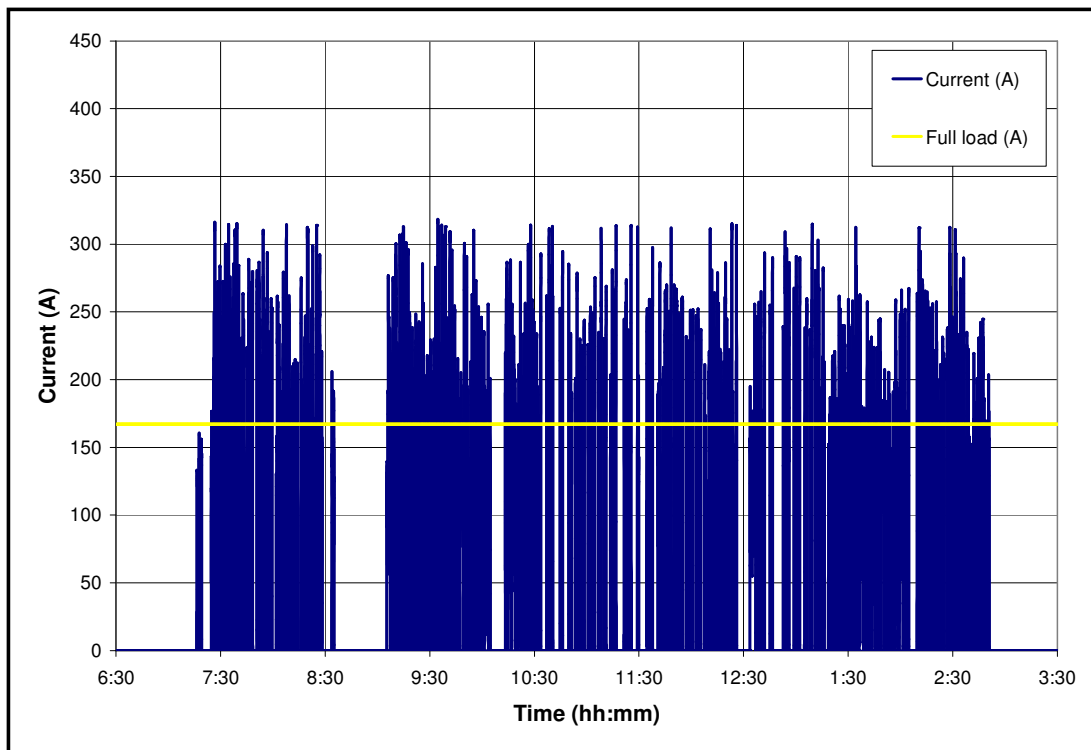
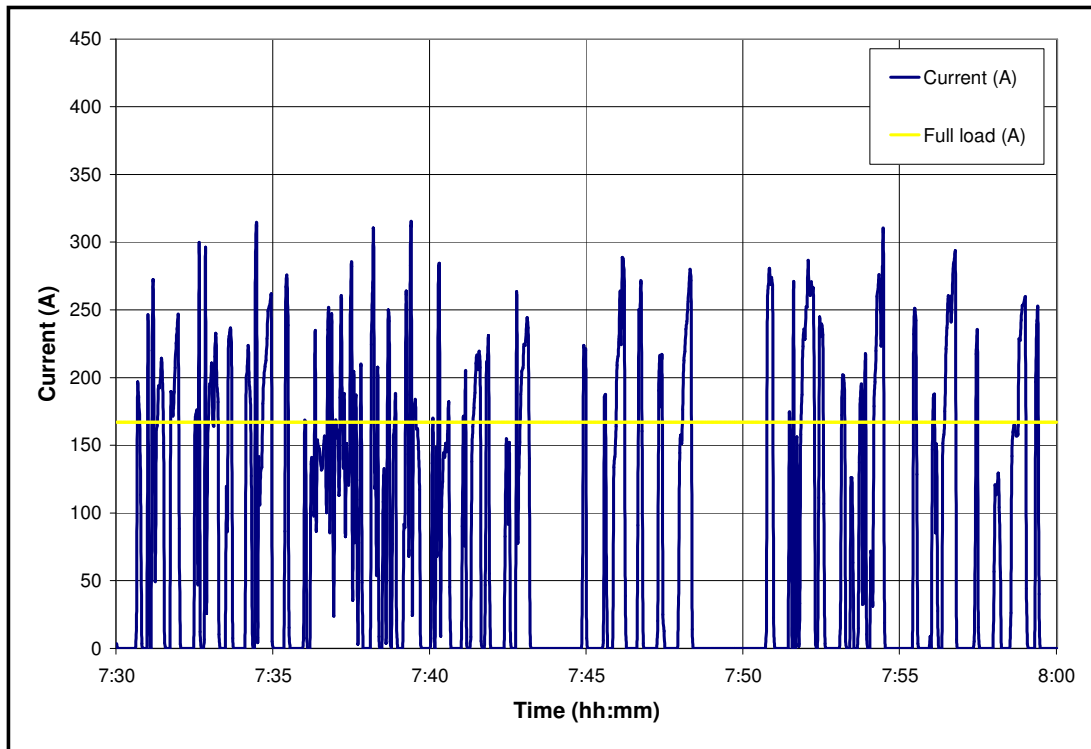


Figure M.1-19: Load current for a LH traction motor – 14 June 2005.



**Figure M.1-20: Load current for a LH traction motor
– 14 June 2005 (30 minute period).**

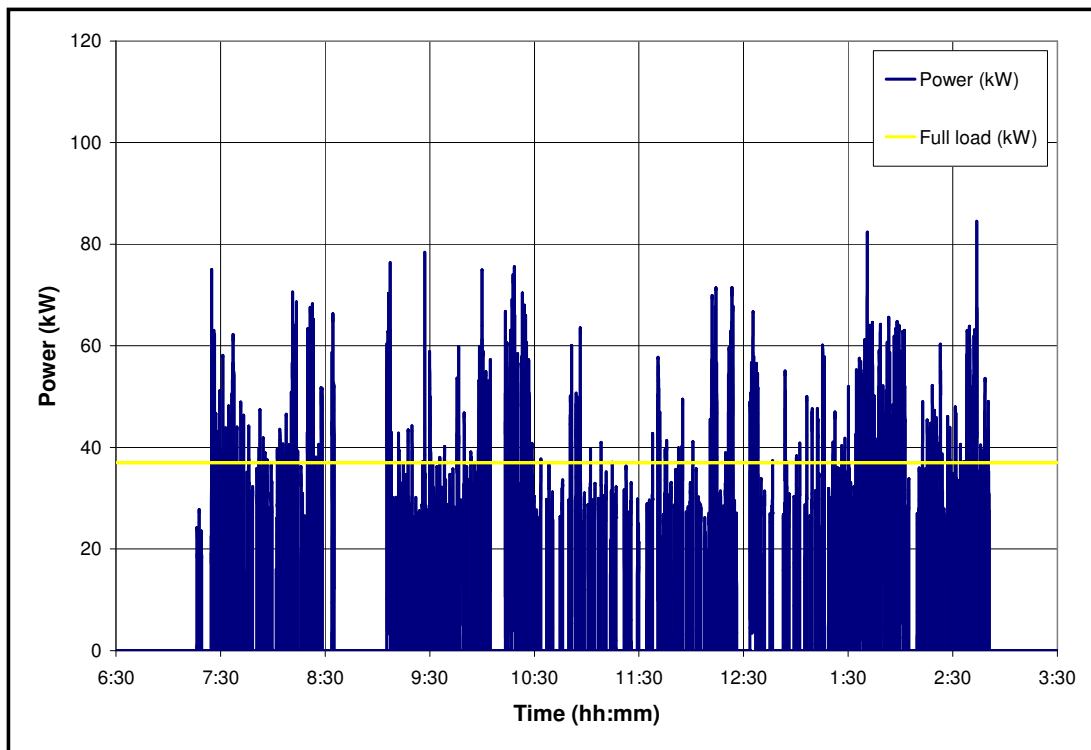
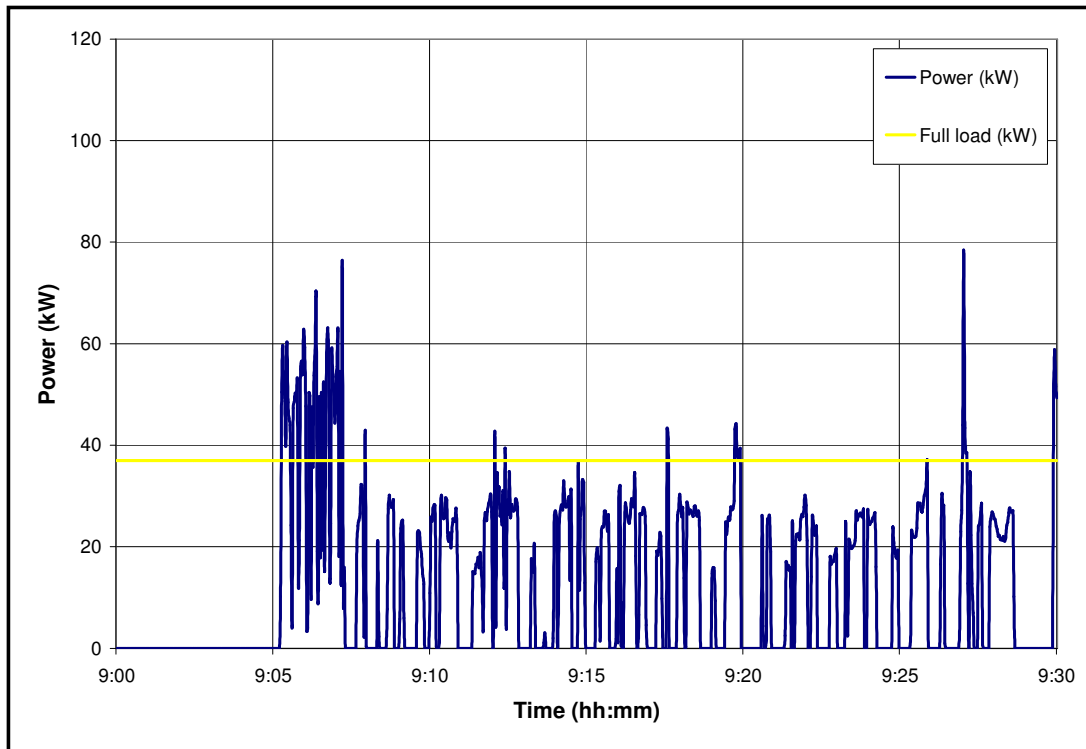


Figure M.1-21: Load power for a RH C traction motor – 14 June 2005.



**Figure M.1-22: Load power for a RH traction motor
– 14 June 2005 (30 minute period).**

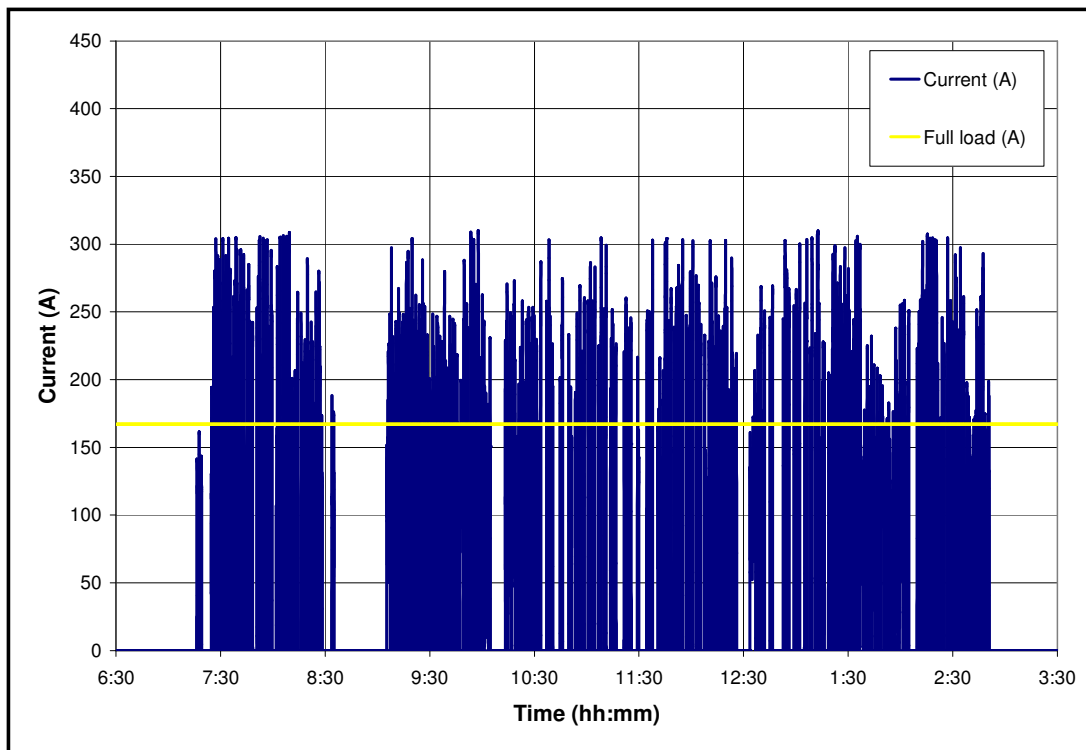
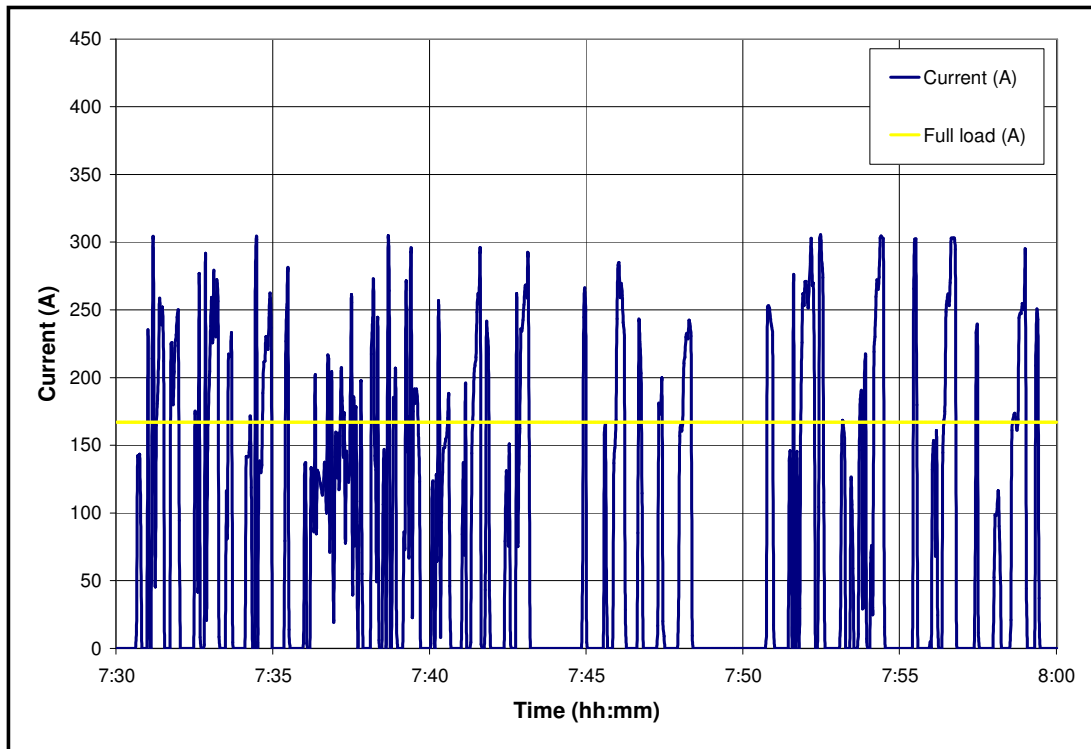


Figure M.1-23: Load current for a RH traction motor – 14 June 2005.



**Figure M.1-24: Load current for a RH traction motor
– 14 June 2005 (30 minute period).**

M.1.1.2 Afternoon shifts

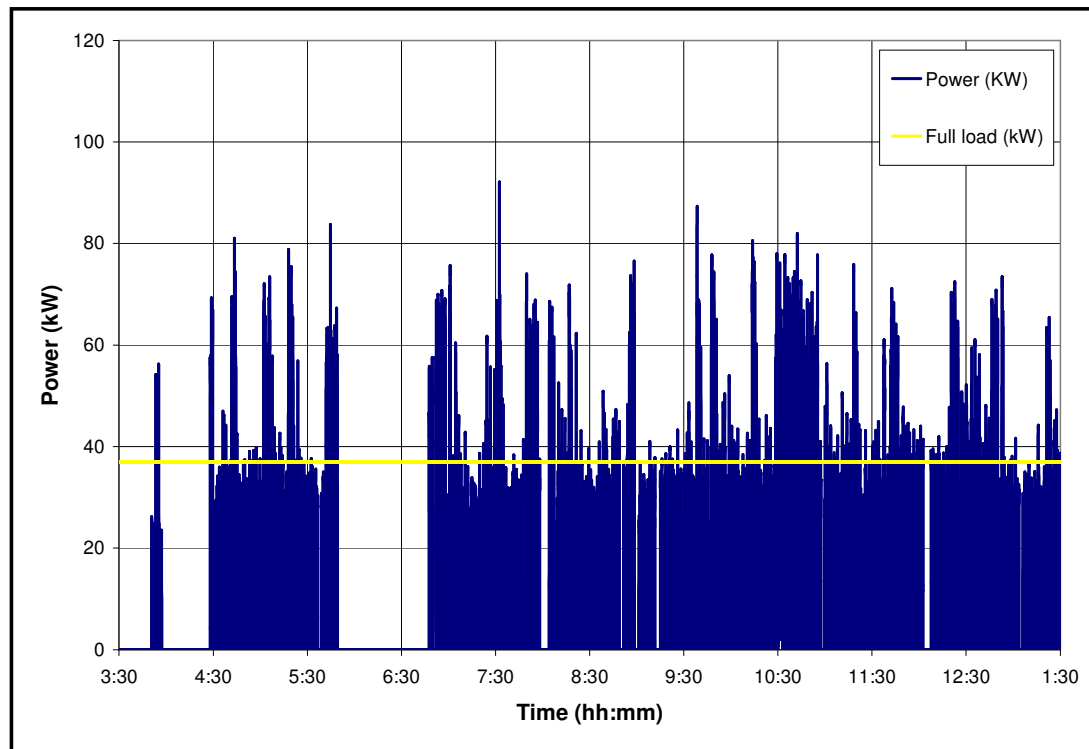
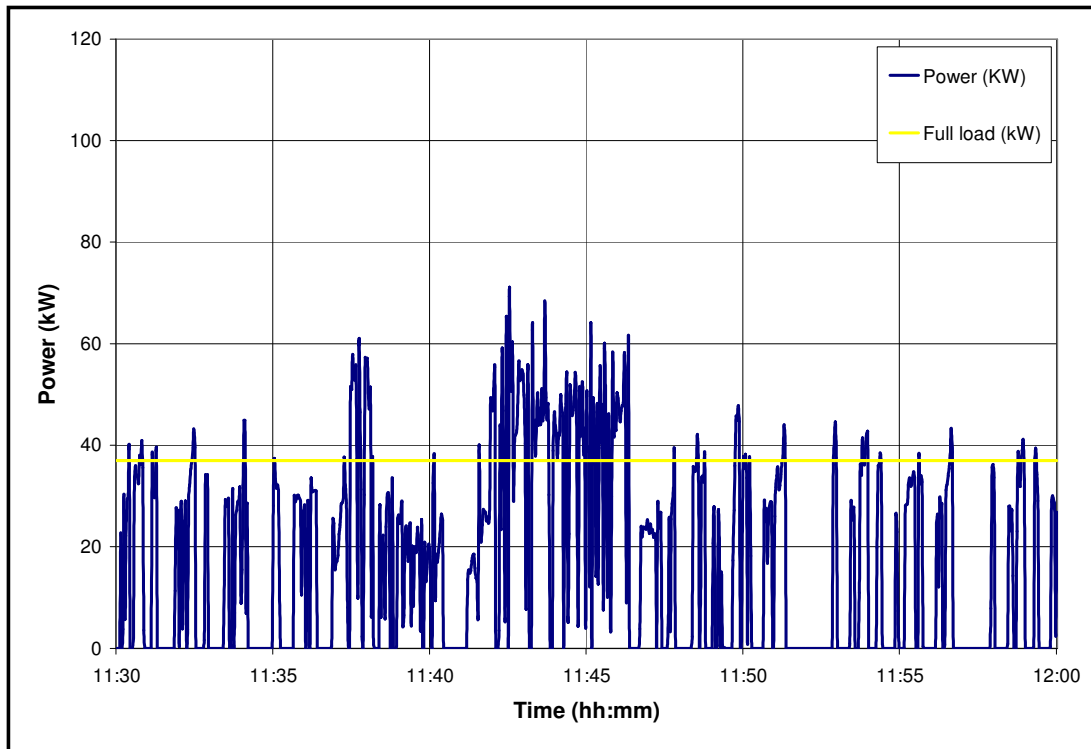


Figure M.1-25: Load power for a LH traction motor – 10 June 2005.



**Figure M.1-26: Load power for a LH traction motor
– 10 June 2005 (30 minute period).**

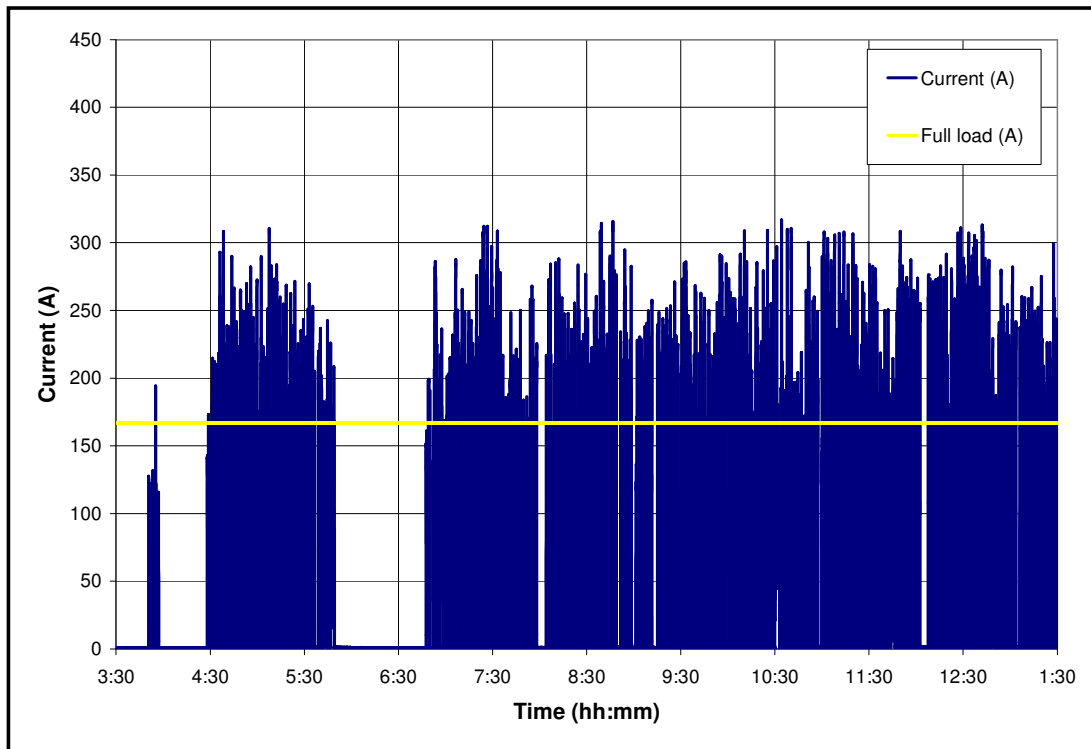
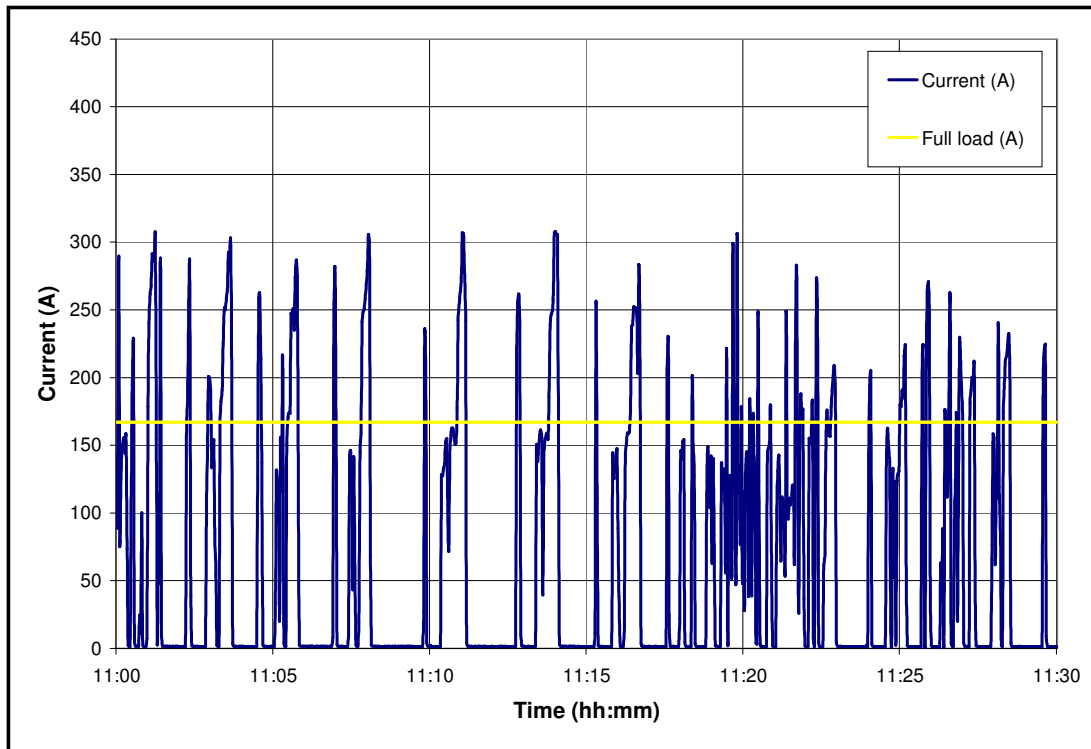


Figure M.1-27: Load current for a LH traction motor – 10 June 2005.



**Figure M.1-28: Load current for a LH traction motor
– 10 June 2005 (30 minute period).**

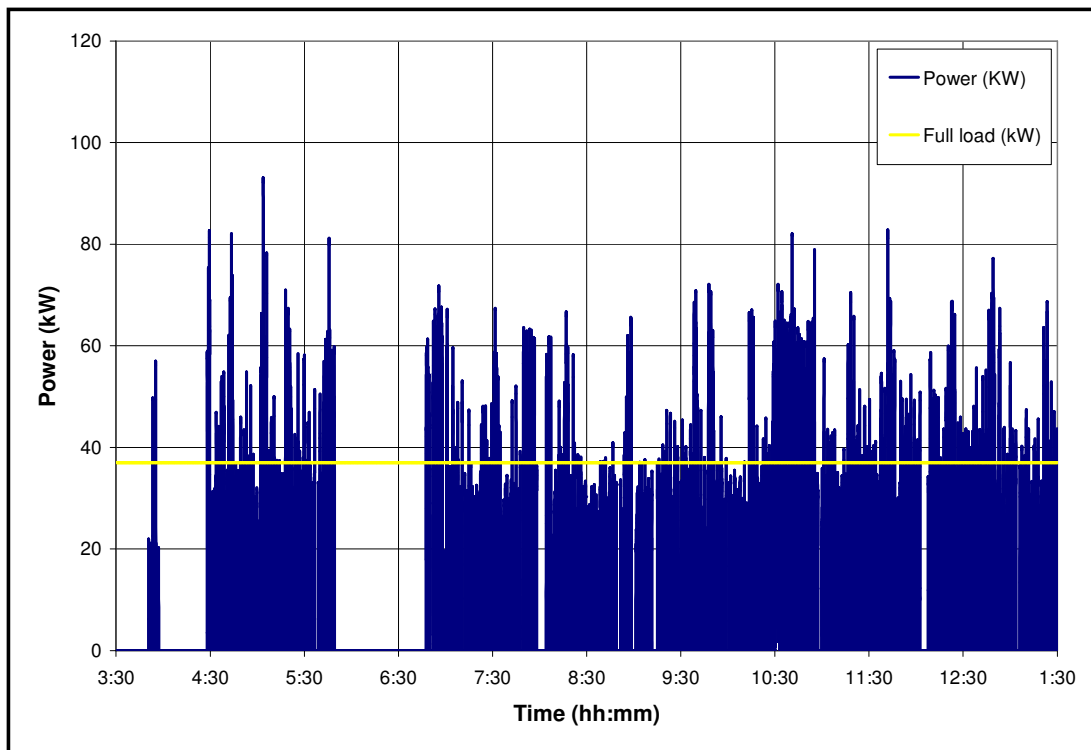
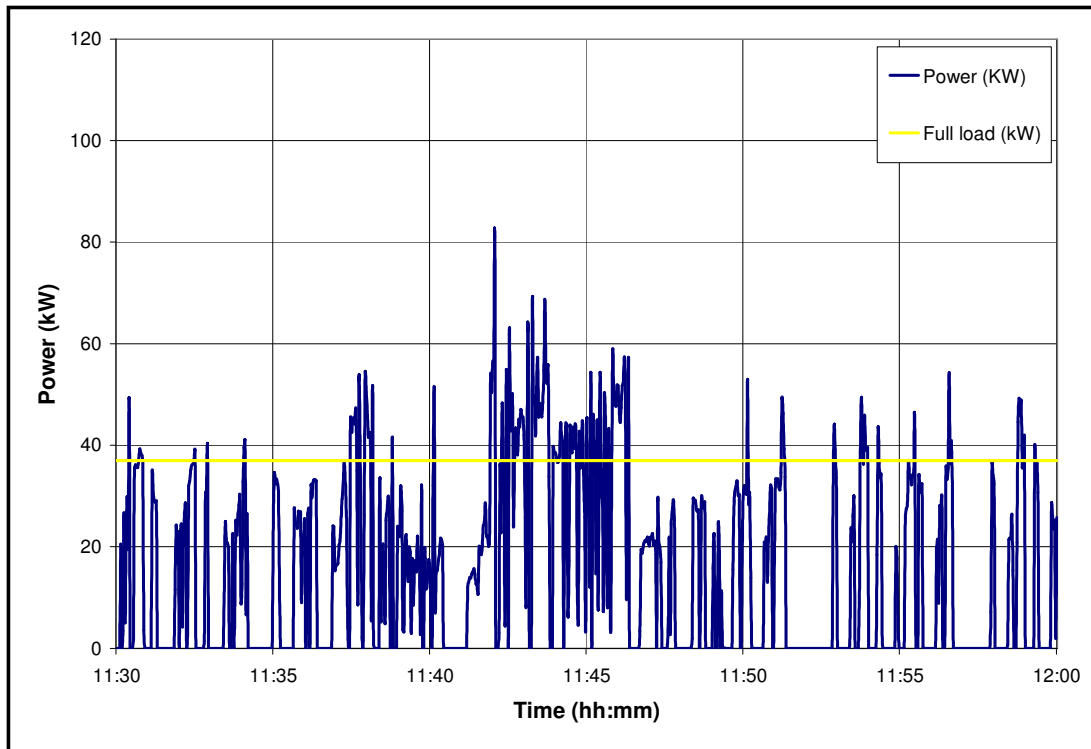


Figure M.1-29: Load power for a RH traction motor – 10 June 2005.



**Figure M.1-30: Load power for a RH traction motor
– 10 June 2005 (30 minute period).**

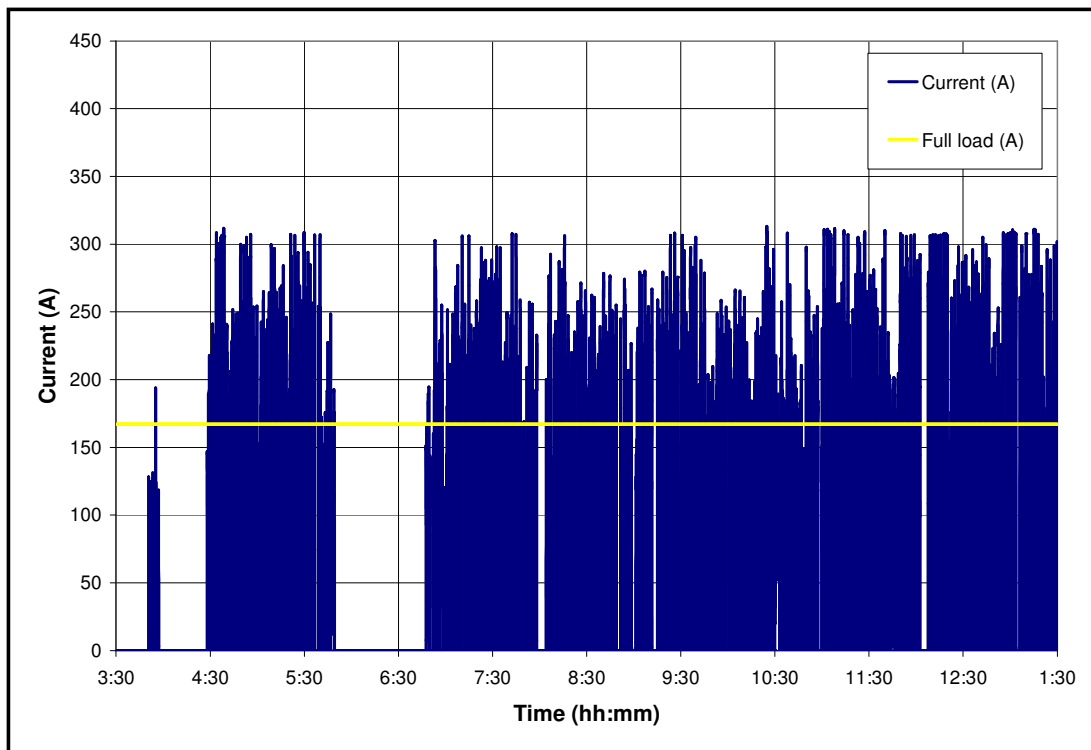
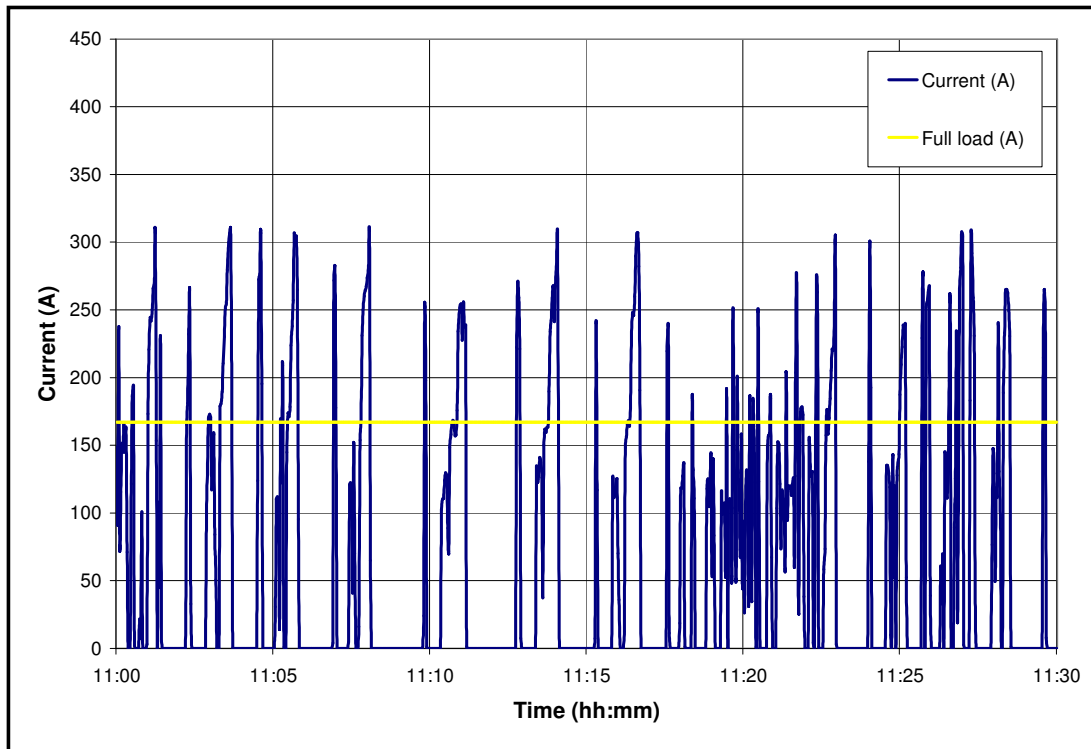


Figure M.1-31: Load current for a RH traction motor – 10 June 2005.



**Figure M.1-32: Load current for a RH traction motor
– 10 June 2005 (30 minute period).**

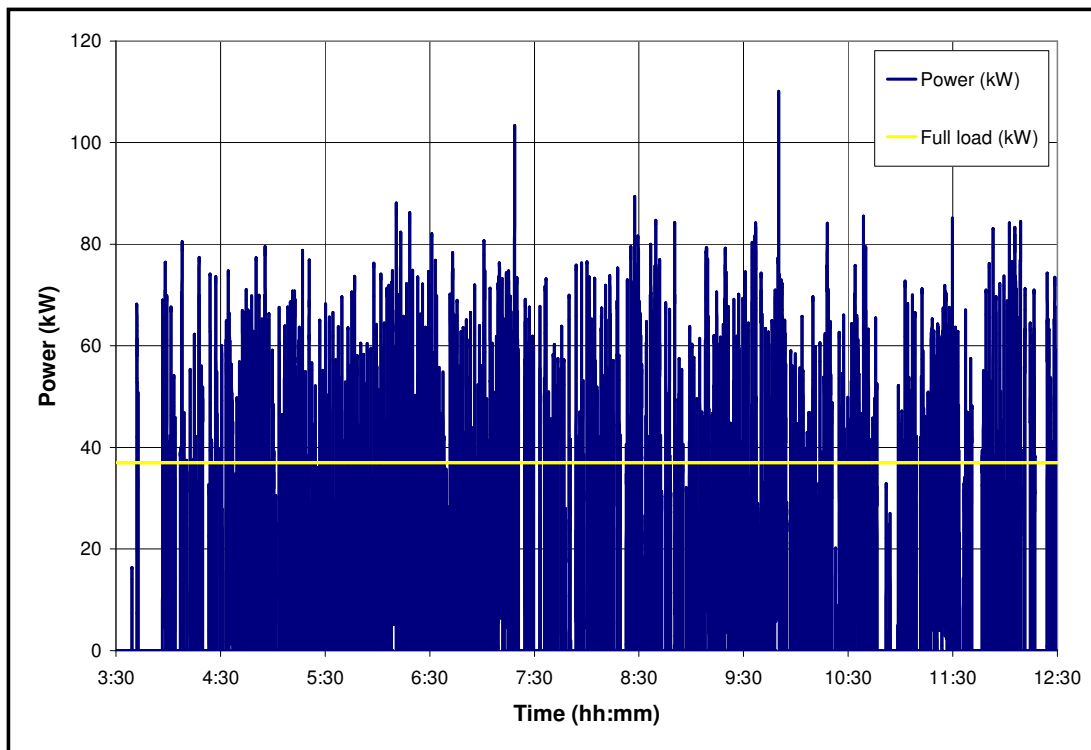
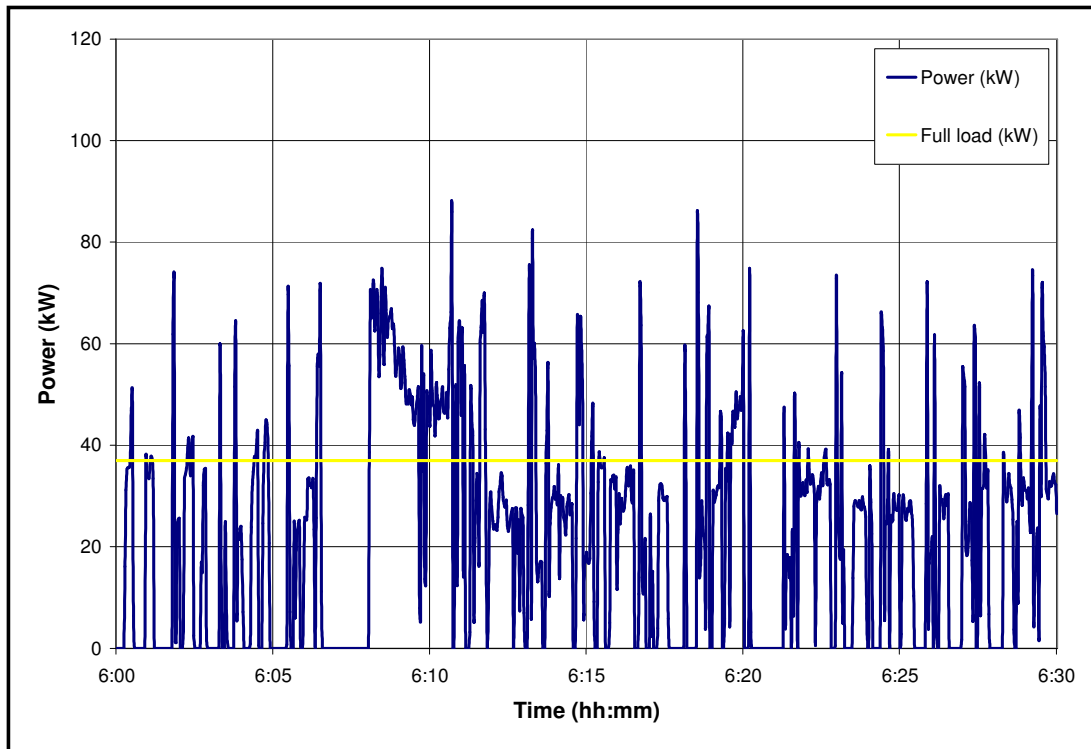


Figure M.1-33: Load power for a LH traction motor – 13 June 2005.



**Figure M.1-34: Load power for a LH traction motor
– 13 June 2005 (30 minute period).**

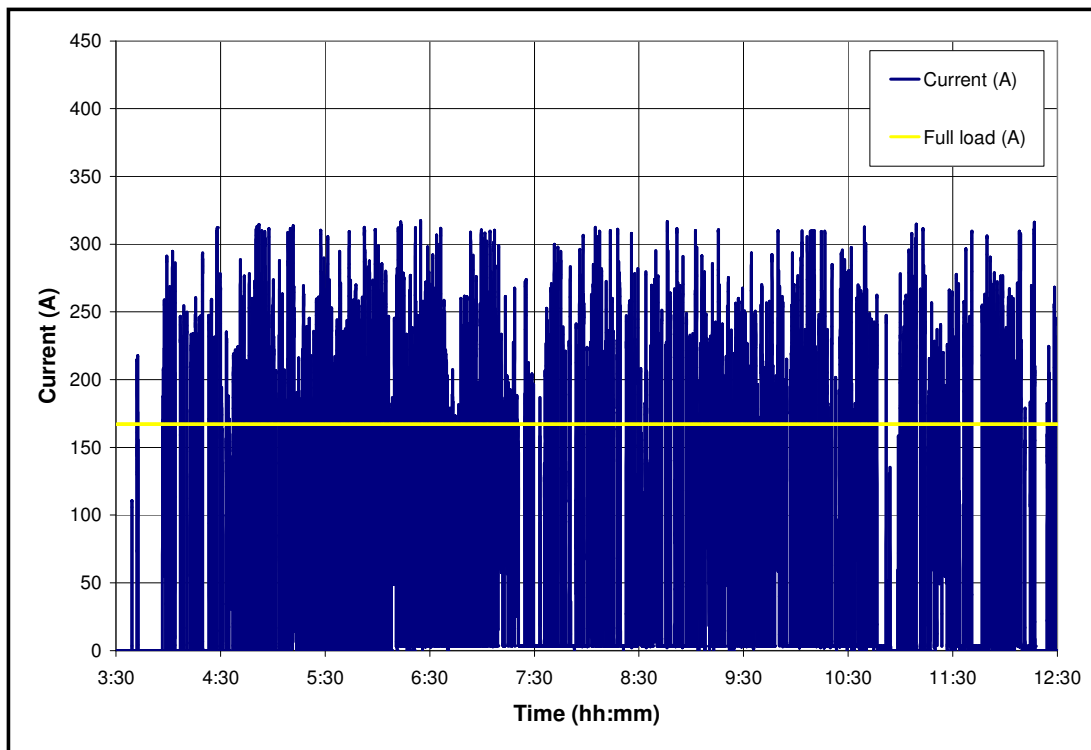
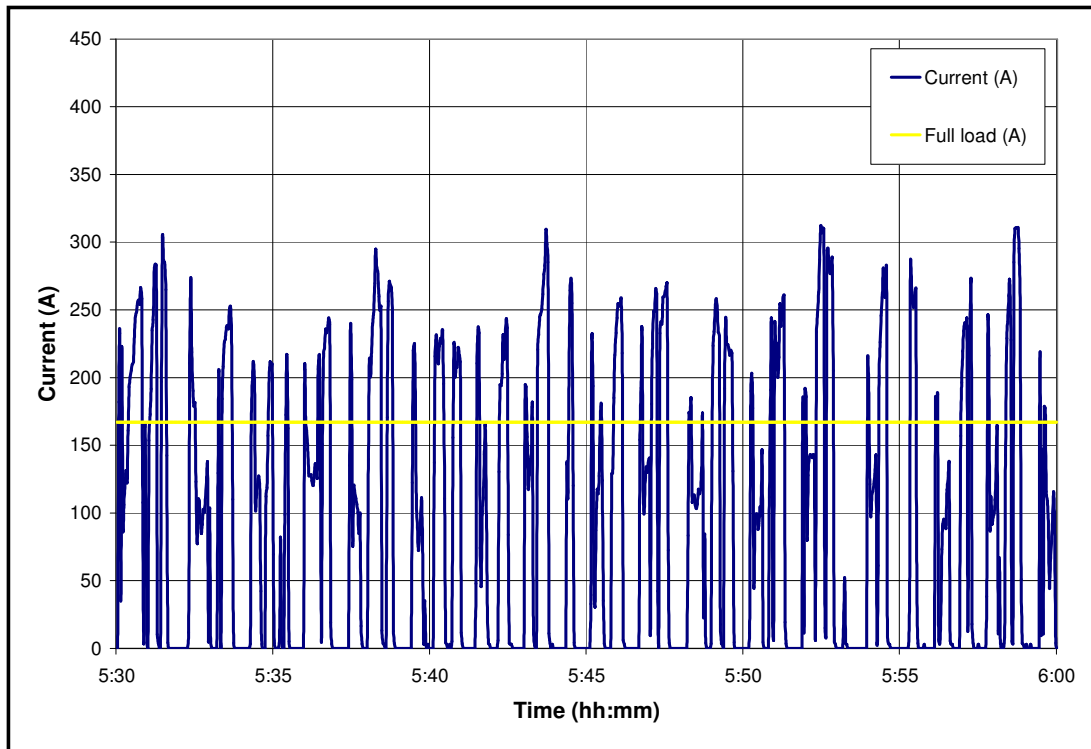


Figure M.1-35: Load current for a LH traction motor – 13 June 2005.



**Figure M.1-36: Load current for a LH traction motor
– 13 June 2005 (30 minute period).**

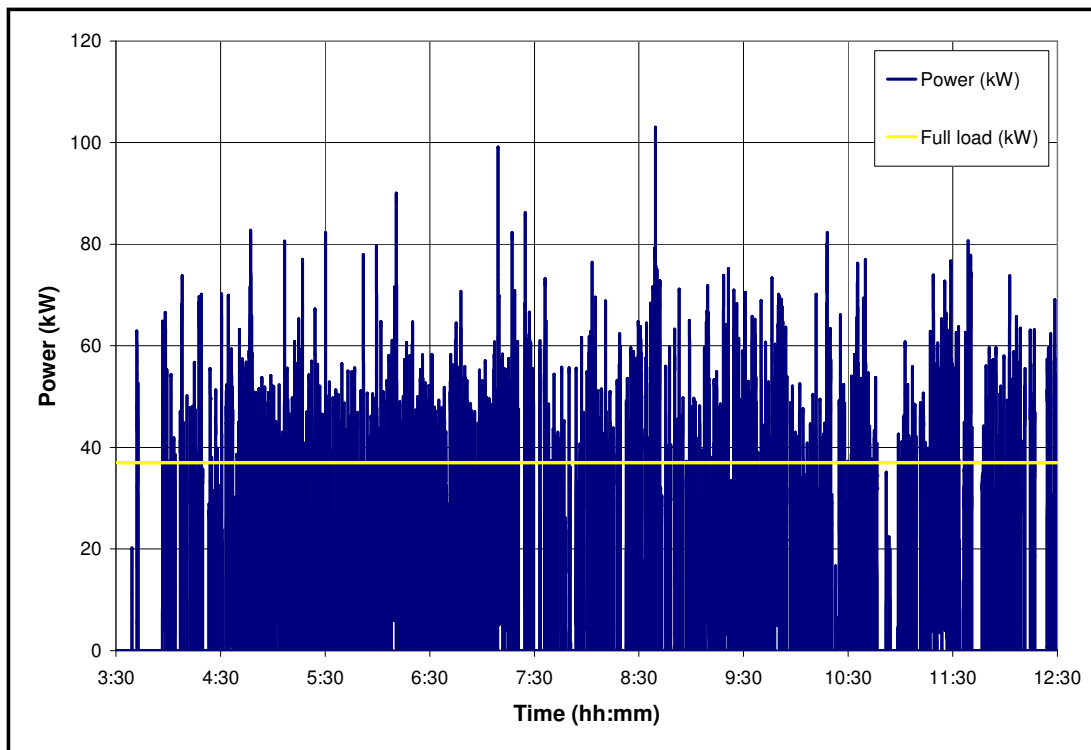
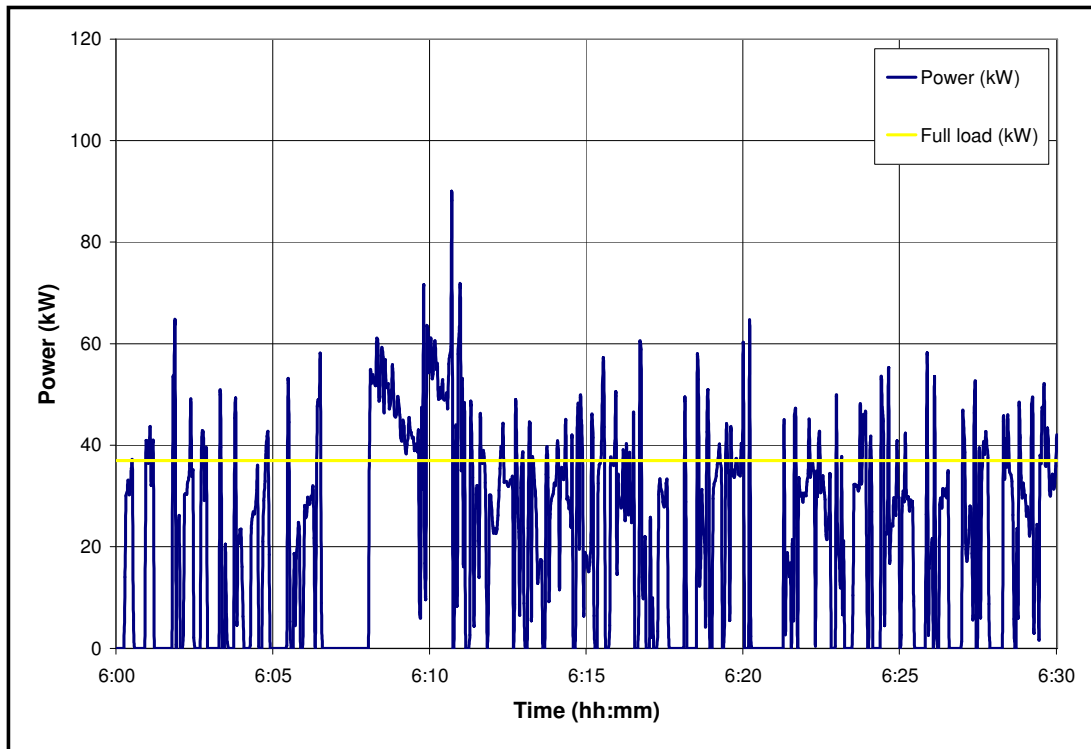


Figure M.1-37: Load power for a RH traction motor – 13 June 2005.



**Figure M.1-38: Load power for a RH traction motor
– 13 June 2005 (30 minute period).**

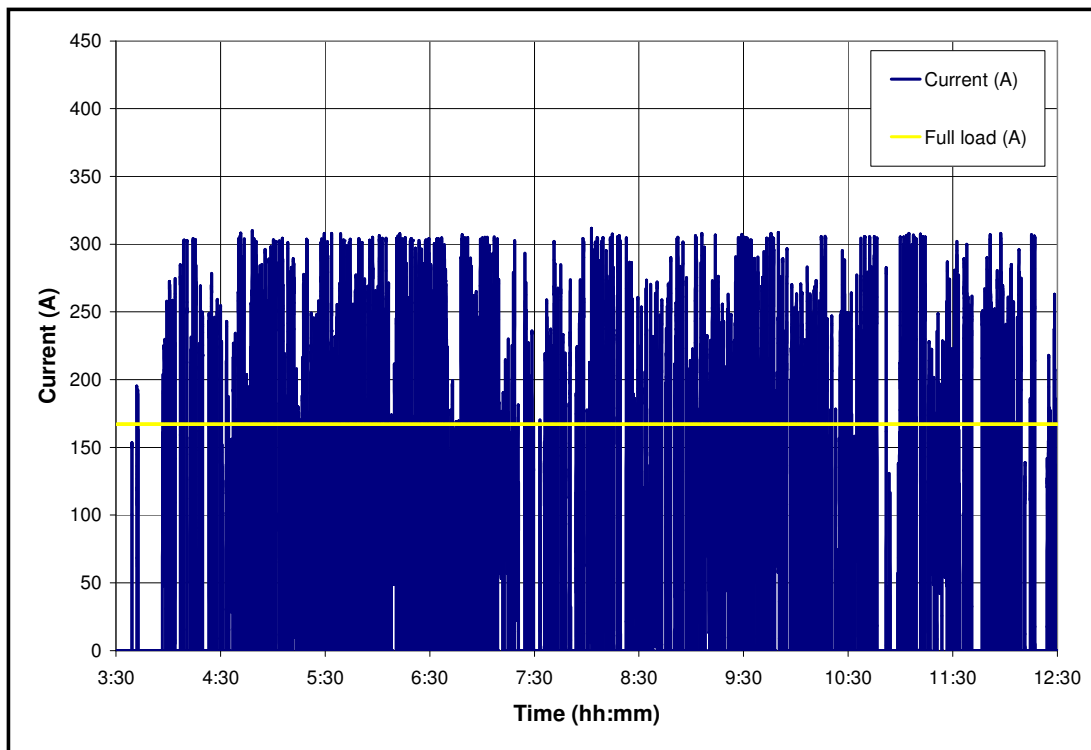
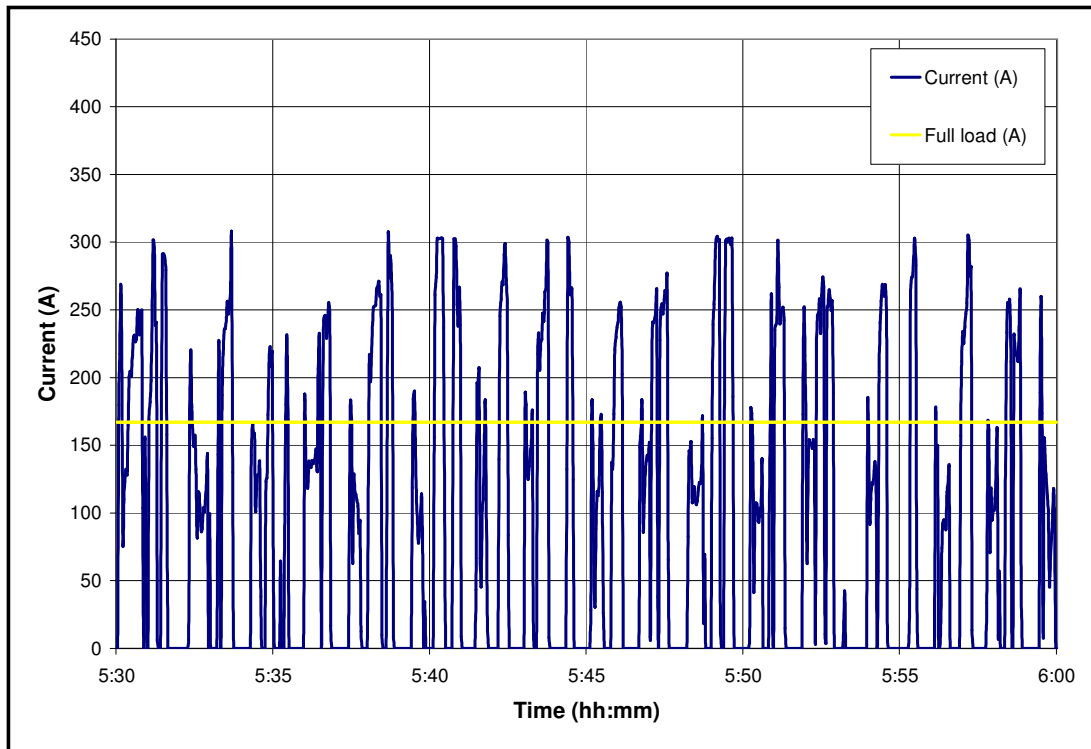


Figure M.1-39: Load current for a RH traction motor – 13 June 2005.



**Figure M.1-40: Load current for a RH traction motor
– 13 June 2005 (30 minute period).**

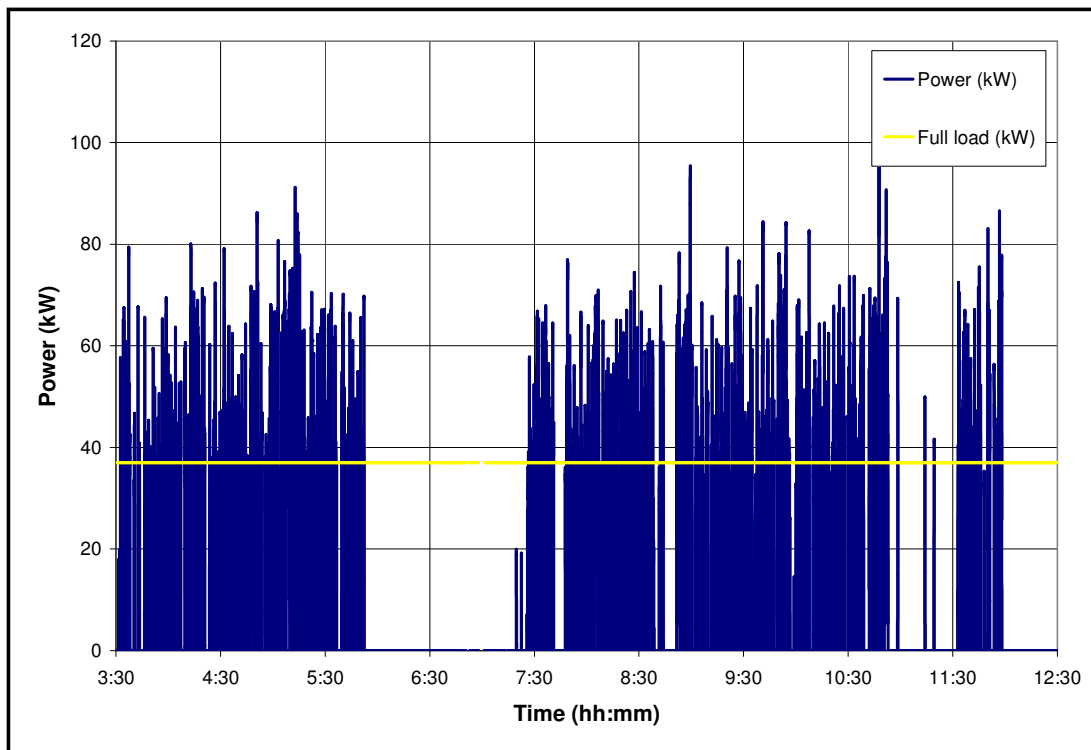
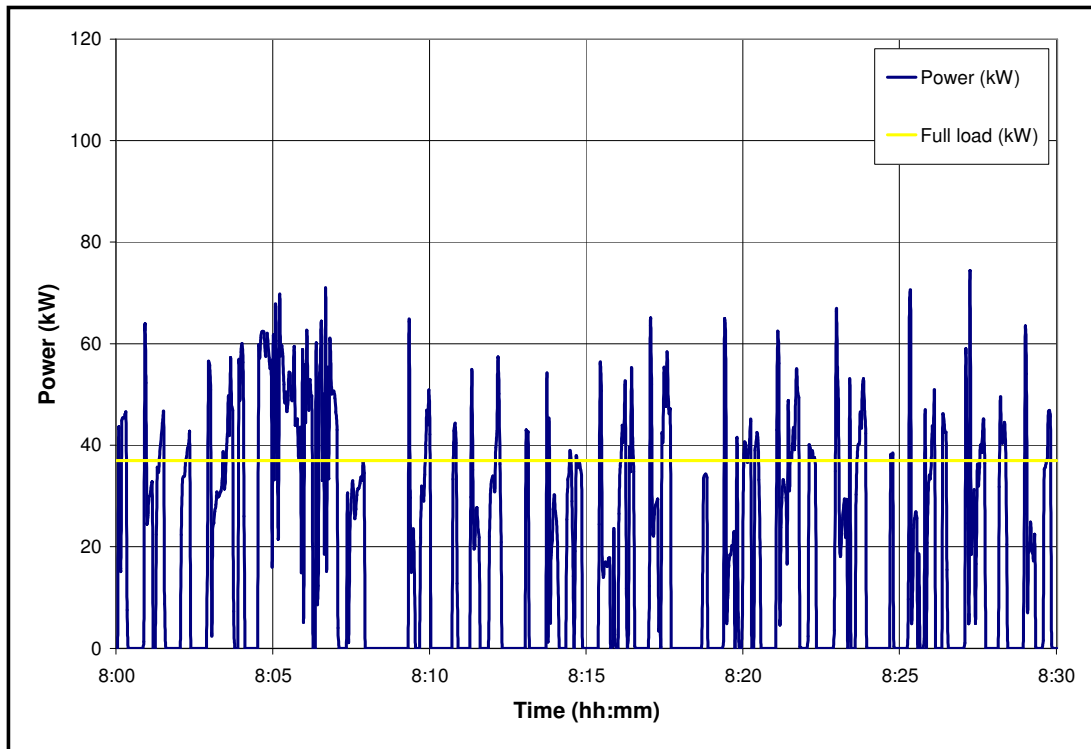


Figure M.1-41: Load power for a LH traction motor – 14 June 2005.



**Figure M.1-42: Load power for a LH traction motor
– 14 June 2005 (30 minute period).**

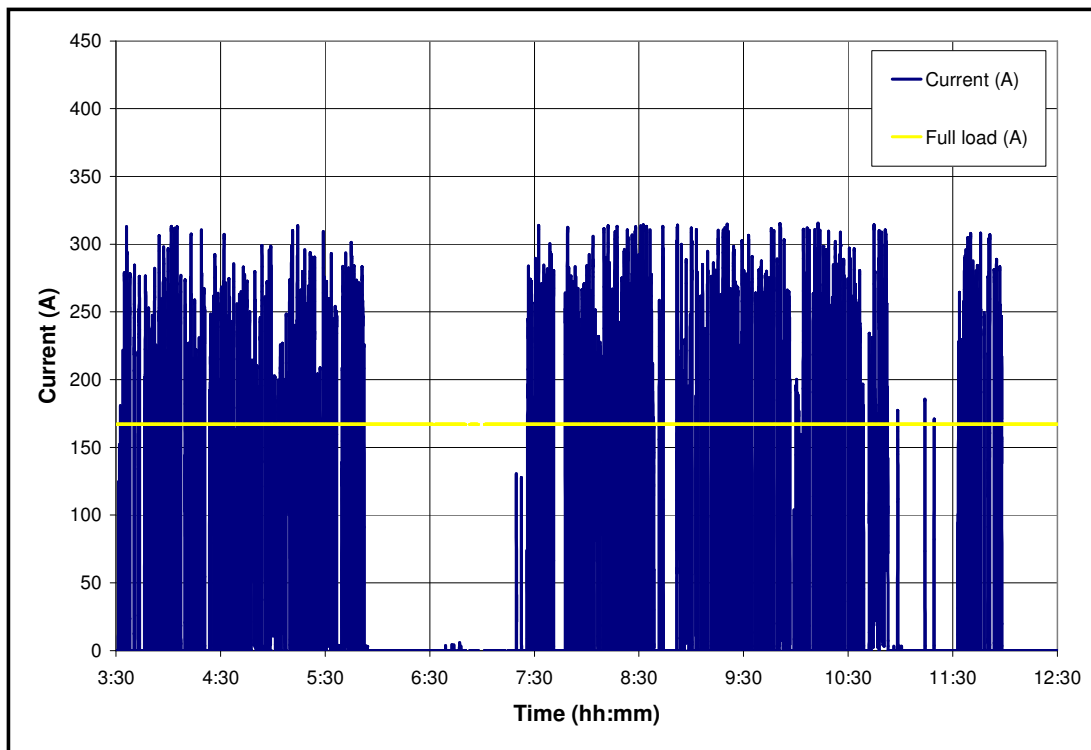
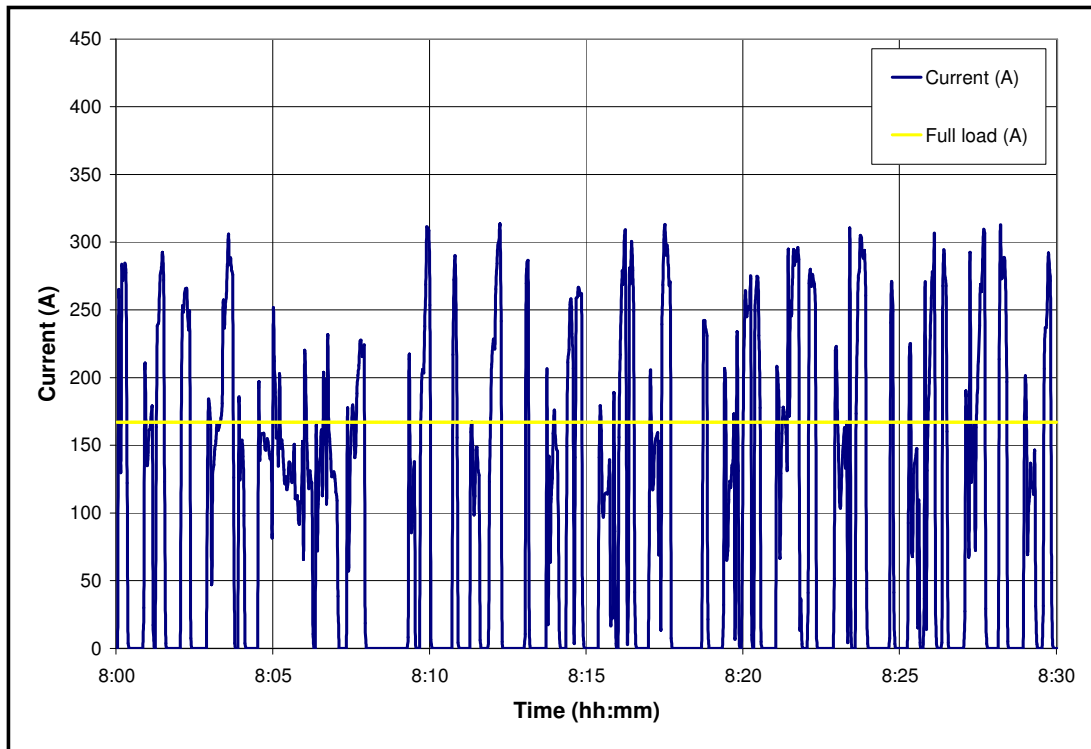


Figure M.1-43: Load current for a LH traction motor – 14 June 2005.



**Figure M.1-44: Load current for a LH traction motor
– 14 June 2005 (30 minute period).**

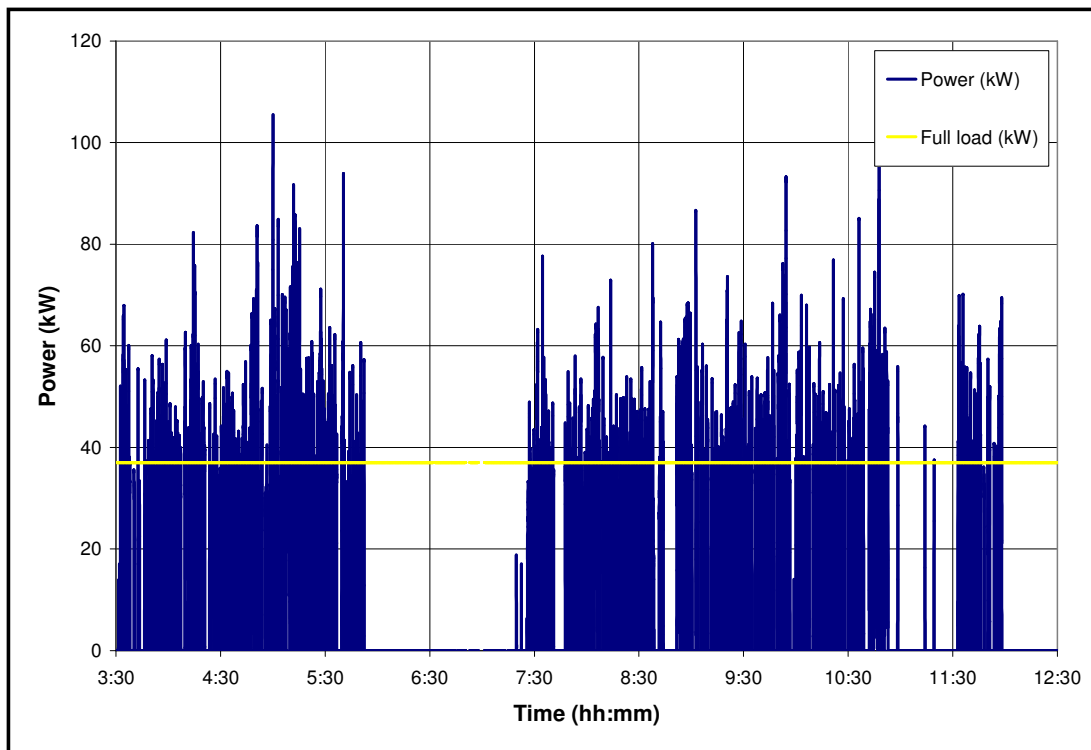
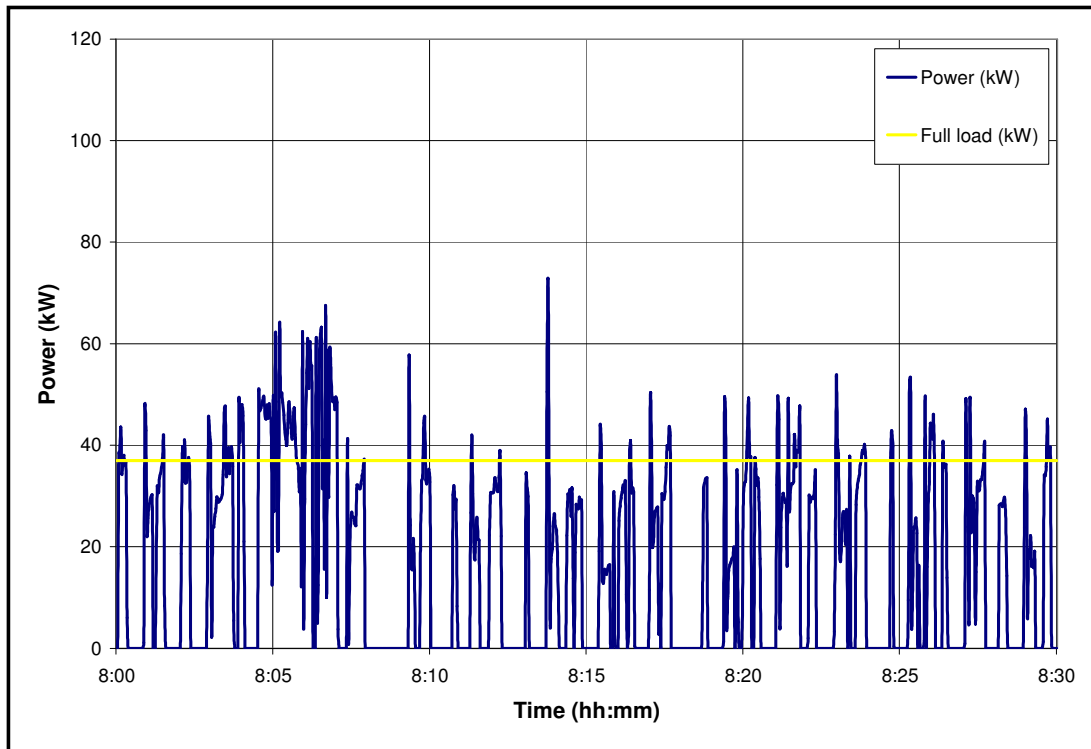


Figure M.1-45: Load power for a RH traction motor – 14 June 2005.



**Figure M.1-46: Load power for a RH traction motor
– 14 June 2005 (30 minute period).**

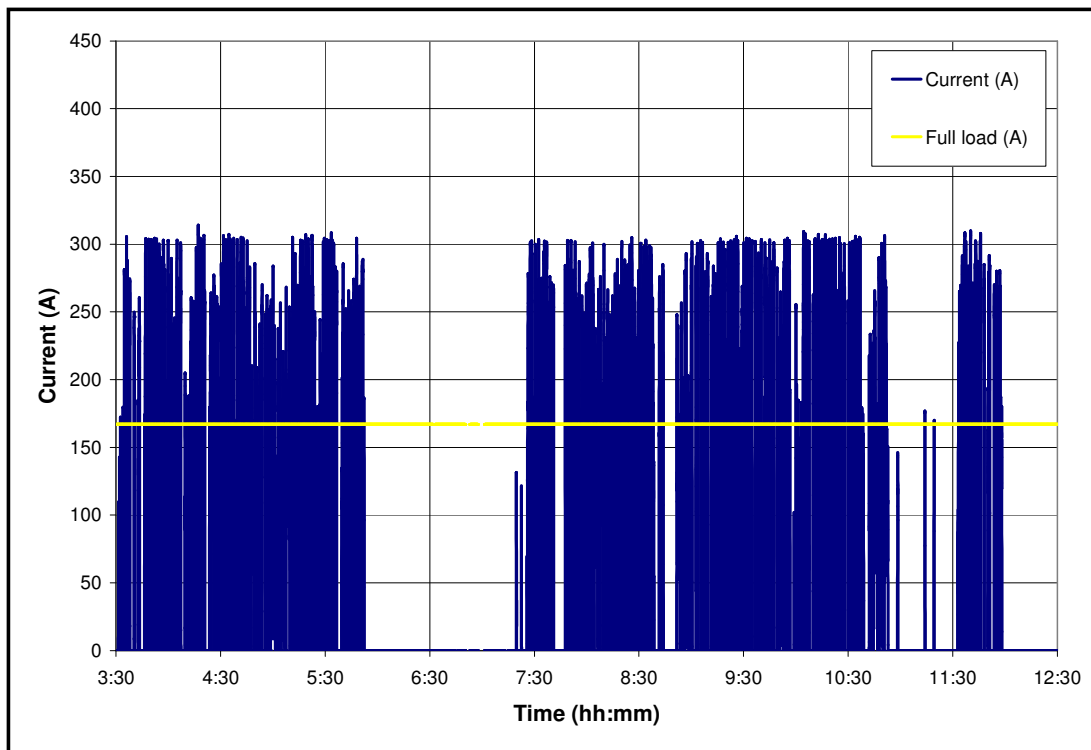
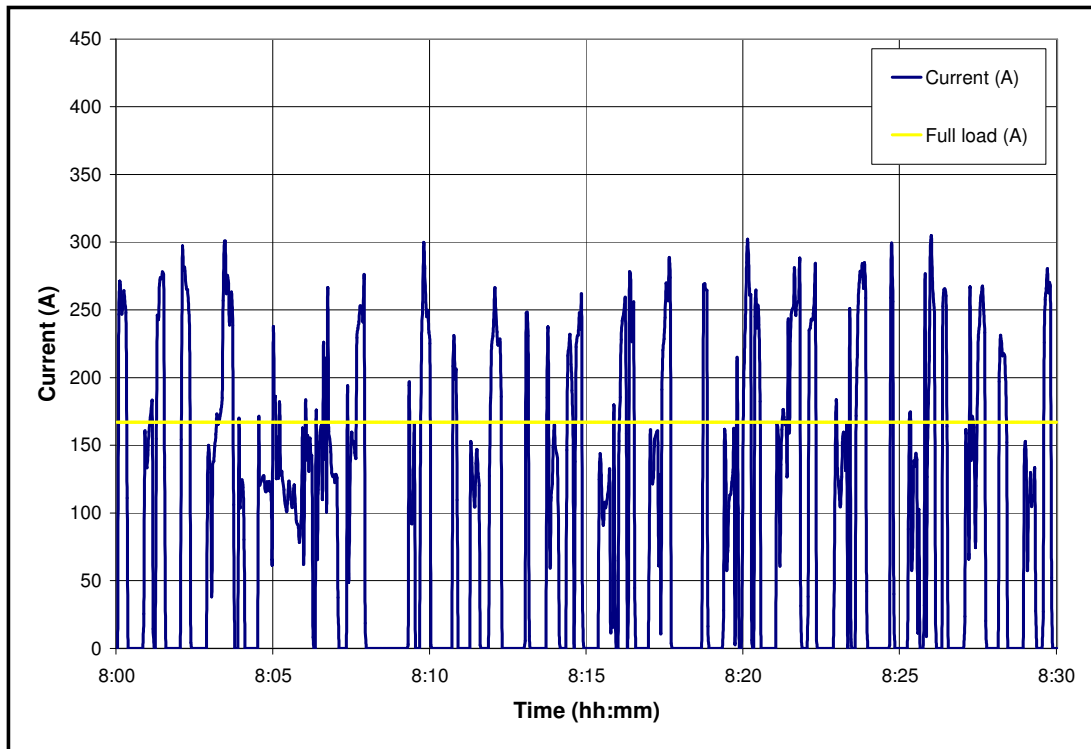


Figure M.1-47: Load current for a RH traction motor – 14 June 2005.



**Figure M.1-48: Load current for a RH traction motor
– 14 June 2005 (30 minute period).**

M.1.2 SECTION 51

M.1.2.1 Morning shifts

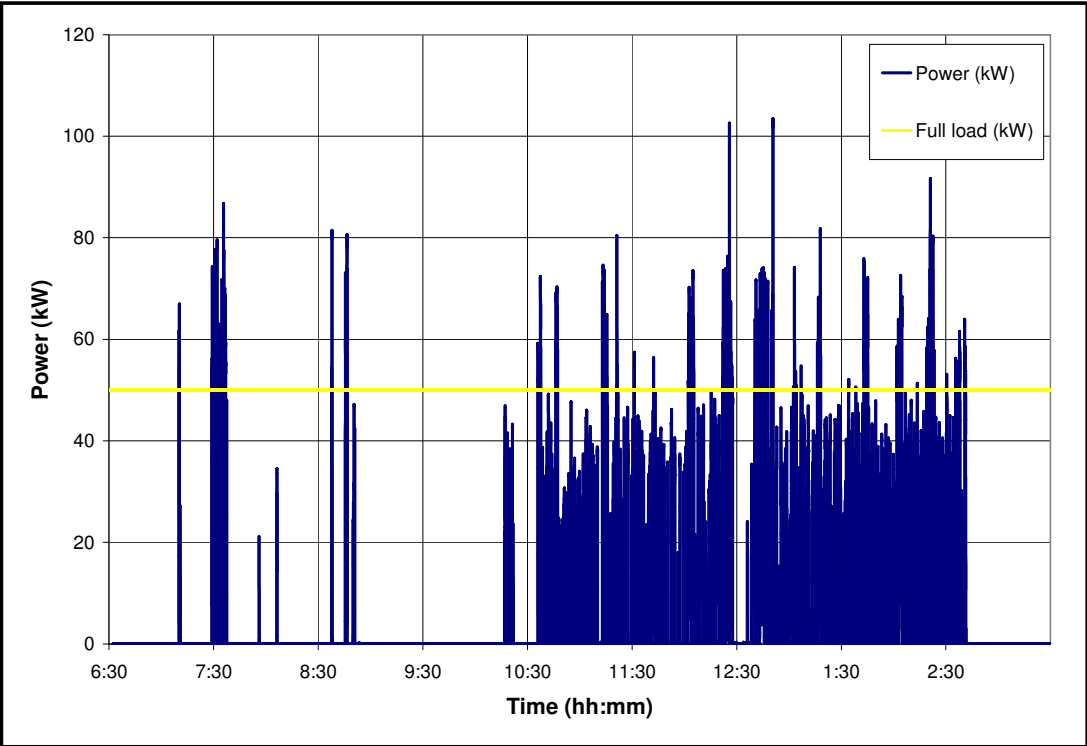
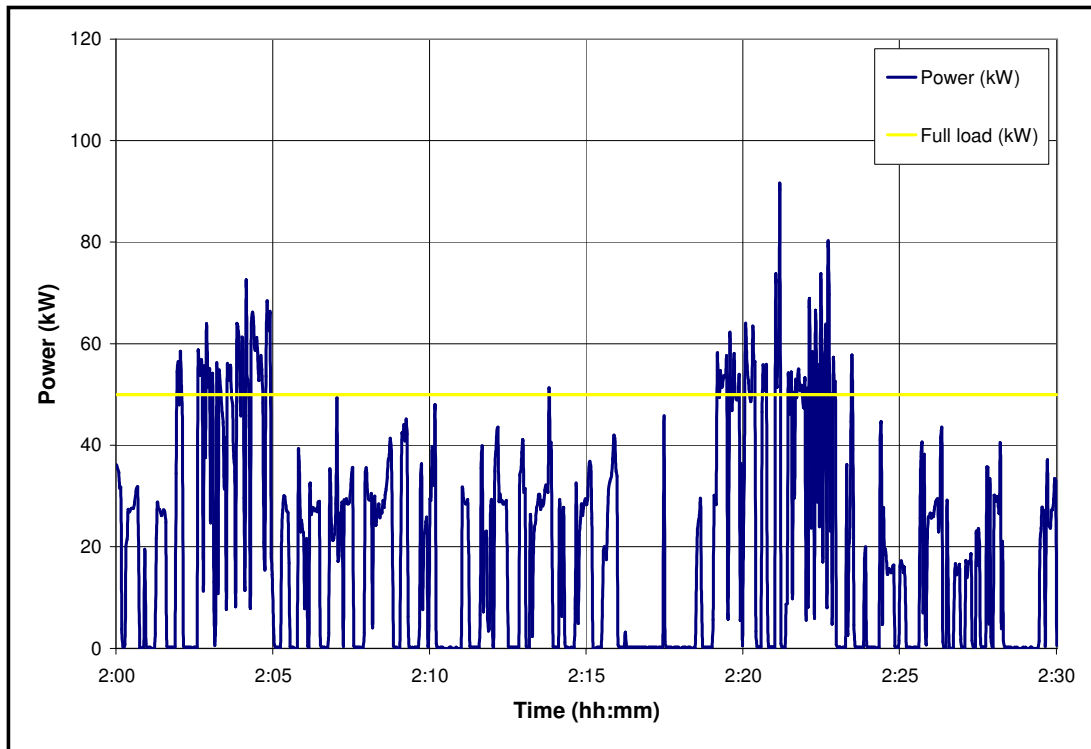


Figure M.1-49: Load power for a LH C traction motor – 29 June 2005.



**Figure M.1-50: Load power for a LH traction motor
– 29 June 2005 (30 minute period).**

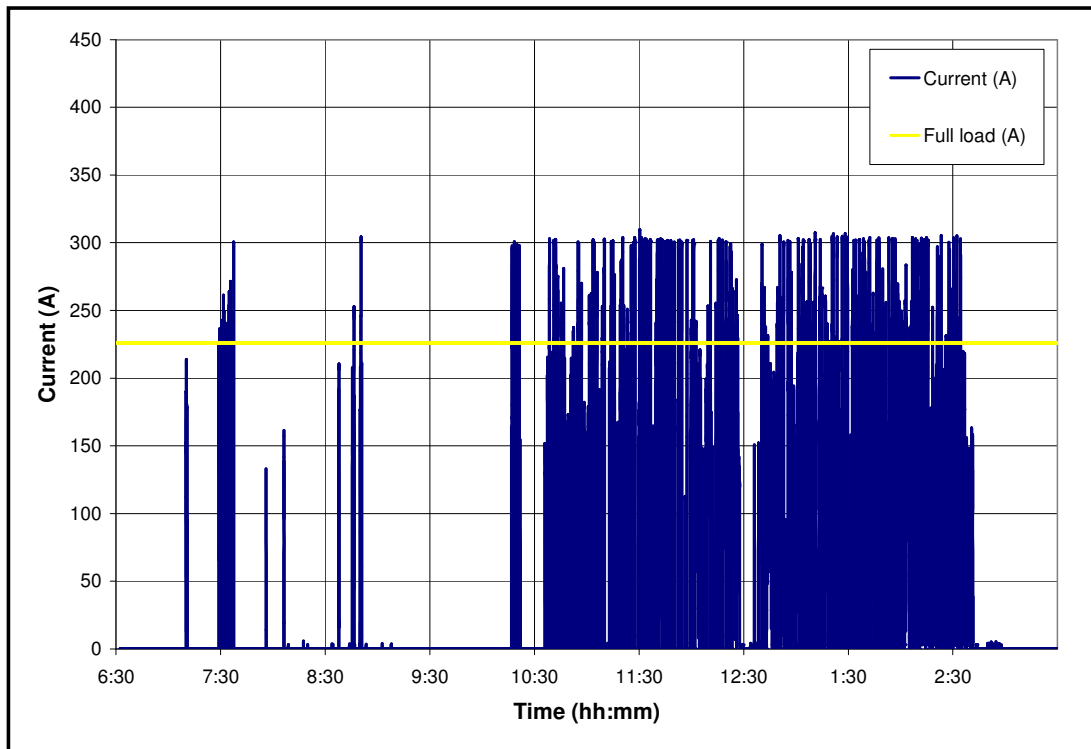
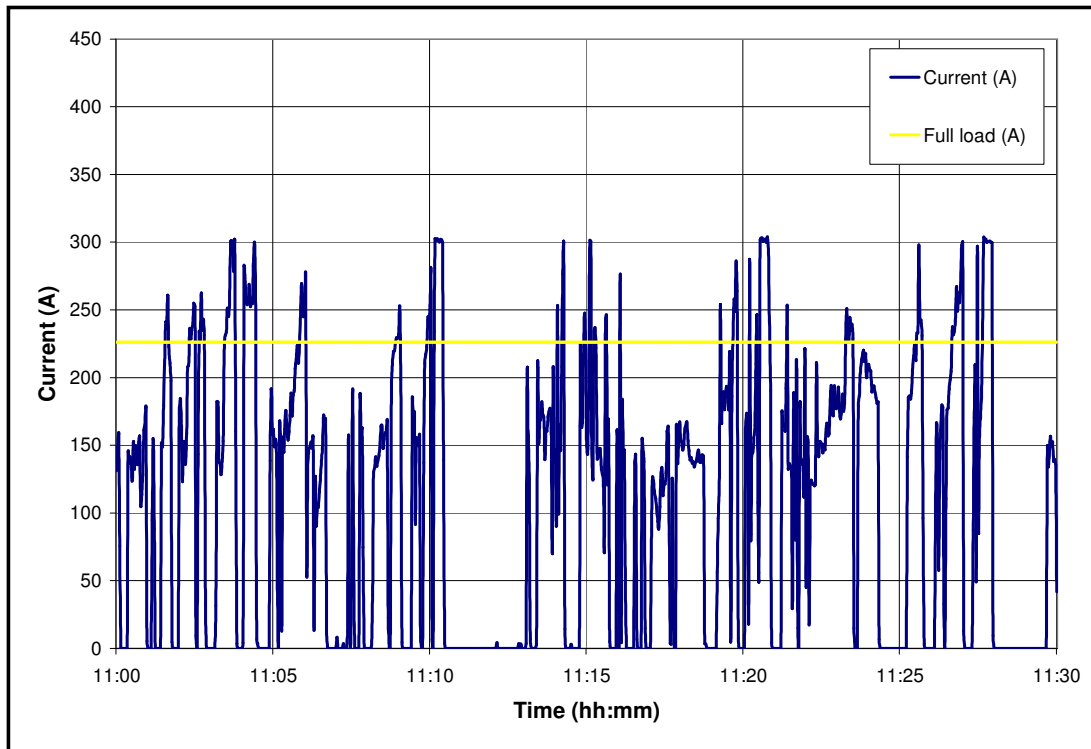


Figure M.1-51: Load current for a LH traction motor – 29 June 2005.



**Figure M.1-52: Load current for a LH traction motor
– 29 June 2005 (30 minute period).**

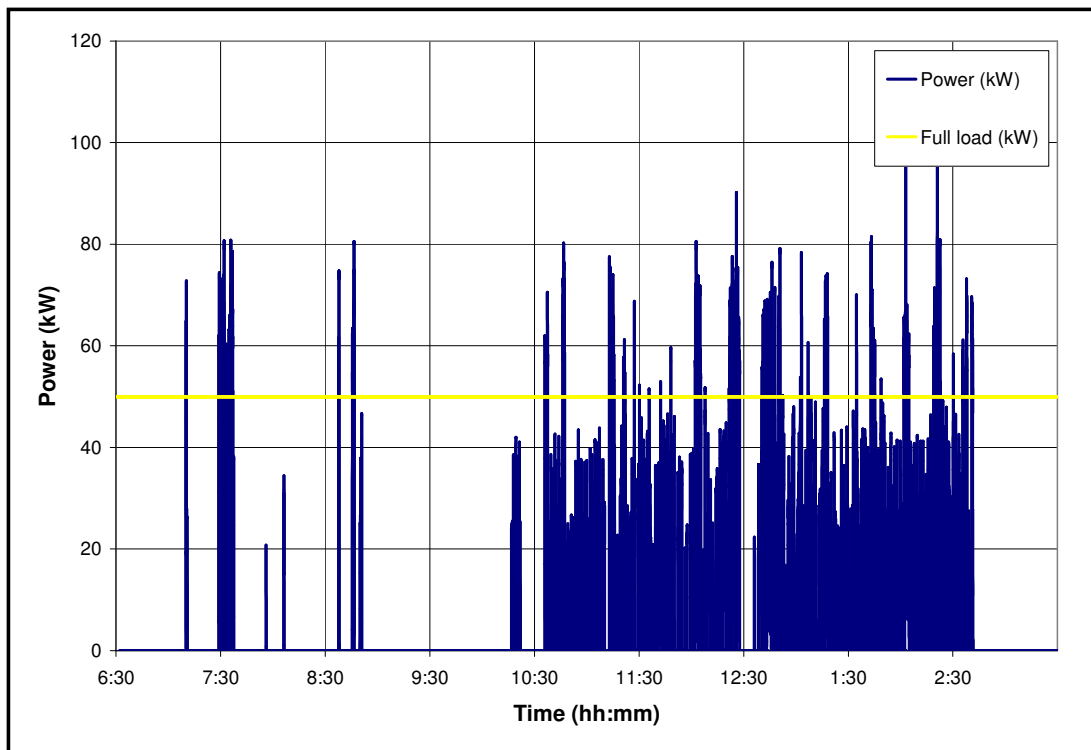
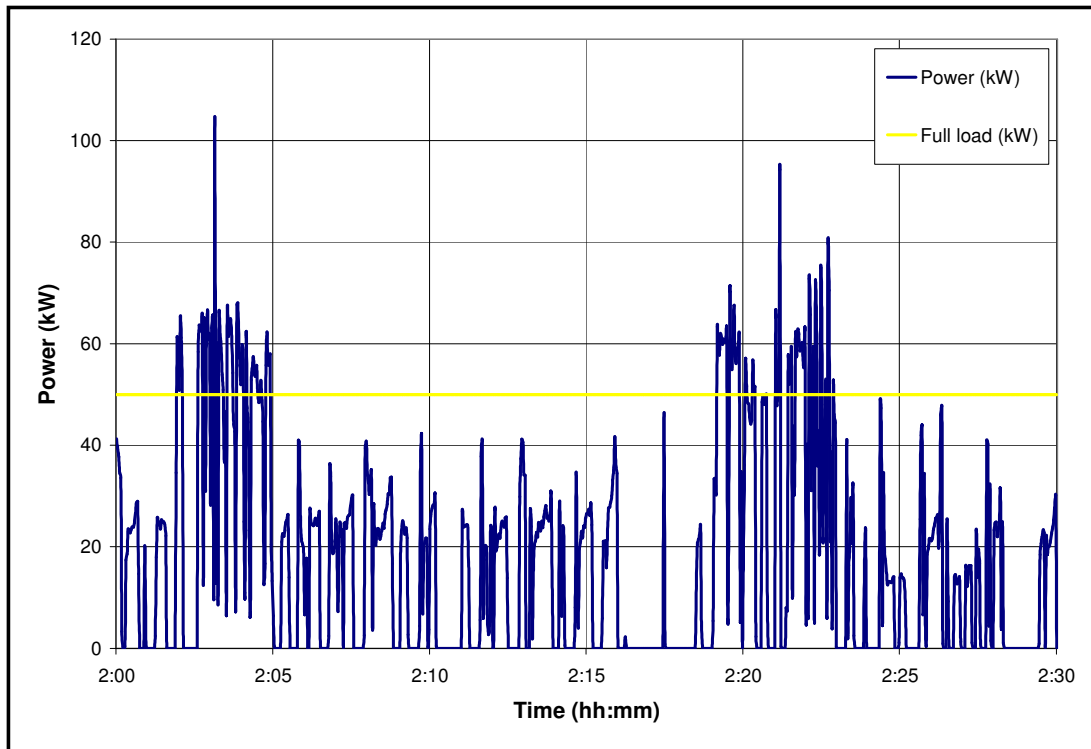


Figure M.1-53: Load power for a RH C traction motor – 29 June 2005.



**Figure M.1-54: Load power for a RH traction motor
– 29 June 2005 (30 minute period).**

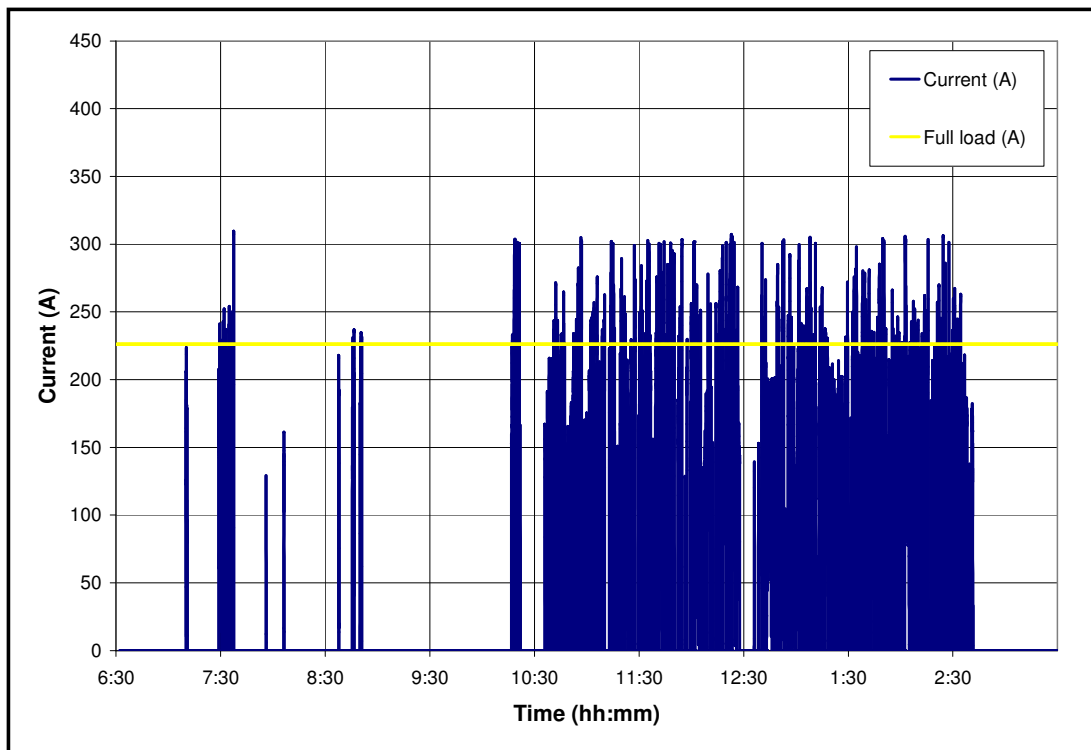
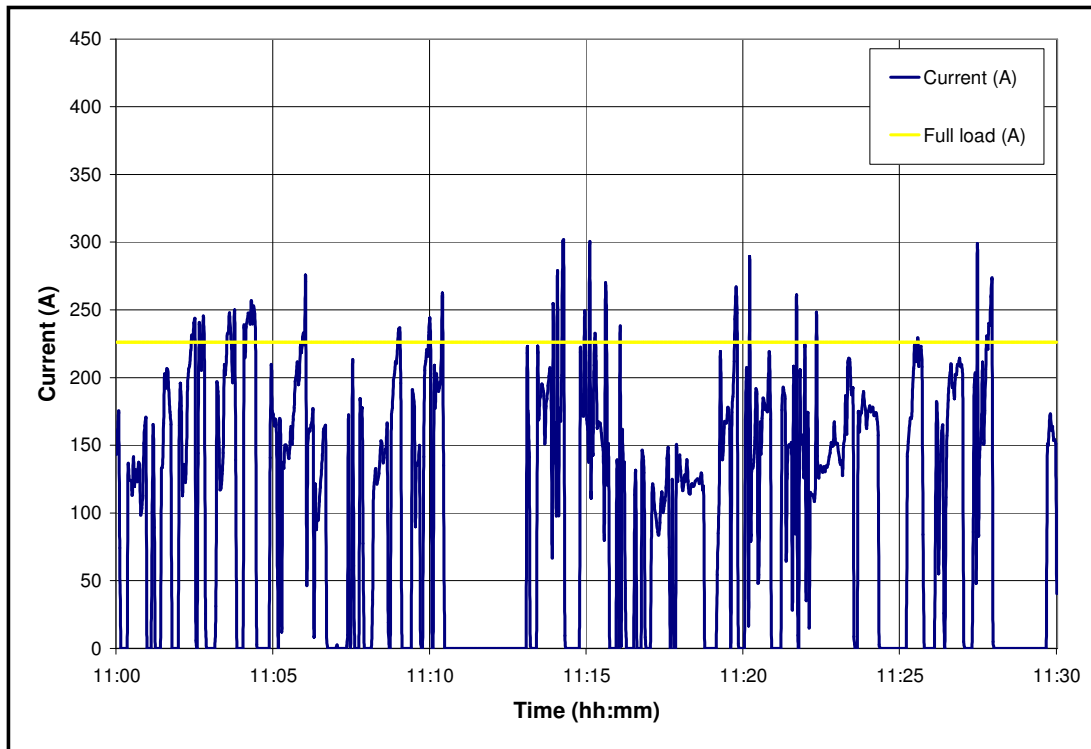


Figure M.1-55: Load current for a RH traction motor – 29 June 2005.



**Figure M.1-56: Load current for a RH traction motor
– 29 June 2005 (30 minute period).**

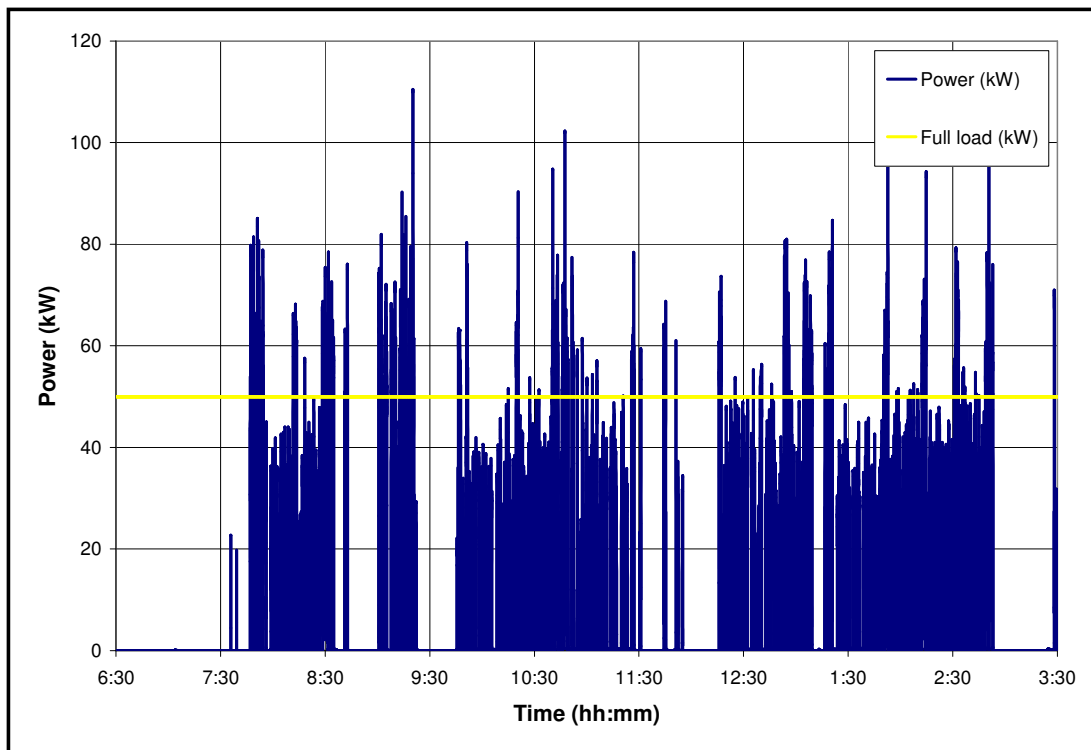
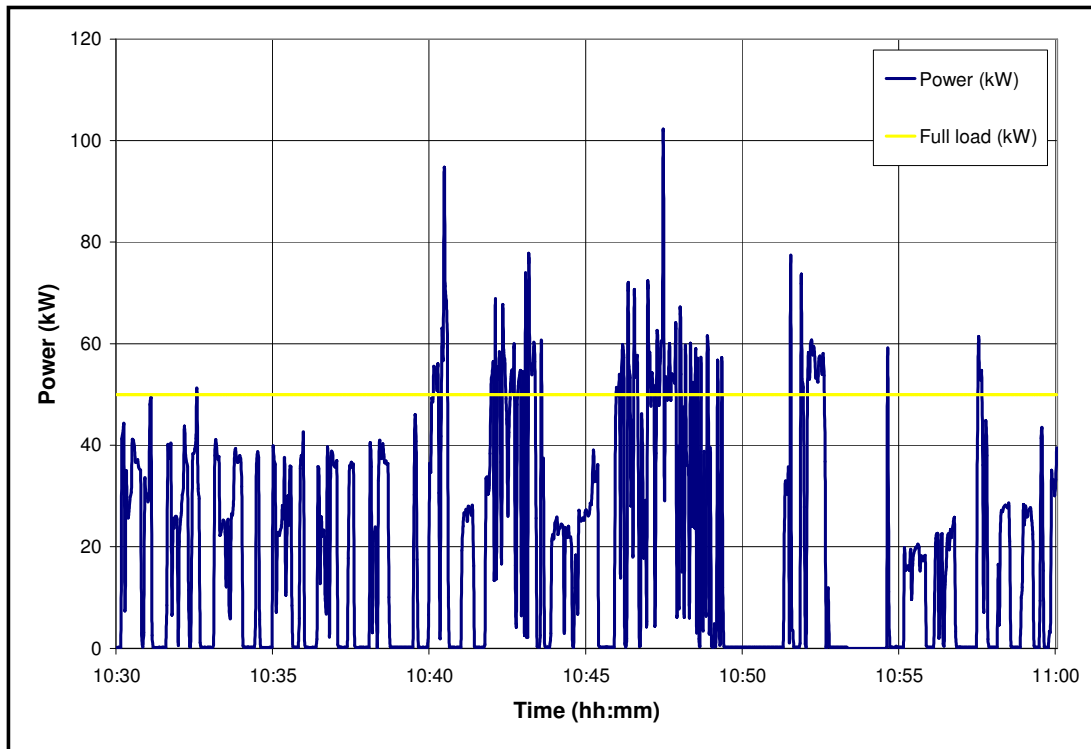


Figure M.1-57: Load power for a LH traction motor – 30 June 2005.



**Figure M.1-58: Load power for a LH traction motor
– 30 June 2005 (30 minute period).**

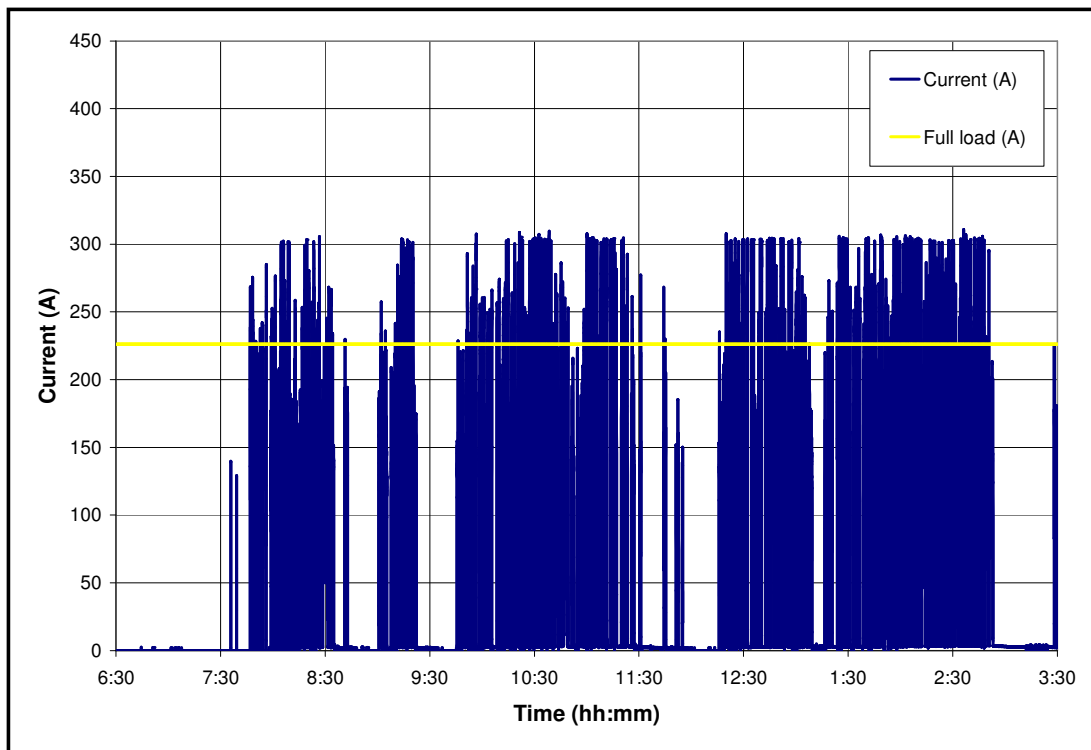
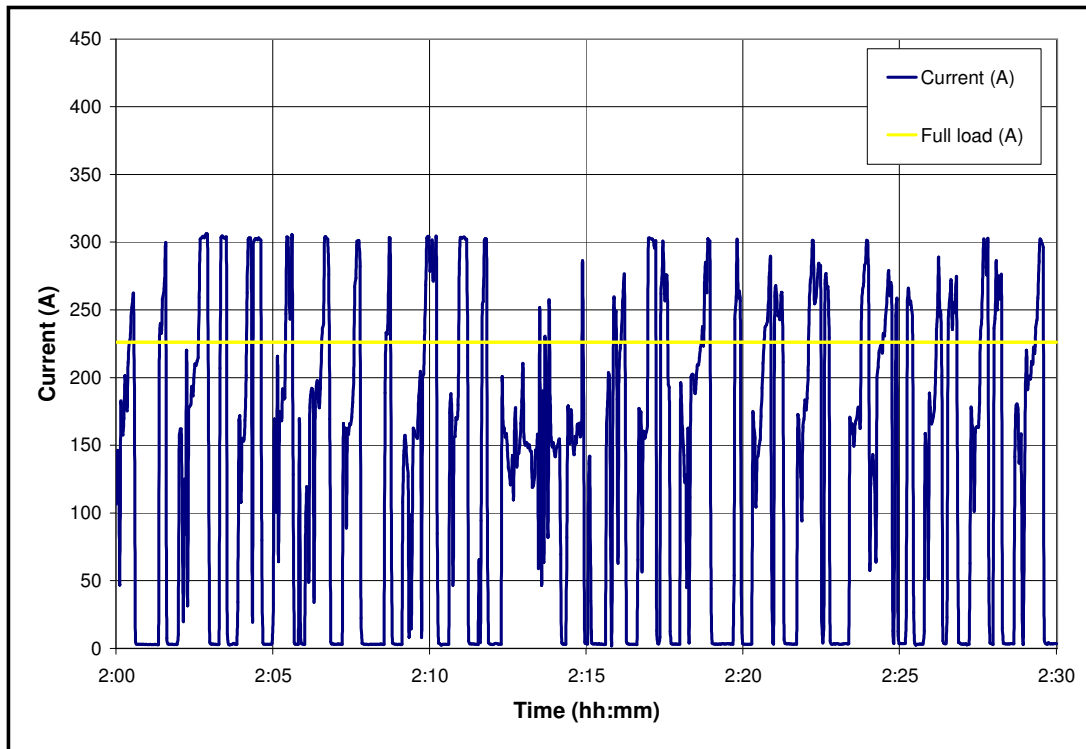


Figure M.1-59: Load current for a LH traction motor – 30 June 2005.



**Figure M.1-60: Load current for a LH traction motor
– 30 June 2005 (30 minute period).**

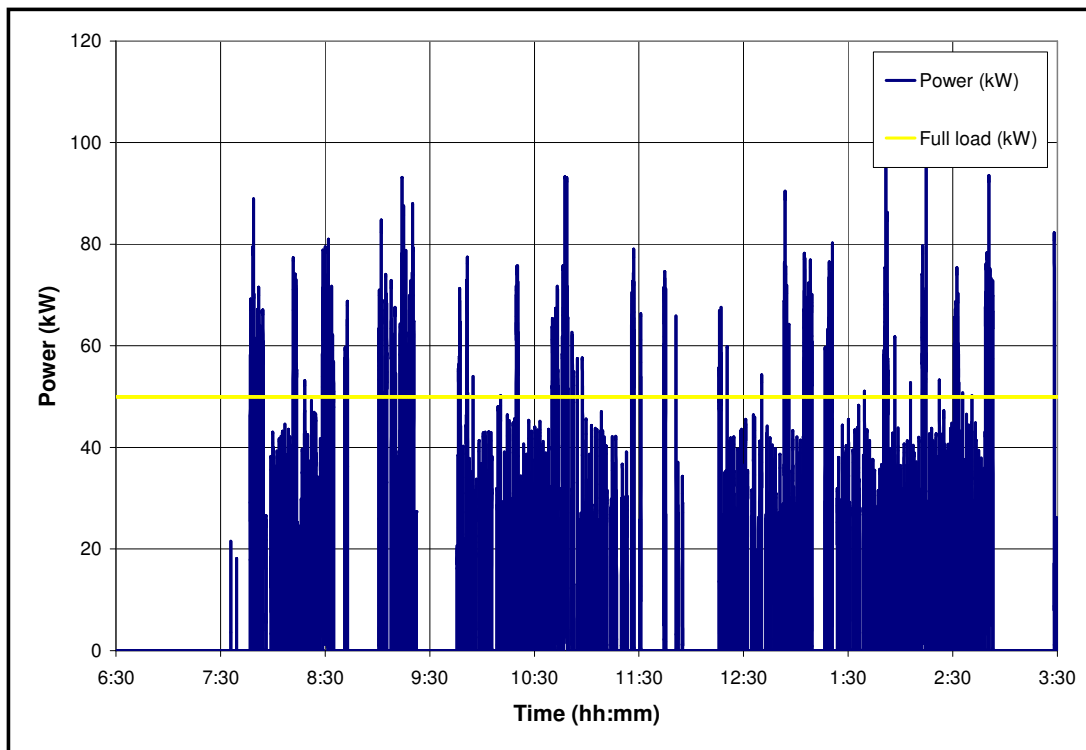
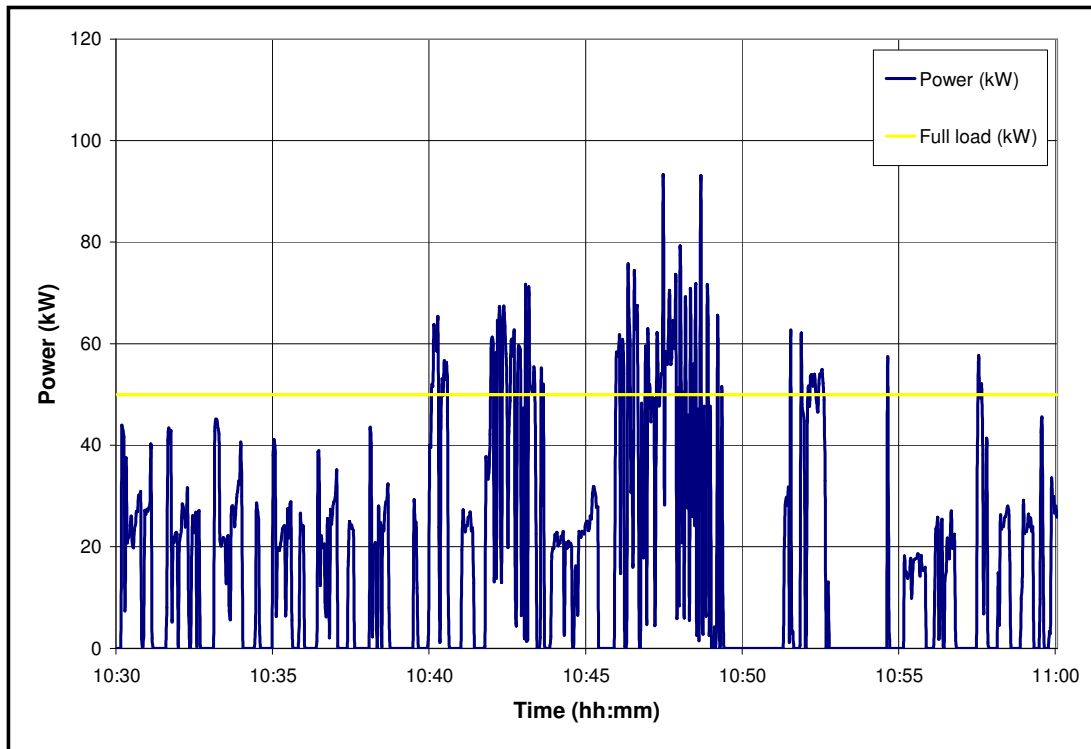


Figure M.1-61: Load power for a RH traction motor – 30 June 2005.



**Figure M.1-62: Load power for a RH traction motor
– 30 June 2005 (30 minute period).**

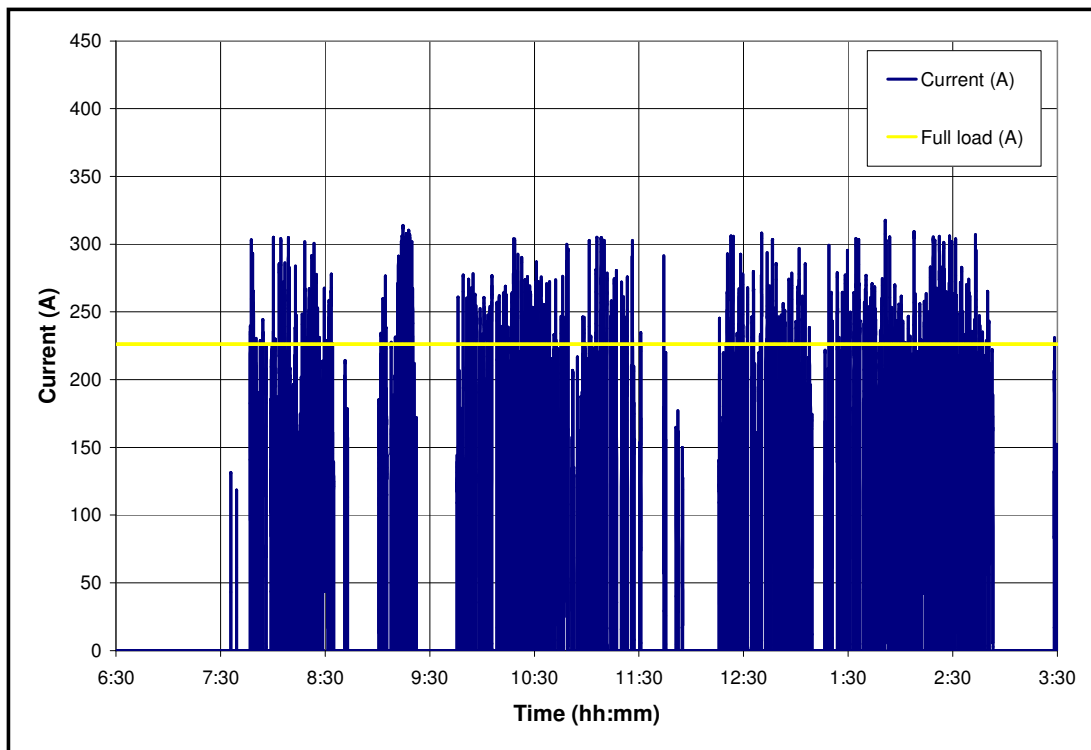
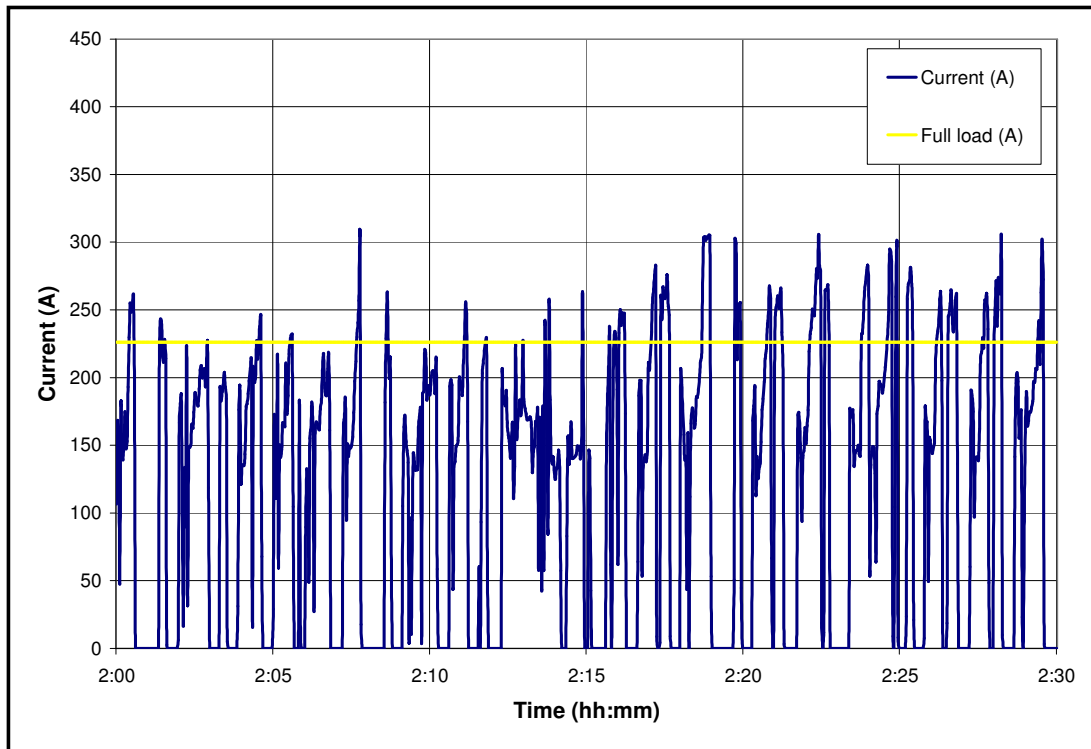


Figure M.1-63: Load current for a RH traction motor – 30 June 2005.



**Figure M.1-64: Load current for a RH traction motor
– 30 June 2005 (30 minute period).**

M.1.2.2 Afternoon shifts

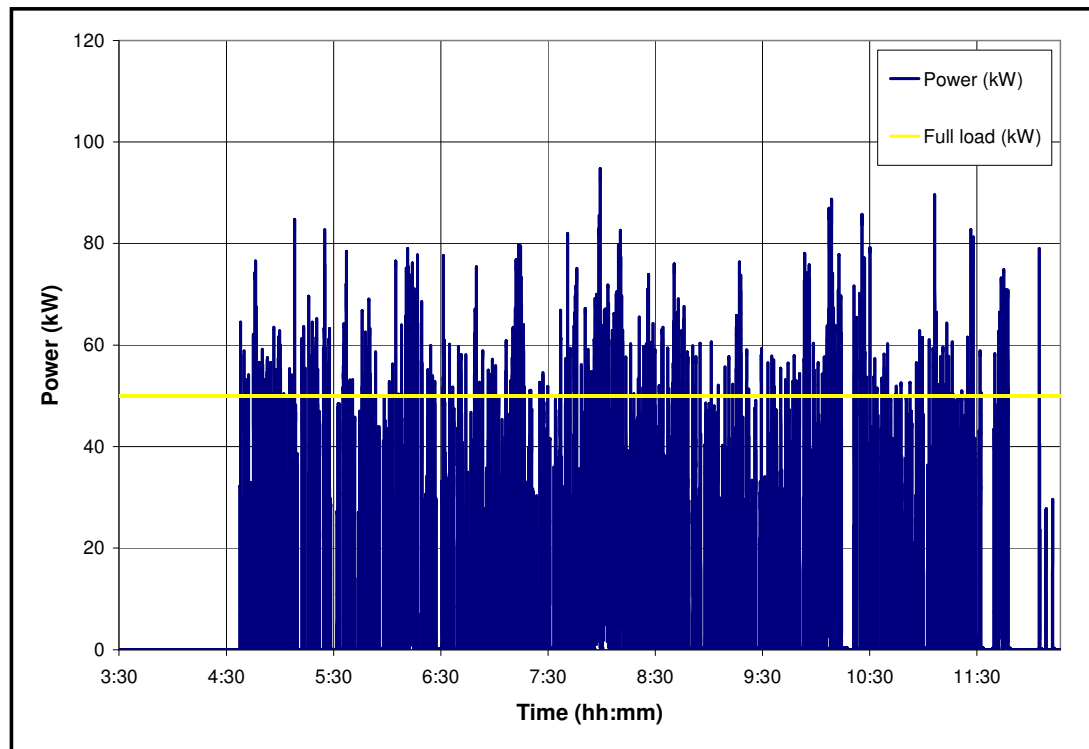
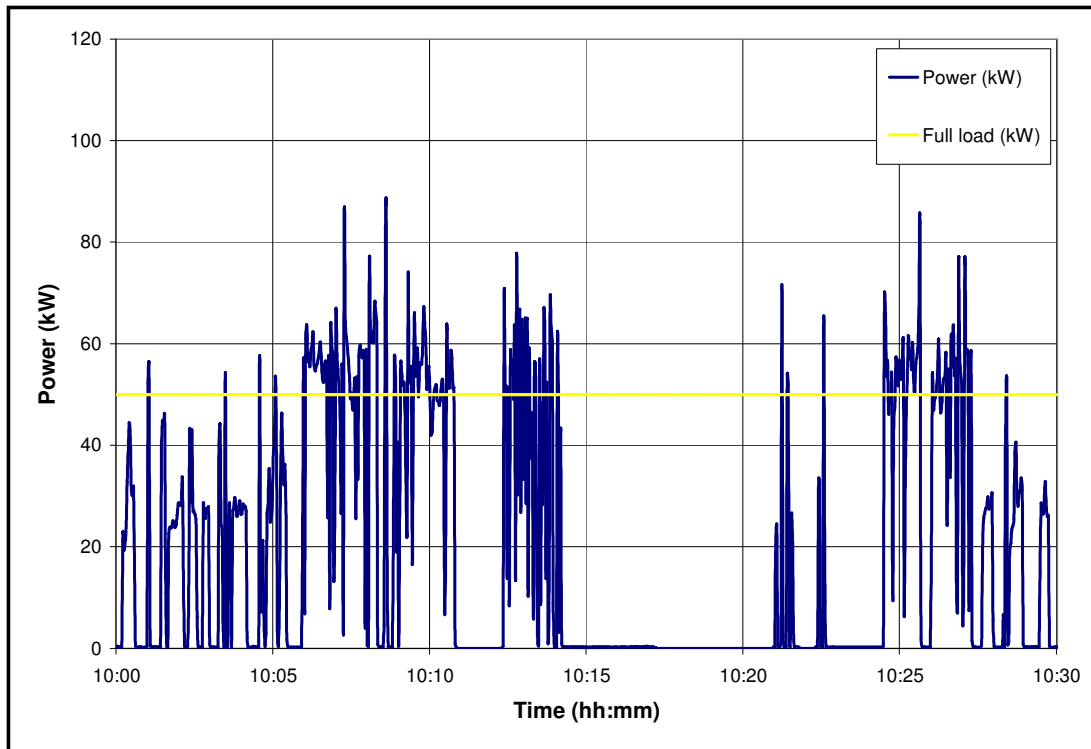


Figure M.1-65: Load power for a LH traction motor – 29 June 2005.



**Figure M.1-66: Load power for a LH traction motor
– 29 June 2905 (30 minute period).**

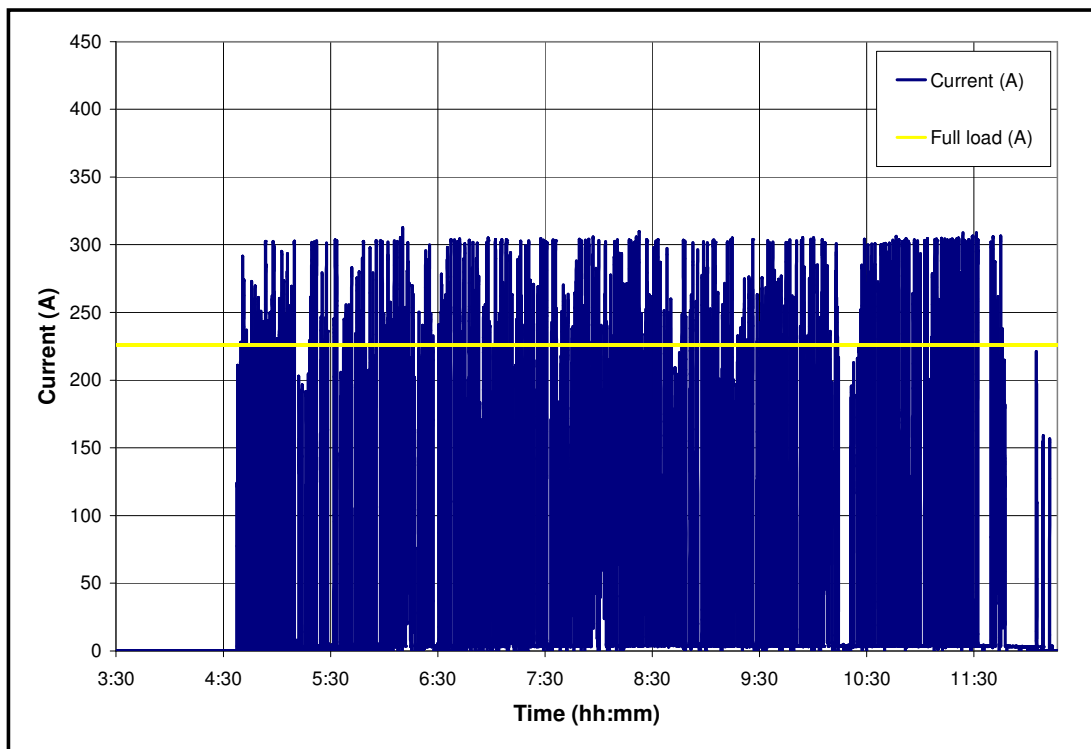
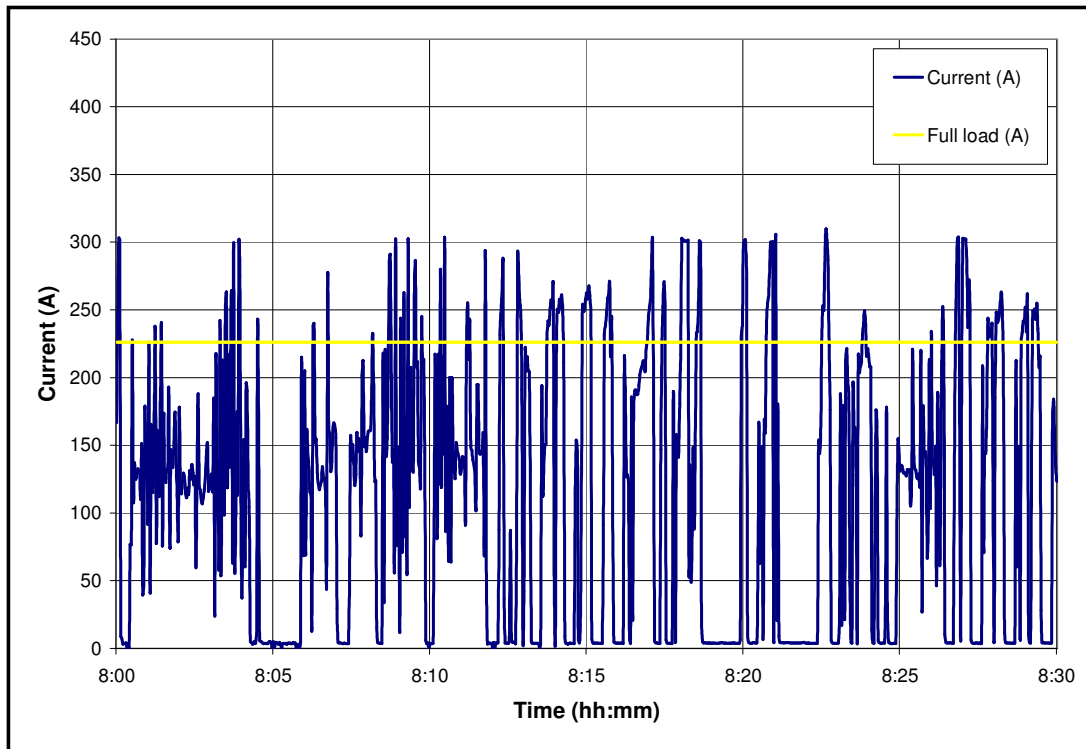


Figure M.1-67: Load current for a LH traction motor – 29 June 2905.



**Figure M.1-68: Load current for a LH traction motor
– 29 June 2005 (30 minute period).**

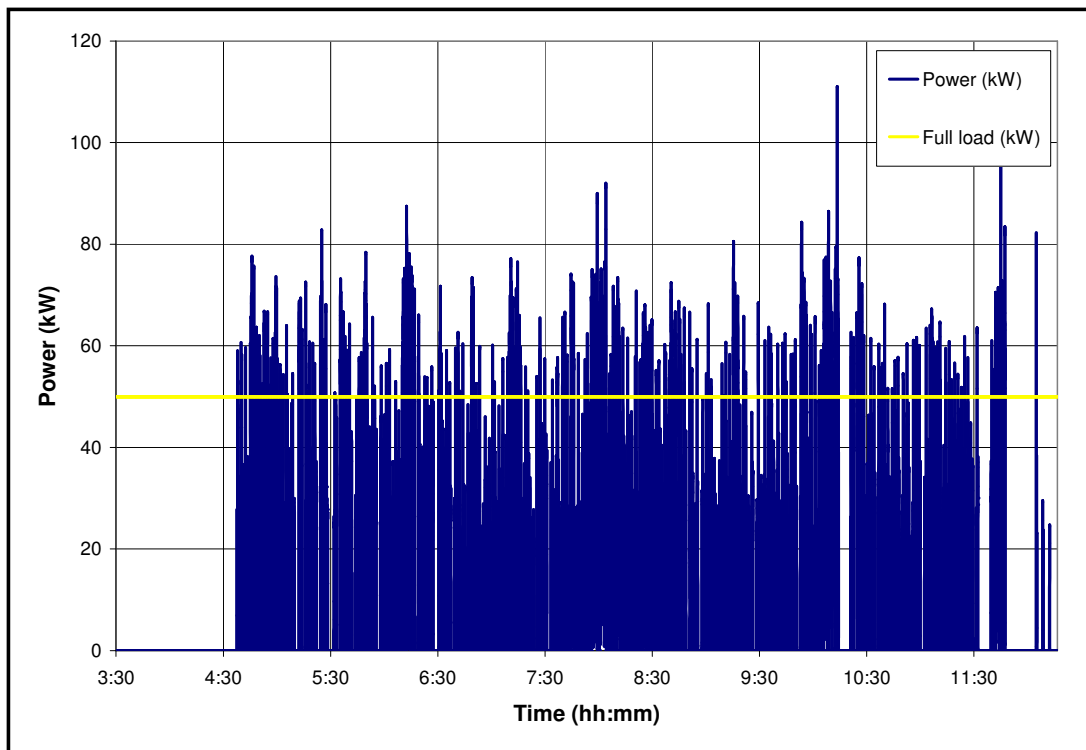
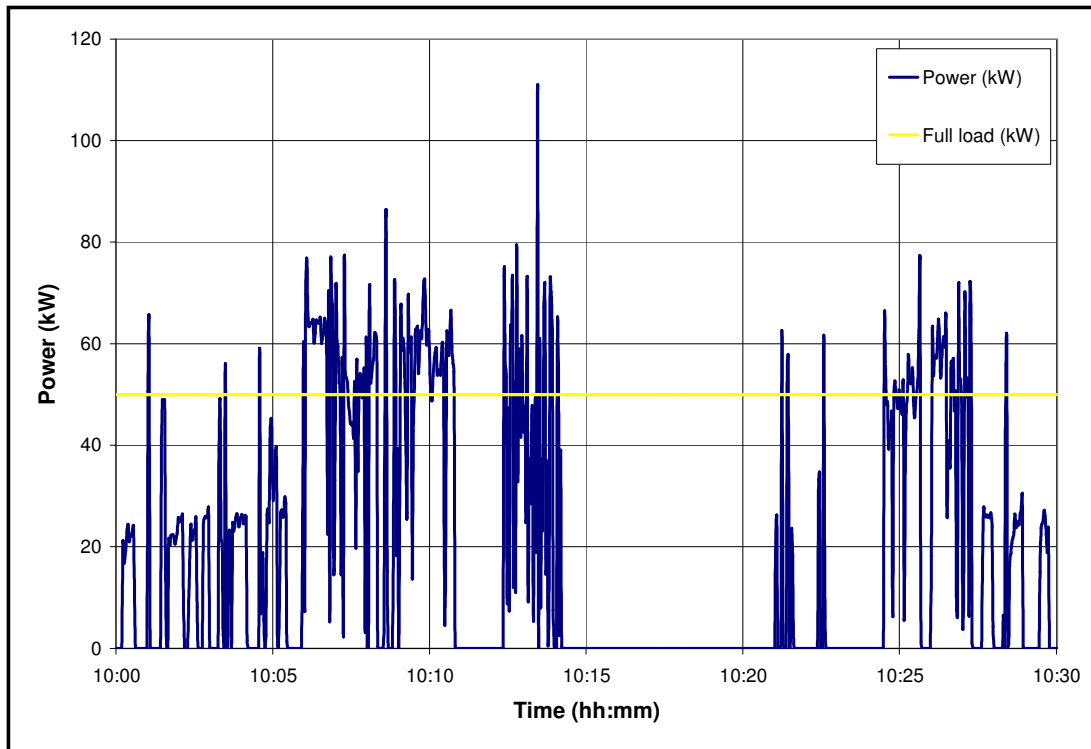


Figure M.1-69: Load power for a RH traction motor – 29 June 2005.



**Figure M.1-70: Load power for a RH traction motor
– 29 June 2005 (30 minute period).**

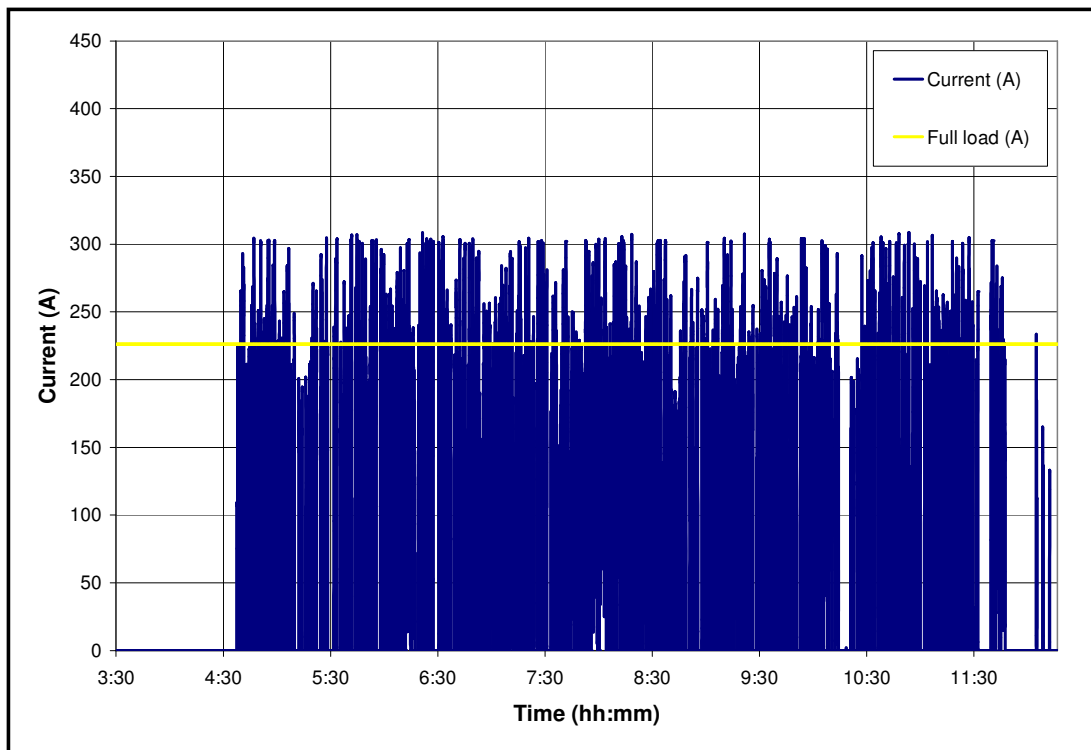
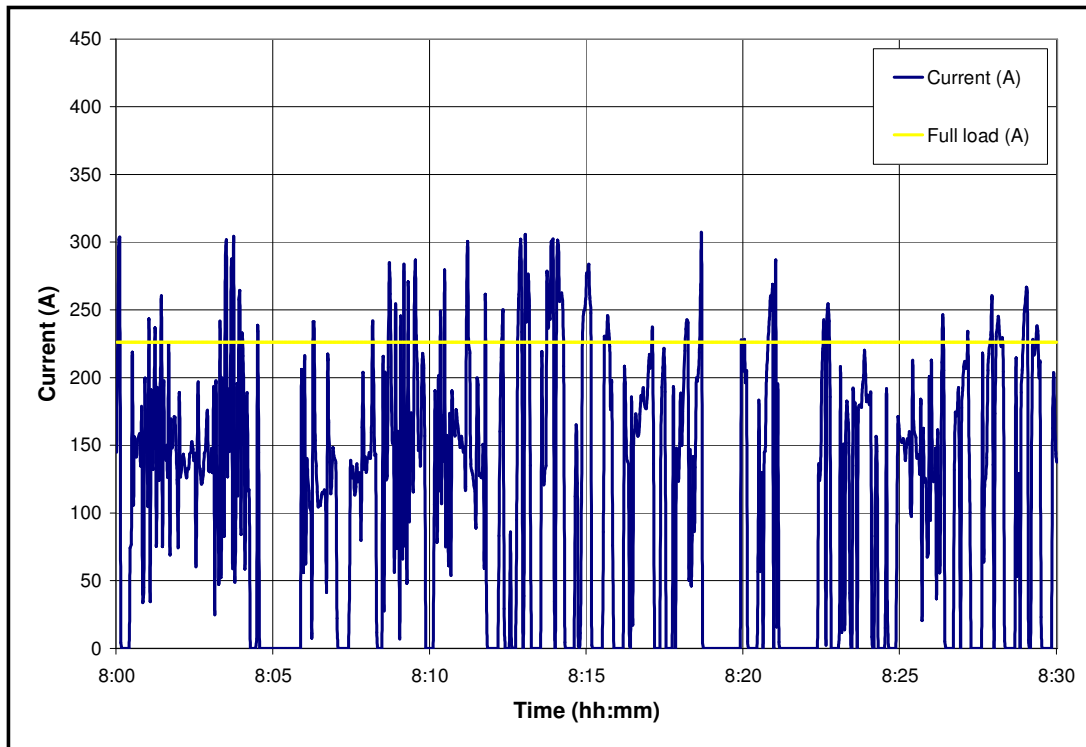


Figure M.1-71: Load current for a RH traction motor – 29 June 2005.



**Figure M.1-72: Load current for a RH traction motor
– 29 June 2005 (30 minute period).**

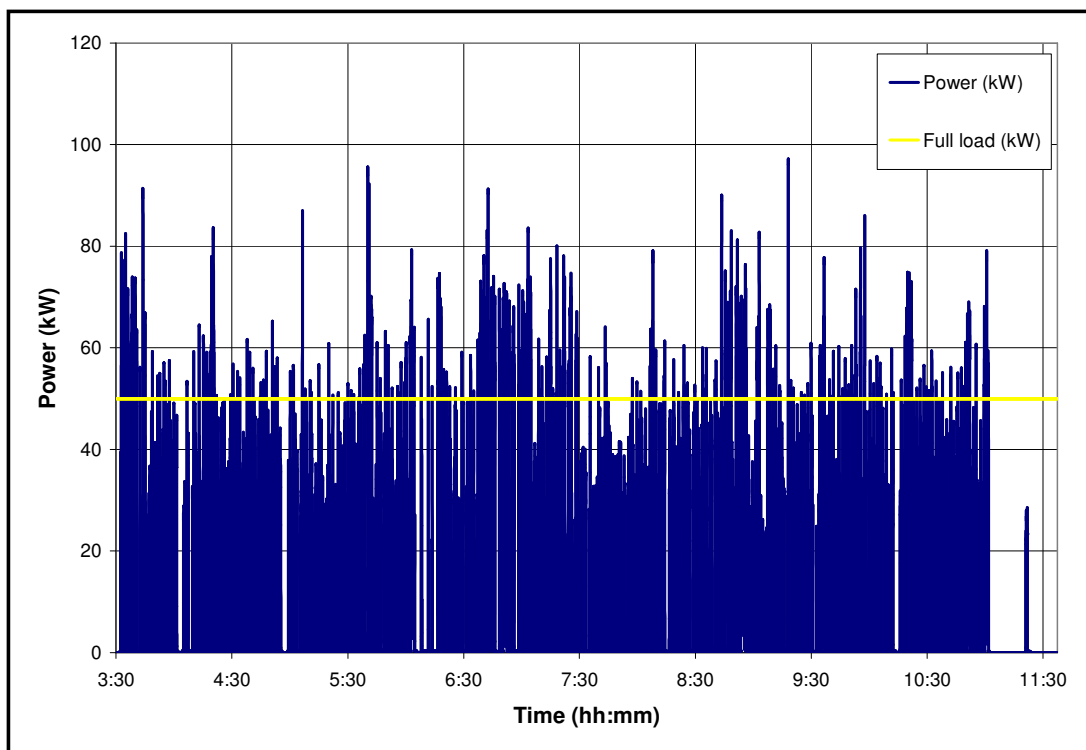
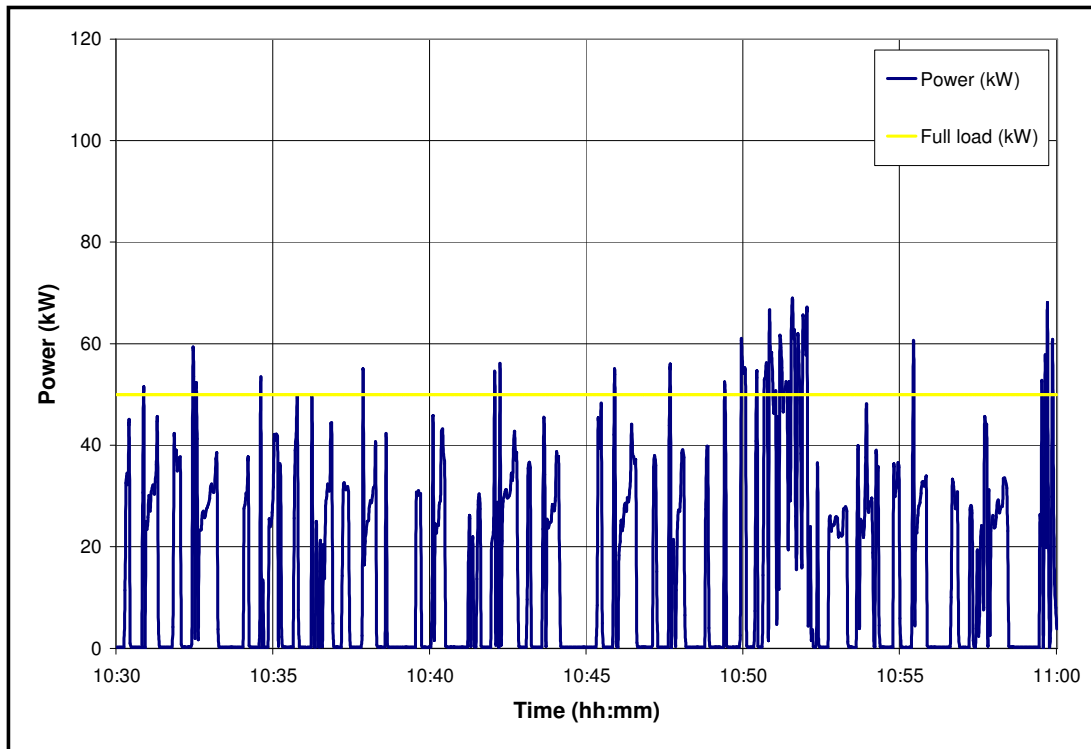


Figure M.1-73: Load power for a LH traction motor – 30 June 2005.



**Figure M.1-74: Load power for a LH traction motor
– 30 June 2005 (30 minute period).**

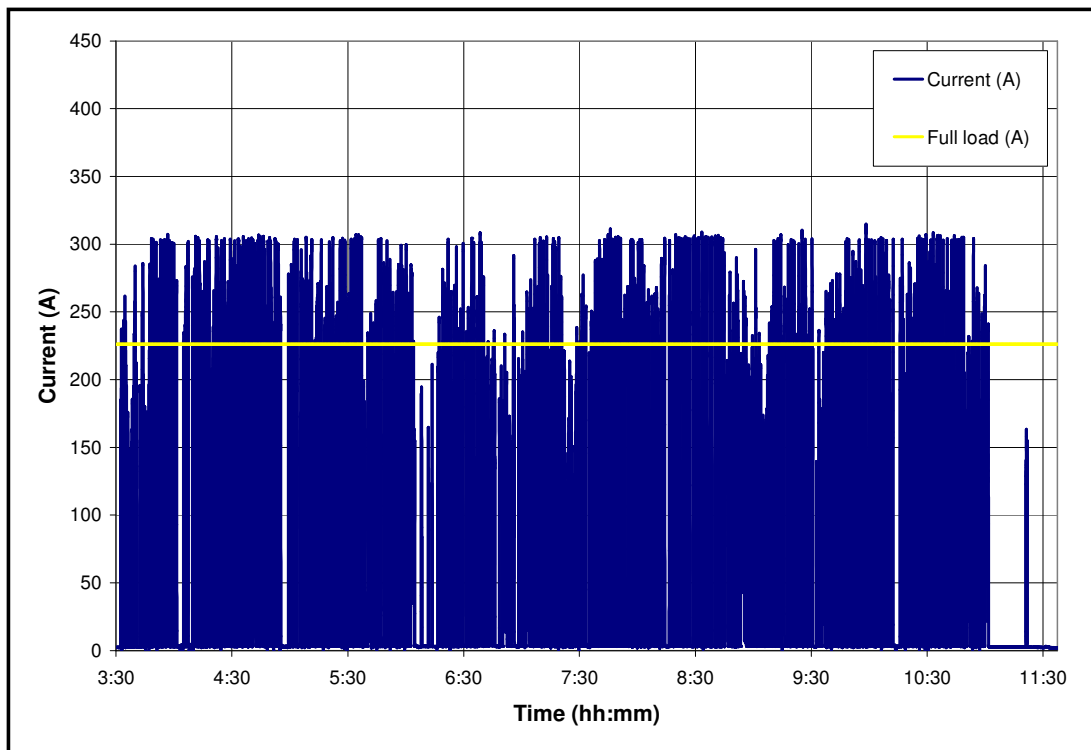
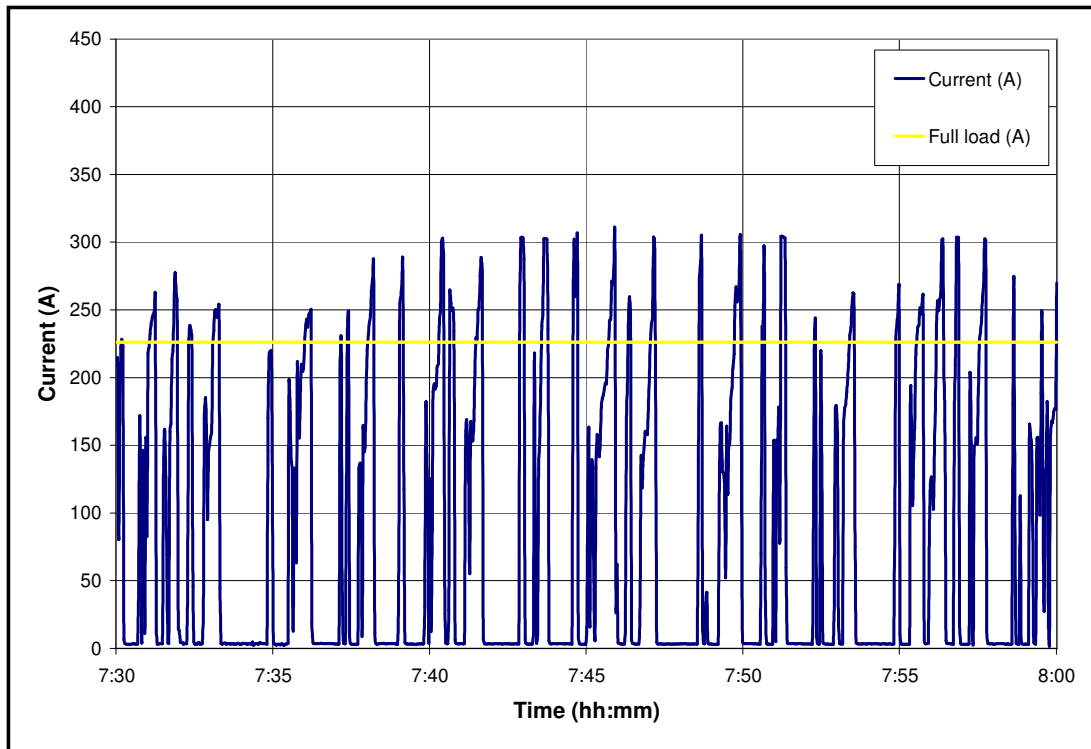


Figure M.1-75: Load current for a LH traction motor – 30 June 2005.



**Figure M.1-76: Load current for a LH traction motor
– 30 June 2005 (30 minute period).**

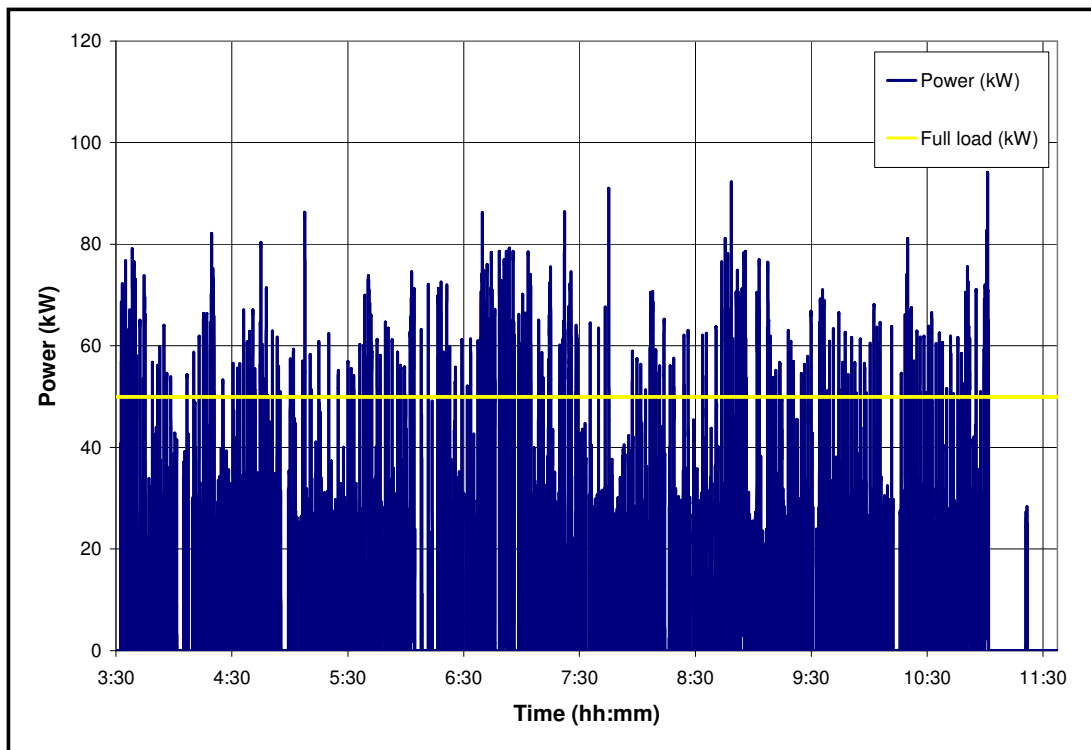
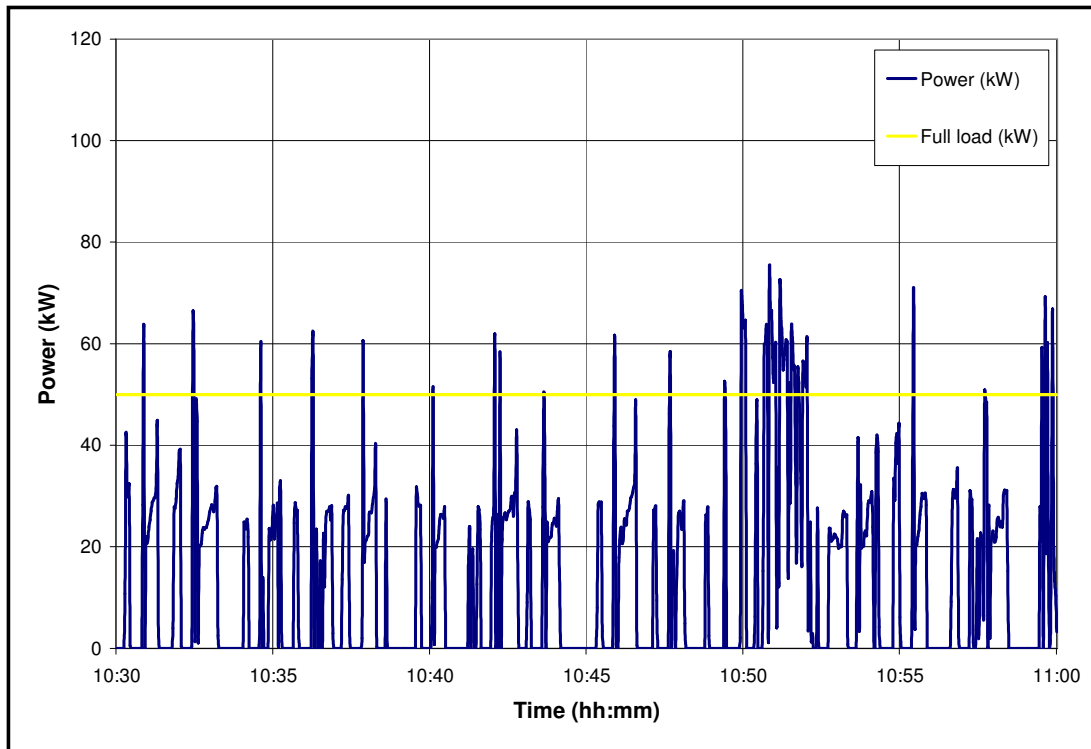


Figure M.1-77: Load power for a RH traction motor – 30 June 2005.



**Figure M.1-78: Load power for a RH traction motor
– 30 June 2005 (30 minute period).**

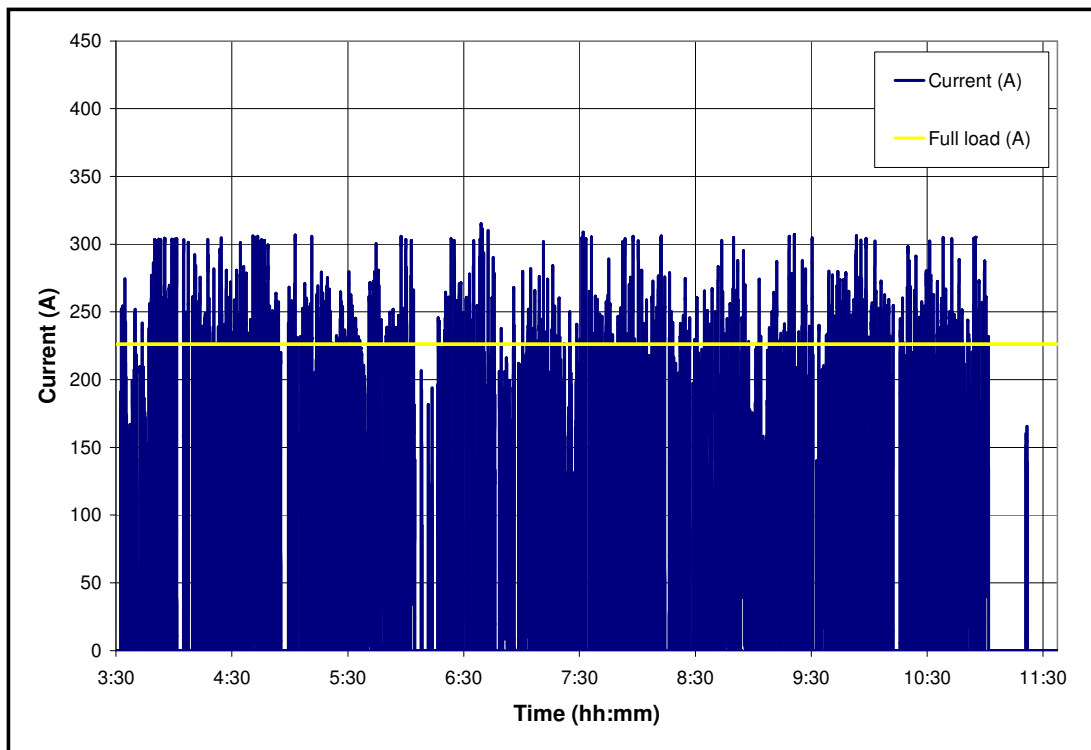
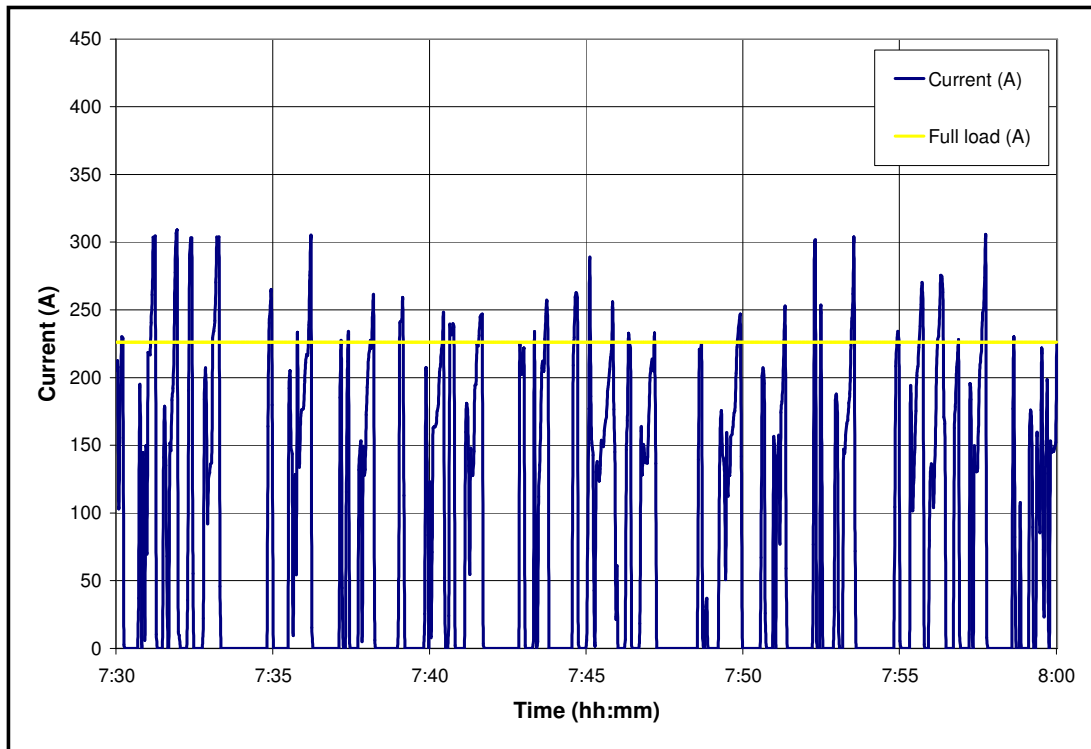


Figure M.1-79: Load current for a RH traction motor – 30 June 2005.



**Figure M.1-80: Load current for a RH traction motor
– 30 June 2005 (30 minute period).**

M.2 HISTOGRAM

The next section focuses on the frequency with which a CMs traction motors consumed a certain load power and current. The graphs show the number of times a certain power or current has been consumed. The tables give data about the tonnes produced during the shift and the percentage time of the shift that the motors were producing. The time that the motors have been over loaded or loaded within the full load rating of the motor is given as a percentage of the actual producing time. The morning shifts and afternoon shifts are separated as well as the measurements made at the different sections.

M.2.1 SECTION 21

M.2.1.1 Morning shifts

Table M-3: Data for the total consumption of a LH traction motor in section 21.

	10-Jun-05	13-Jun-05	14-Jun-05
Tonnes/CM/Shift	1575	2310	1610
% Time of shift producing	34.81%	37.92%	32.42%
% of Production time underloaded	60.00%	61.43%	64.45%
% of Production time overloaded	40.00%	38.57%	35.55%

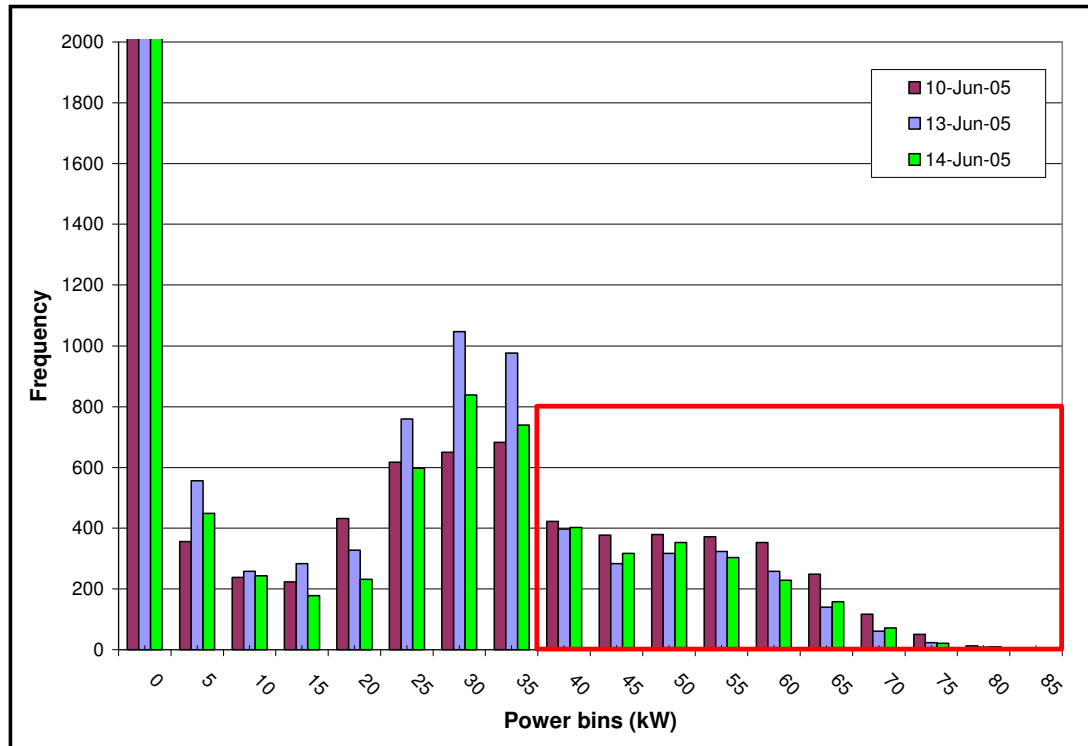


Figure M.2-1: Histogram for power consumed by a LH traction motor.

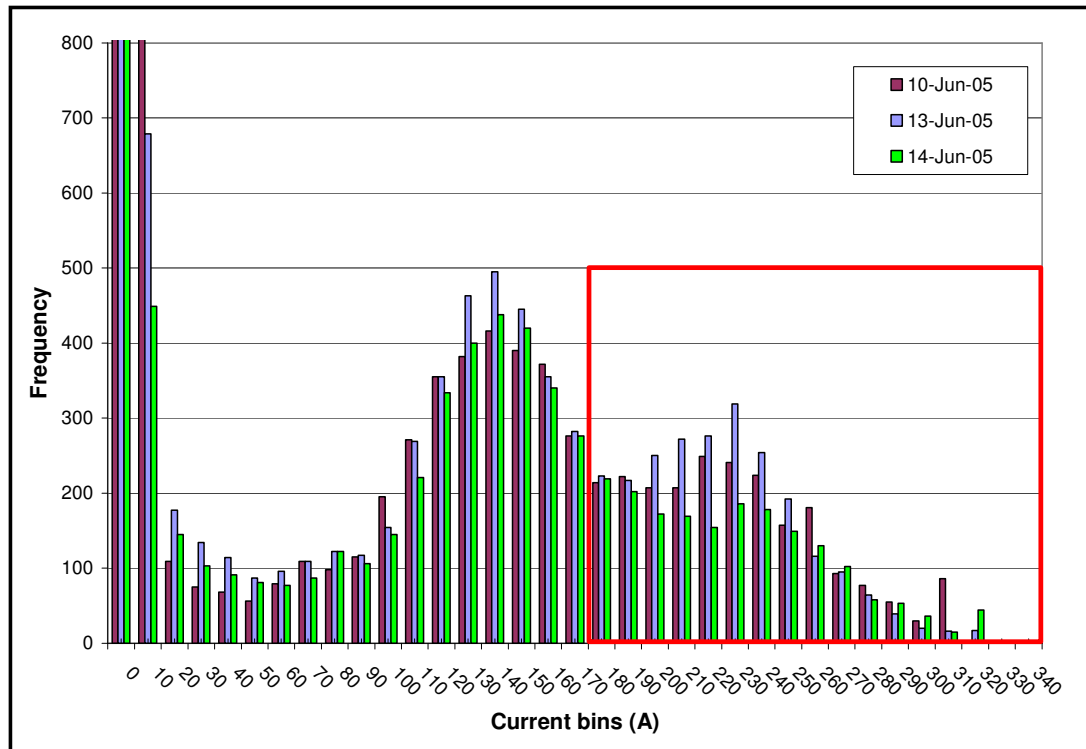


Figure M.2-2: Histogram for current consumed by a LH C traction motor.

Table M-4: Data for the total consumption of a RH traction motor in section 21.

	10-Jun-05	13-Jun-05	14-Jun-05
Tonnes/CM/Shift	1575	2310	1610
% Time of shift producing	34.63%	37.49%	31.98%
% of Production time underloaded	60.46%	63.42%	66.94%
% of Production time overloaded	39.54%	36.58%	33.06%

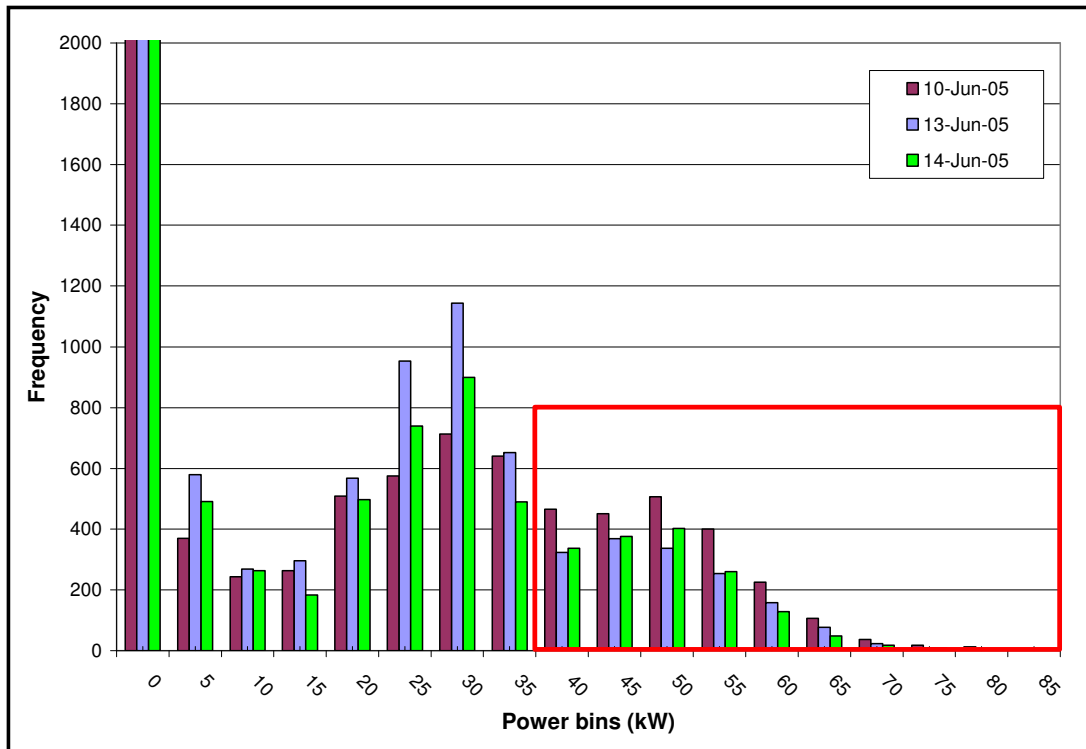


Figure M.2-3: Histogram for power consumed by a RH traction motor.

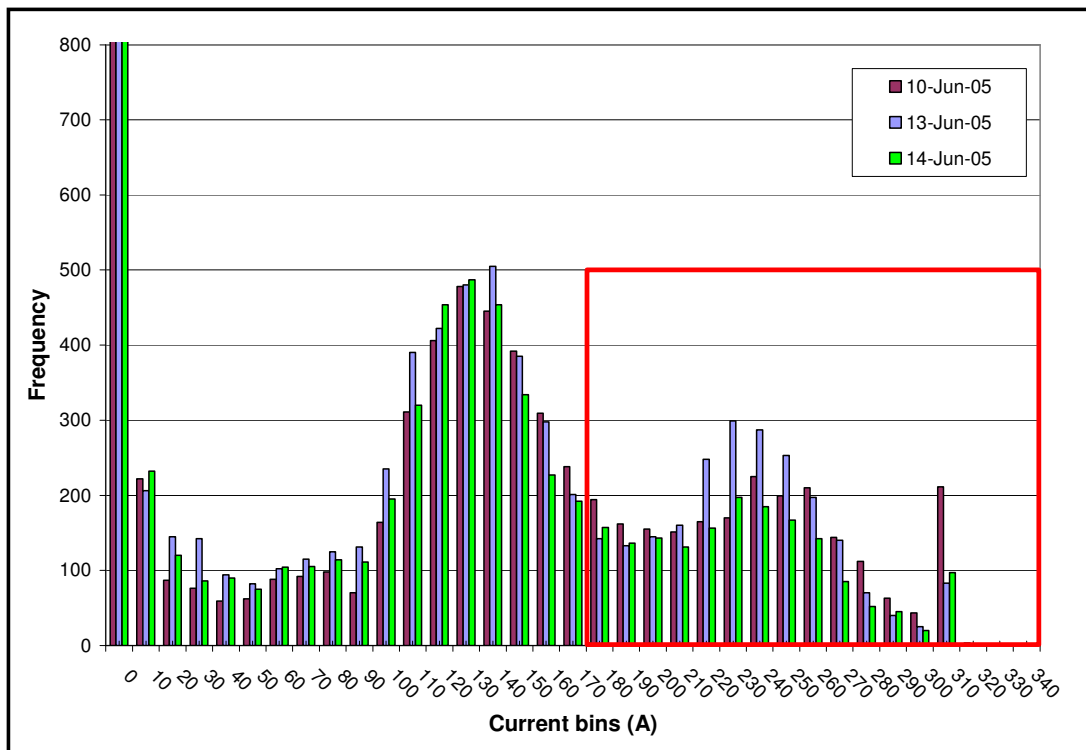


Figure M.2-4: Histogram for current consumed by a RH traction motor.

M.2.1.2 Afternoon shifts

Table M-5: Data for the total consumption of a LH traction motor in section 21.

	10-Jun-05	13-Jun-05	14-Jun-05
Tonnes/CM/Shift	2695	2520	1750
% Time of shift producing	37.91%	49.04%	33.70%
% of Production time underloaded	63.28%	55.50%	53.33%
% of Production time overloaded	36.72%	44.50%	46.67%

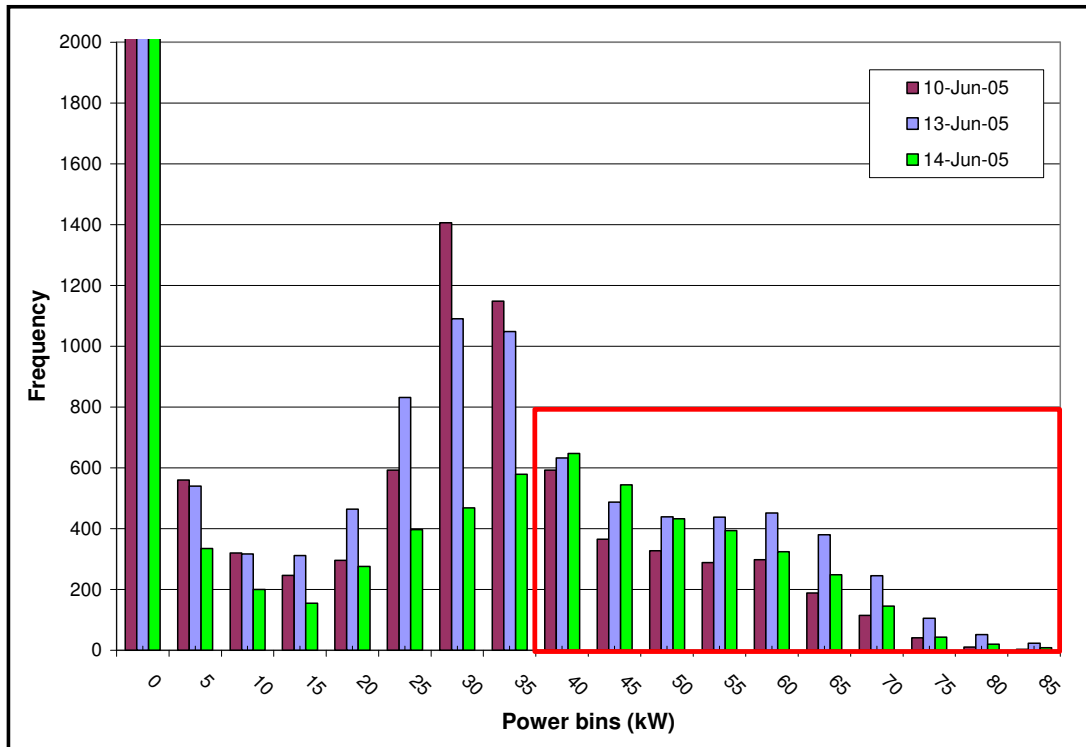


Figure M.2-5: Histogram for power consumed by a LH traction motor.

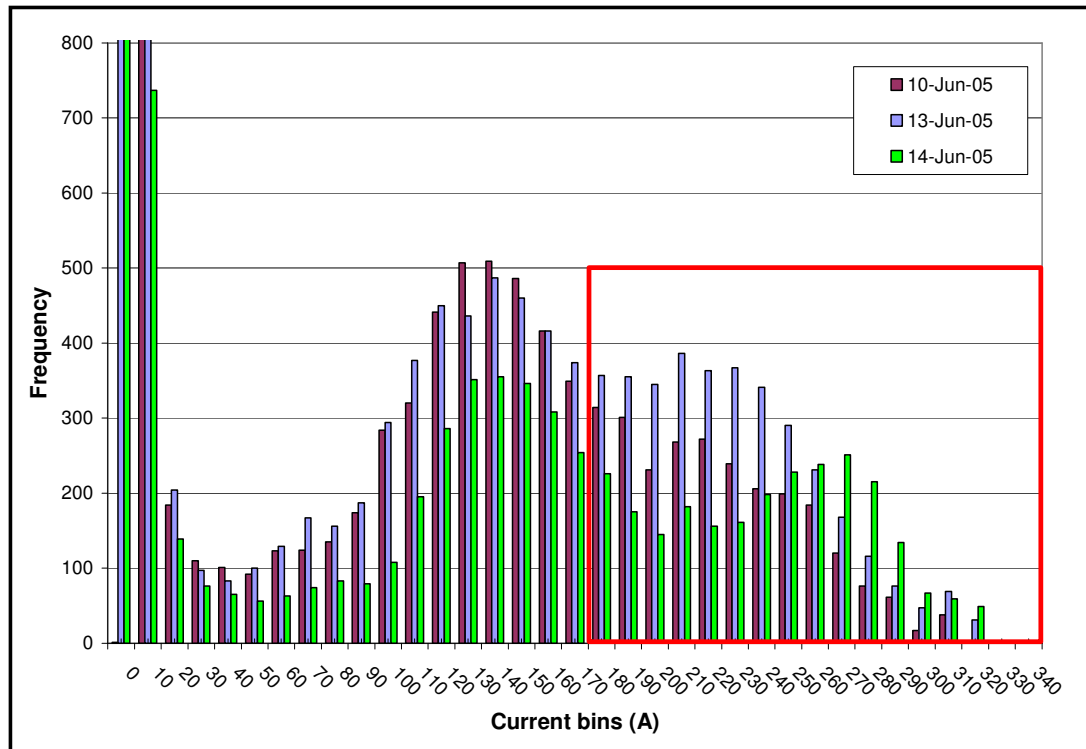


Figure M.2-6: Histogram for current consumed by a LH traction motor.

Table M-6: Data for the total consumption of a RH traction motor in section 21.

	10-Jun-05	13-Jun-05	14-Jun-05
Tonnes/CM/Shift	2695	2520	1750
% Time of shift producing	37.56%	48.55%	33.31%
% of Production time underloaded	64.63%	55.41%	54.14%
% of Production time overloaded	35.37%	44.59%	45.86%

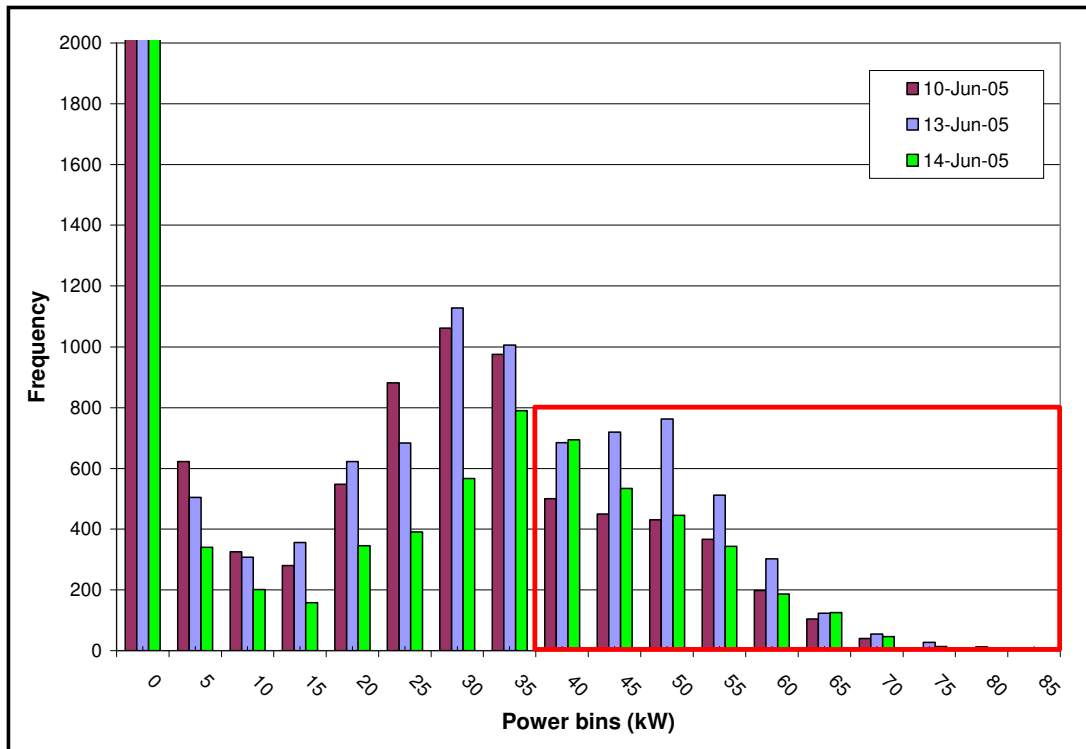


Figure M.2-7: Histogram for power consumed by a RH traction motor.

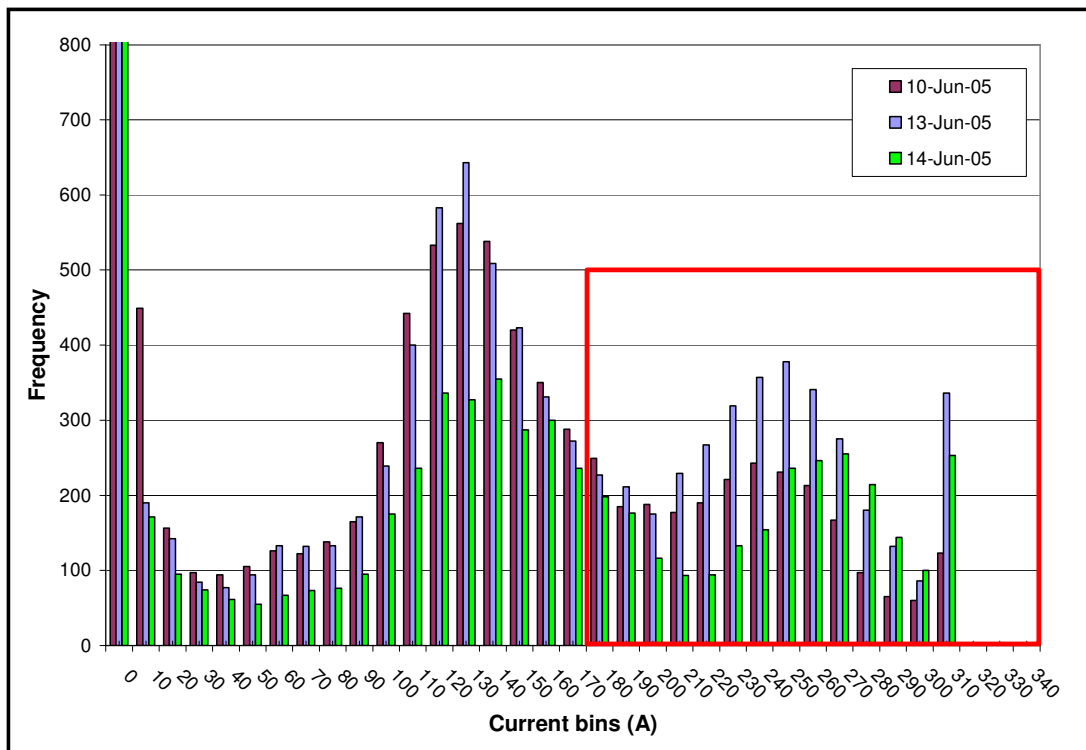


Figure M.2-8: Histogram for current consumed by a RH traction motor.

M.2.2SECTION 51

M.2.2.1 Morning shifts

Table M-7: Data for the total consumption of a LH traction motor in section 51.

	29-Jun-05	30-Jun-05
Tonnes/CM/Shift	1305	1740
% Time of shift producing	26.48%	36.01%
% of Production time underloaded	76.87%	74.22%
% of Production time overloaded	23.13%	25.78%

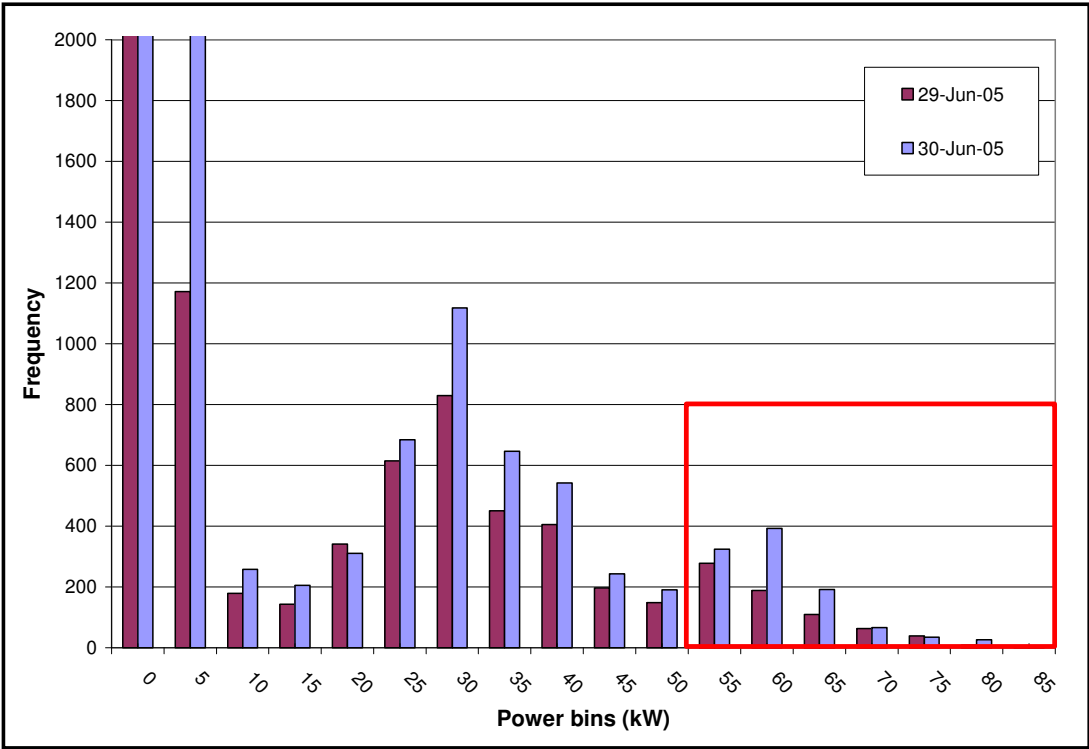


Figure M.2-9: Histogram for power consumed by a LH traction motor.

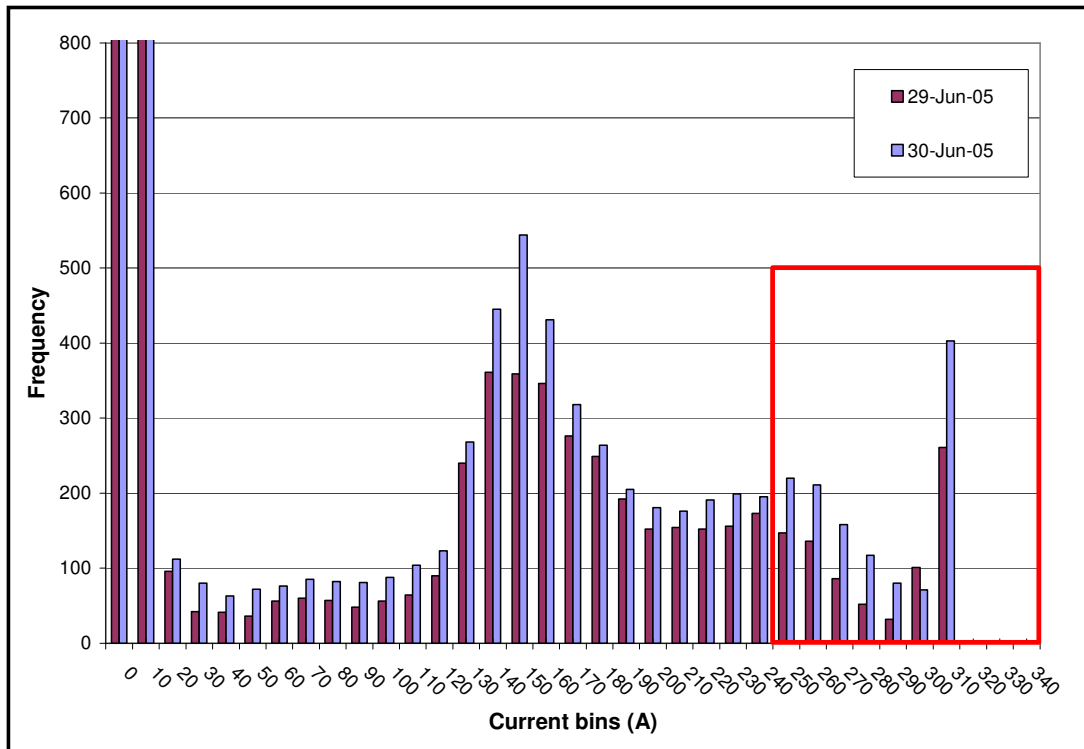


Figure M.2-10: Histogram for current consumed by a LH traction motor.

Table M-8: Data for the total consumption of a RH traction motor in section 51.

	29-Jun-05	30-Jun-05
Tonnes/CM/Shift	1305	1740
% Time of shift producing	26.17%	35.61%
% of Production time underloaded	88.11%	82.94%
% of Production time overloaded	11.89%	17.06%

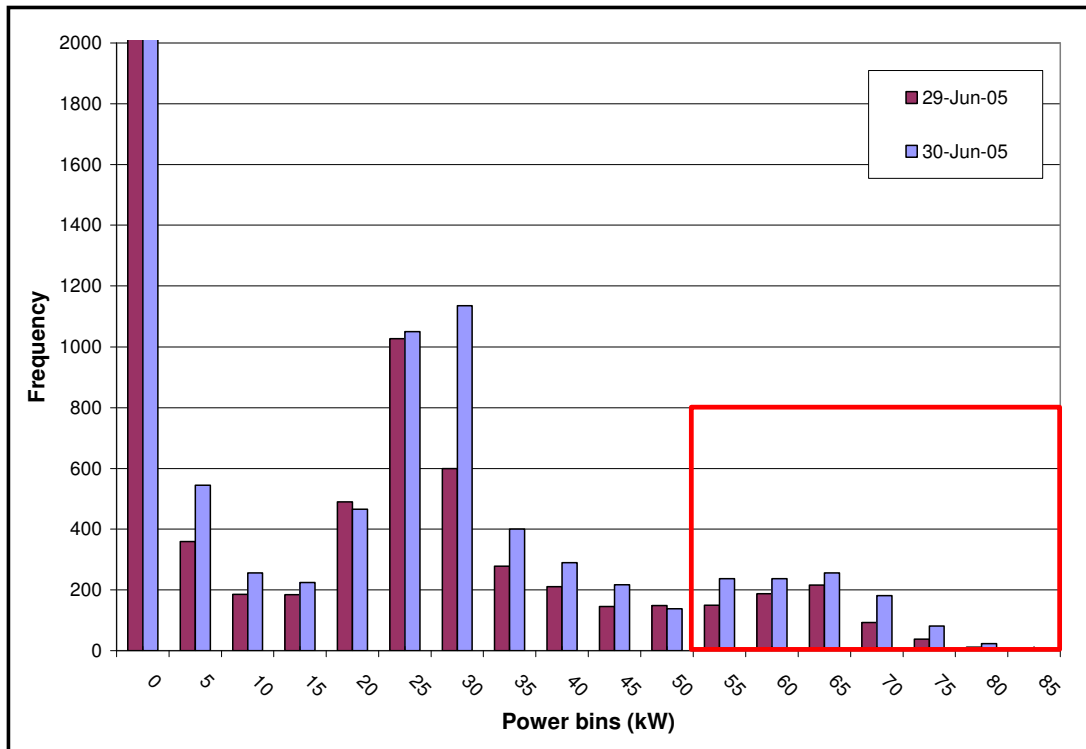


Figure M.2-11: Histogram for power consumed by a RH traction motor.

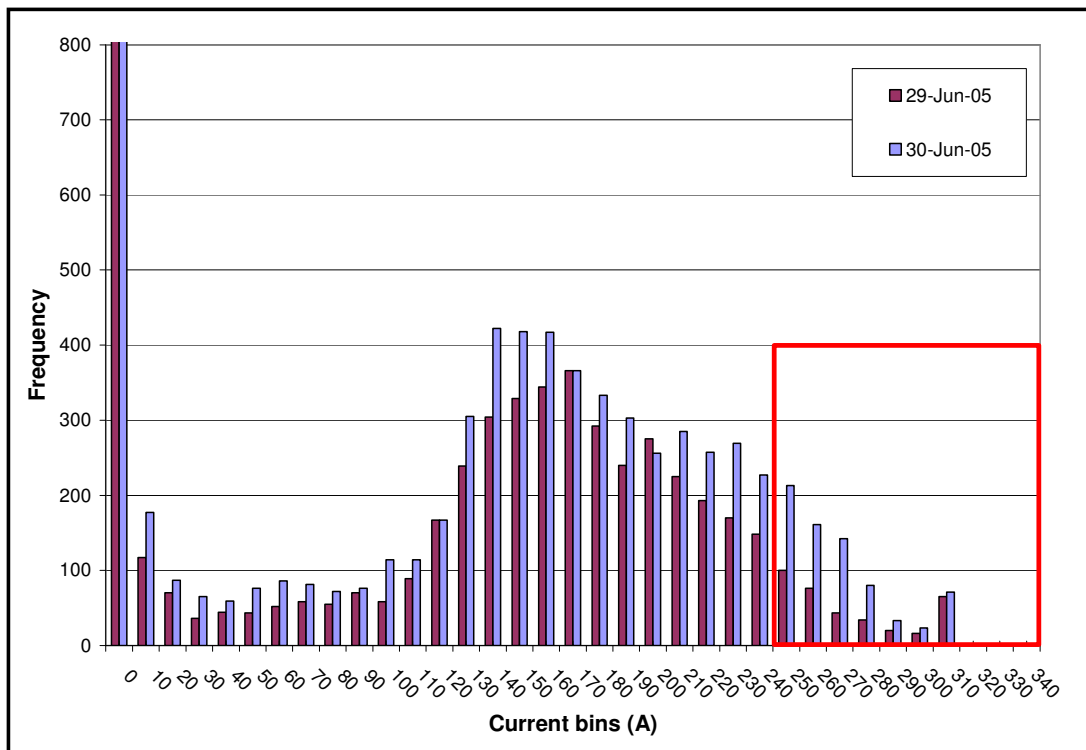


Figure M.2-12: Histogram for current consumed by a RH C traction motor.

M.2.2.2 Afternoon shifts

Table M-9: Data for the total consumption of a LH traction motor in section 51.

	29-Jun-05	30-Jun-05
Tonnes/CM/Shift	2175	2320
% Time of shift producing	42.74%	44.51%
% of Production time underloaded	73.74%	71.11%
% of Production time overloaded	26.26%	28.89%

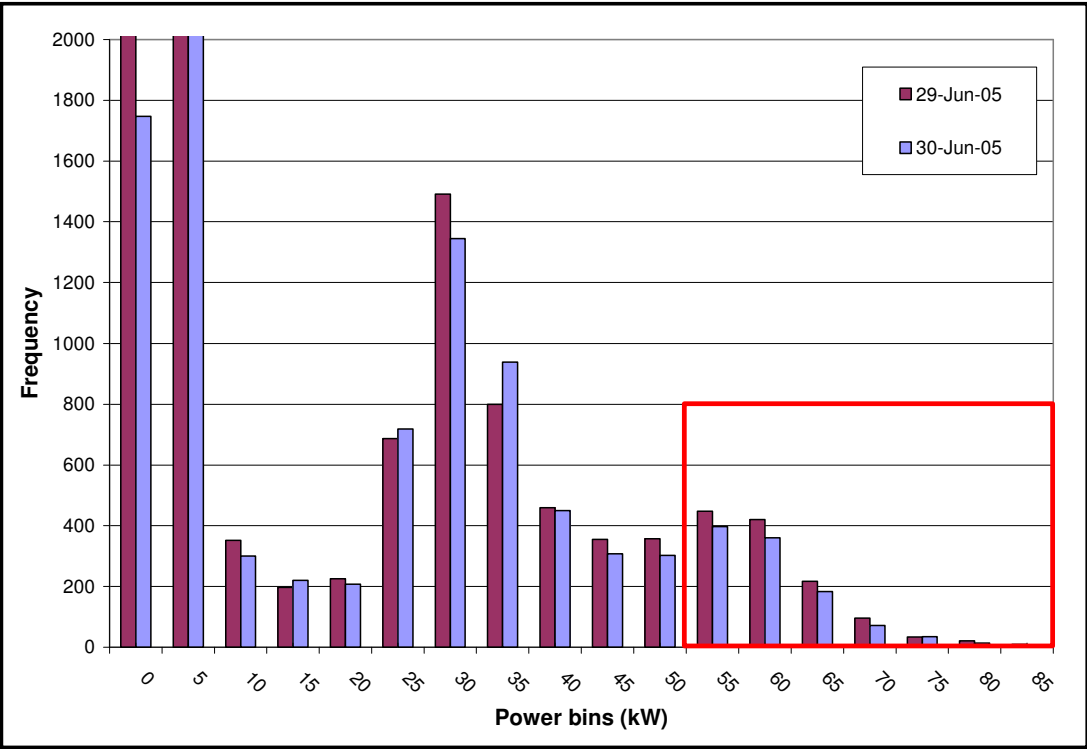


Figure M.2-13: Histogram for power consumed by a LH traction motor.

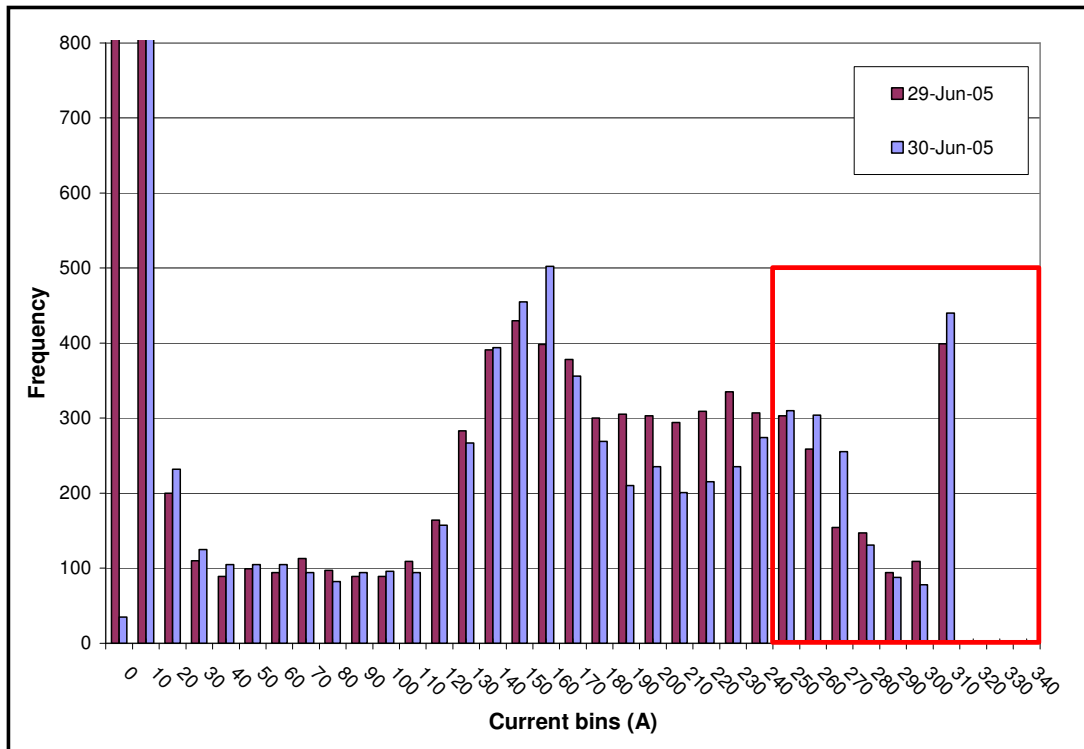


Figure M.2-14: Histogram for current consumed by a LH traction motor.

Table M-10: Data for the total consumption of a RH traction motor in section 51.

	29-Jun-05	30-Jun-05
Tonnes/CM/Shift	2175	2320
% Time of shift producing	41.95%	43.70%
% of Production time underloaded	82.16%	81.67%
% of Production time overloaded	17.84%	18.33%

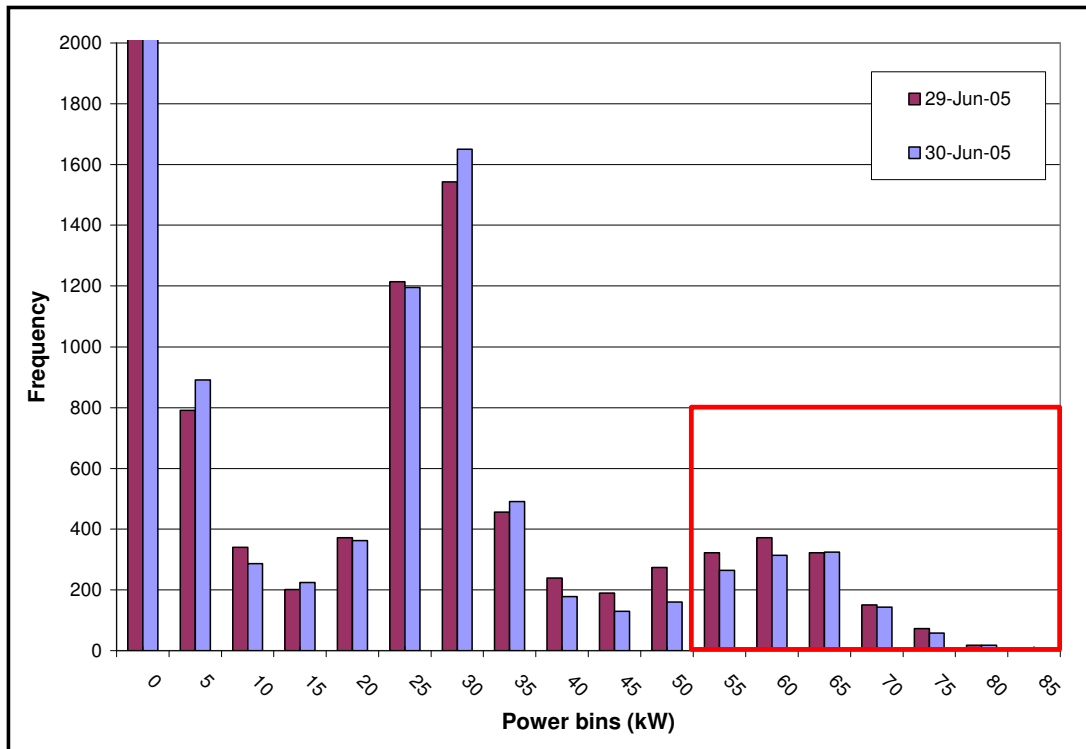


Figure M.2-15: Histogram for power consumed by a RH traction motor.

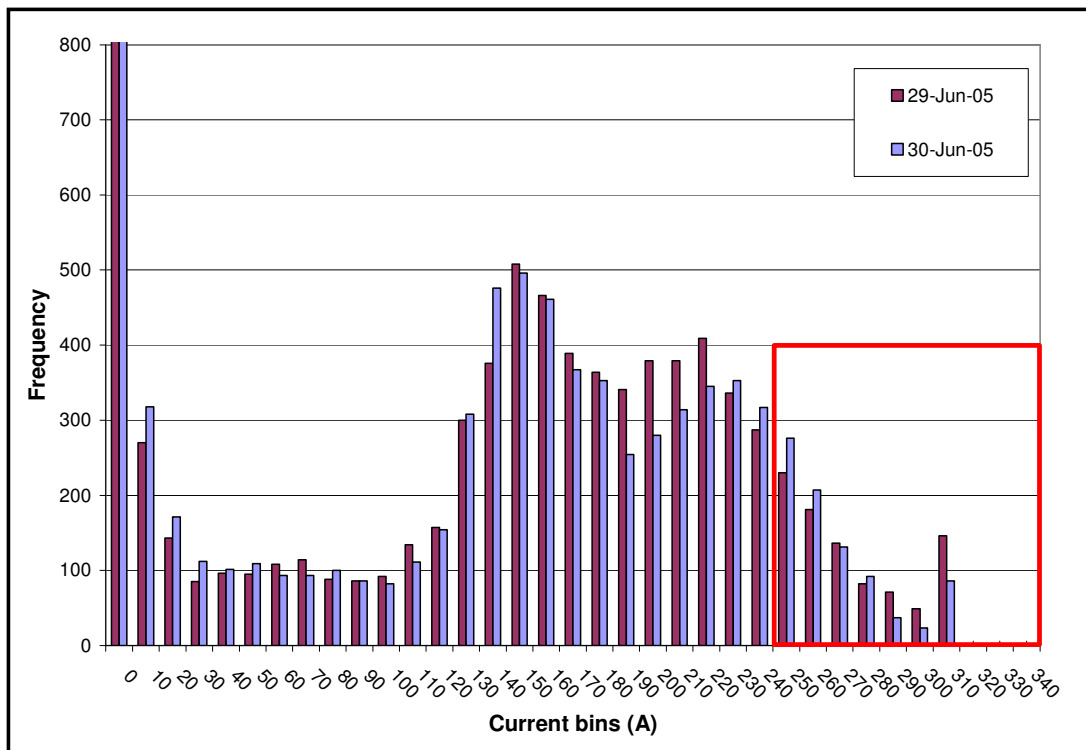


Figure M.2-16: Histogram for current consumed by a RH traction motor.

M.2.3 FLASHCARD RECORDER

M.2.3.1 Morning shifts

Table M-11: Data for the total consumption of a LH traction motor in section 21 & 61.

	16-May-05	17-May-05	18-May-05	23-May-05
Tonnes/CM/Shift	1551	858	1320	1740
% Time of shift producing	38.59%	23.11%	22.87%	42.92%
% of Production time underloaded	58.78%	50.29%	53.86%	81.40%
% of Production time overloaded	41.22%	49.71%	46.14%	18.60%

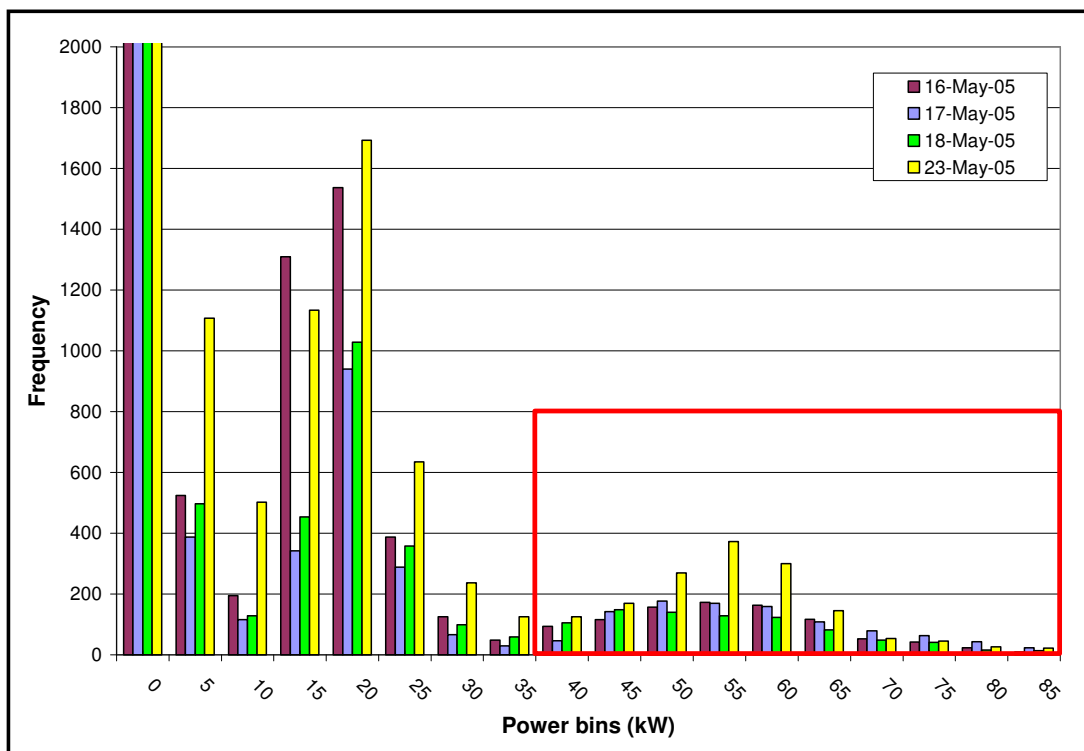


Figure M.2-17: Histogram for power consumed by a LH traction motor.

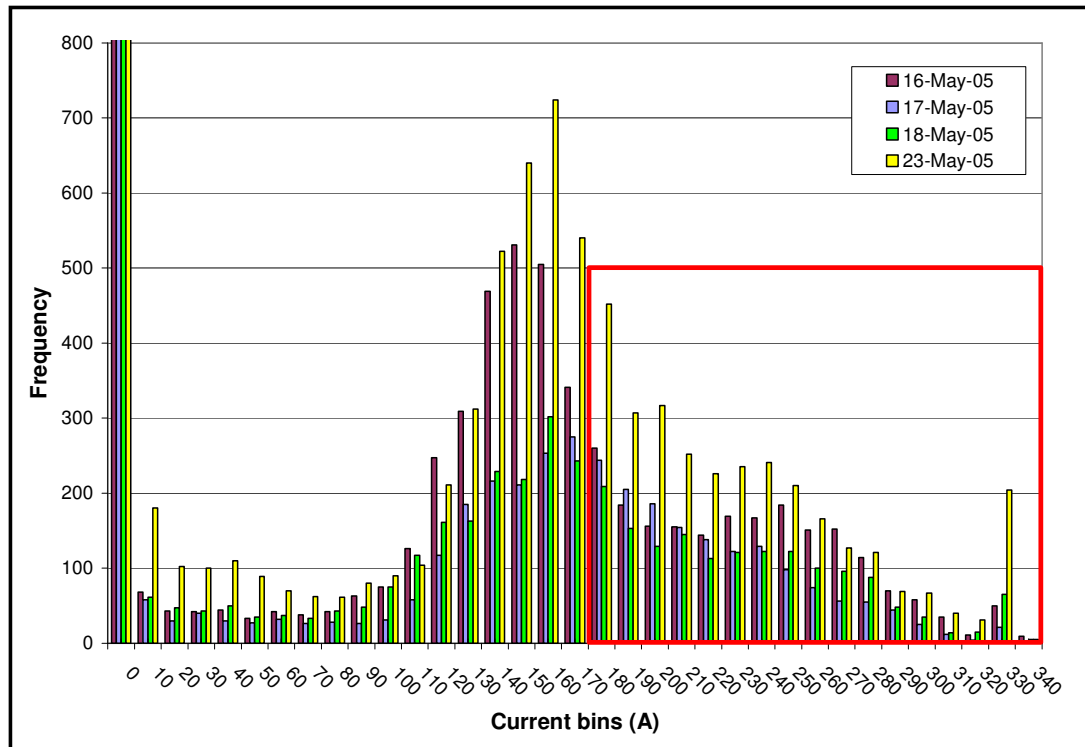


Figure M.2-18: Histogram for current consumed by a LH traction motor.

Table M-12: Data for the total consumption of a RH traction motor in section 21 & 61.

	16-May-05	17-May-05	18-May-05	23-May-05
Tonnes/CM/Shift	1551	858	1320	1740
% Time of shift producing	38.68%	23.15%	22.40%	42.71%
% of Production time underloaded	62.19%	51.17%	57.67%	77.75%
% of Production time overloaded	37.81%	48.83%	42.33%	22.25%

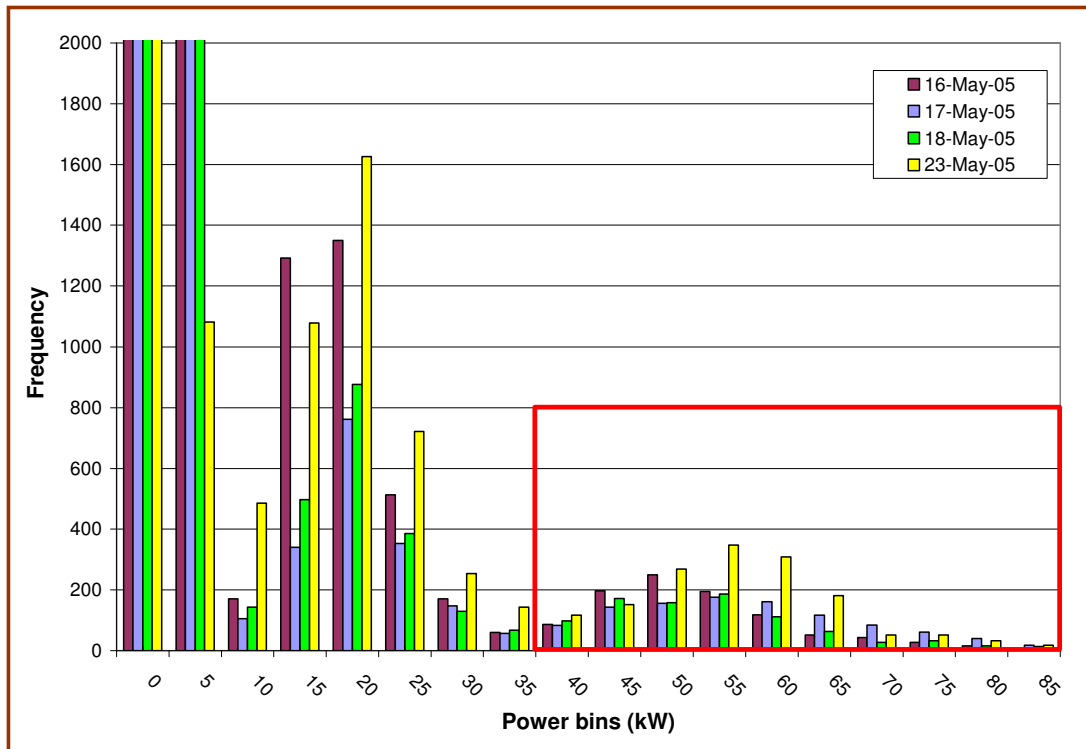


Figure M.2-19: Histogram for power consumed by a RH traction motor.

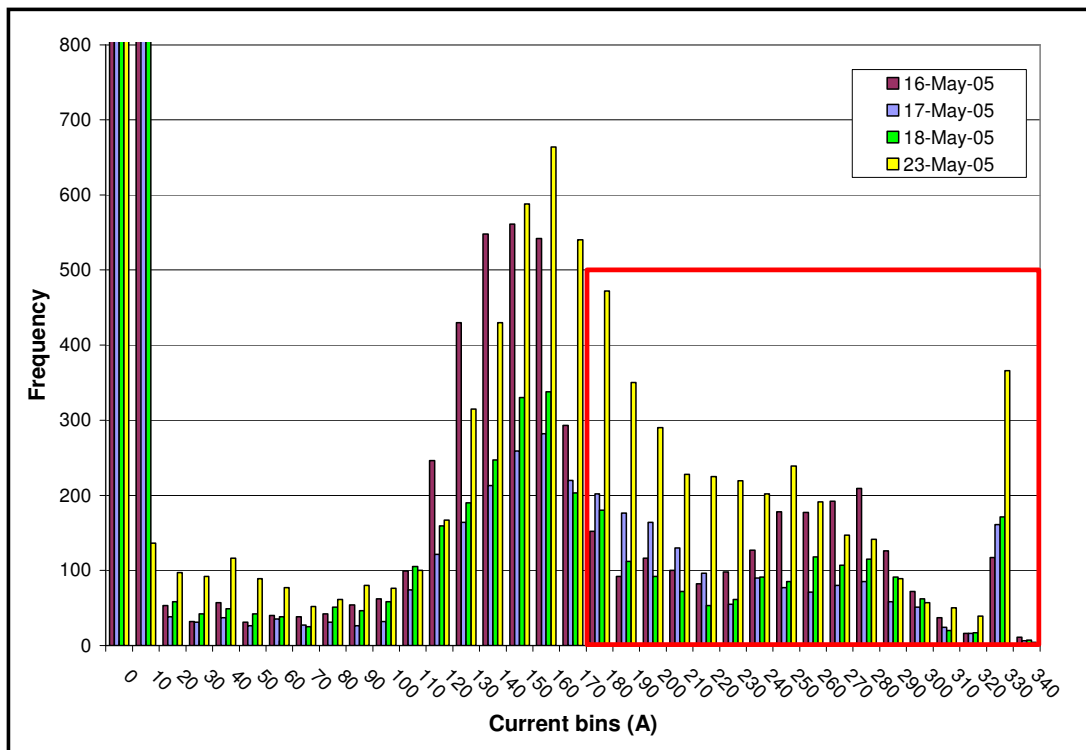


Figure M.2-20: Histogram for current consumed by a RH traction motor.

M.2.3.2 Afternoon shifts

Table M-13: Data for the total consumption of a LH traction motor in section 21 & 61.

	16-May-05	17-May-05	18-May-05	23-May-05
Tonnes/CM/Shift	1485	2145	2112	2030
% Time of shift producing	37.20%	34.24%	45.00%	44.99%
% of Production time underloaded	52.93%	38.14%	44.81%	74.76%
% of Production time overloaded	47.07%	61.86%	55.19%	25.24%

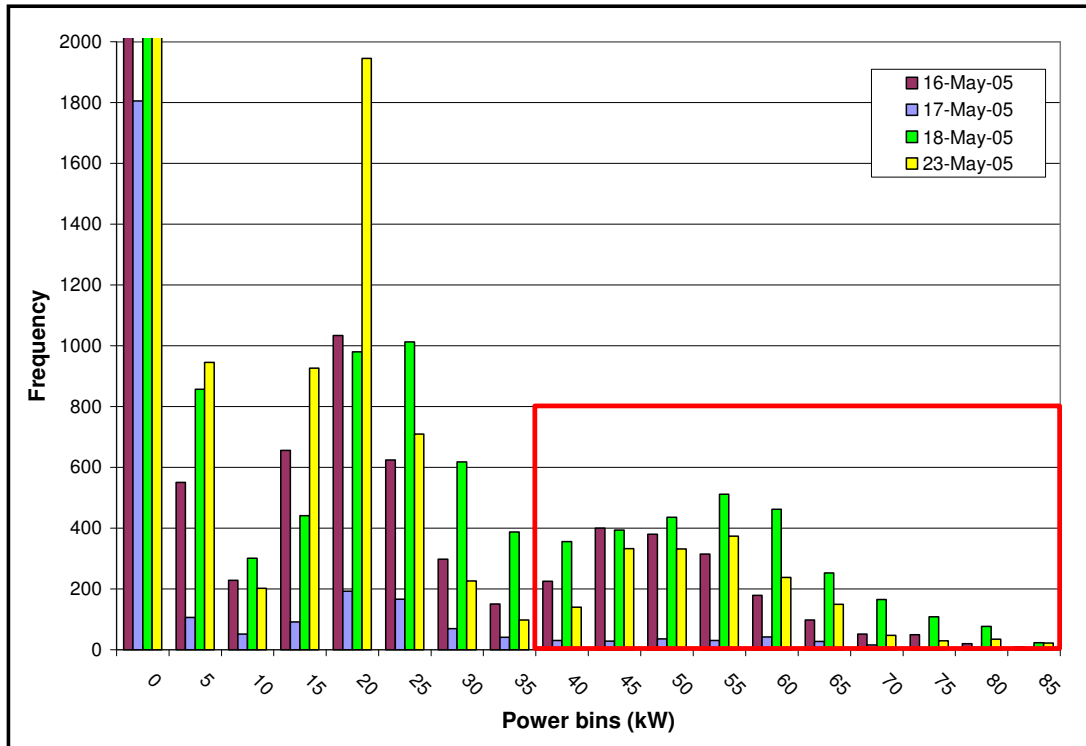


Figure M.2-21: Histogram for power consumed by a LH traction motor.

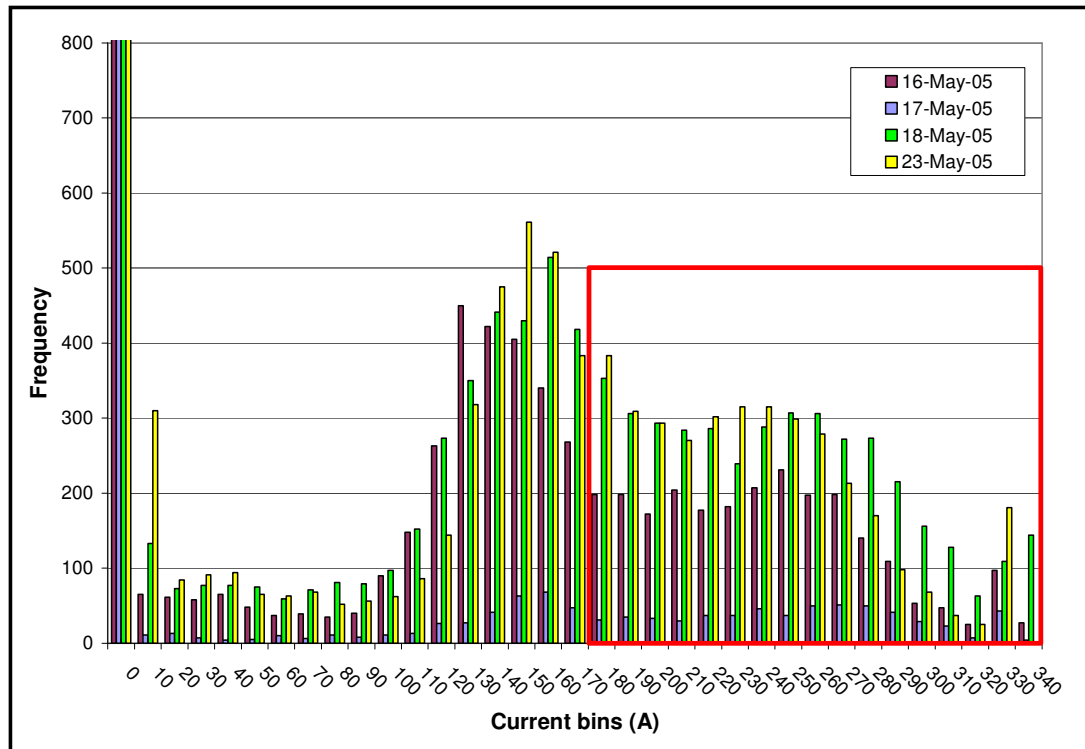


Figure M.2-22: Histogram for current consumed by a LH traction motor.

Table M-14: Data for the total consumption of a RH traction motor in section 21 & 61.

	16-May-05	17-May-05	18-May-05	23-May-05
Tonnes/CM/Shift	1485	2145	2112	2030
% Time of shift producing	37.25%	34.29%	46.65%	44.84%
% of Production time underloaded	49.62%	39.68%	43.42%	70.10%
% of Production time overloaded	50.38%	60.32%	56.58%	29.90%

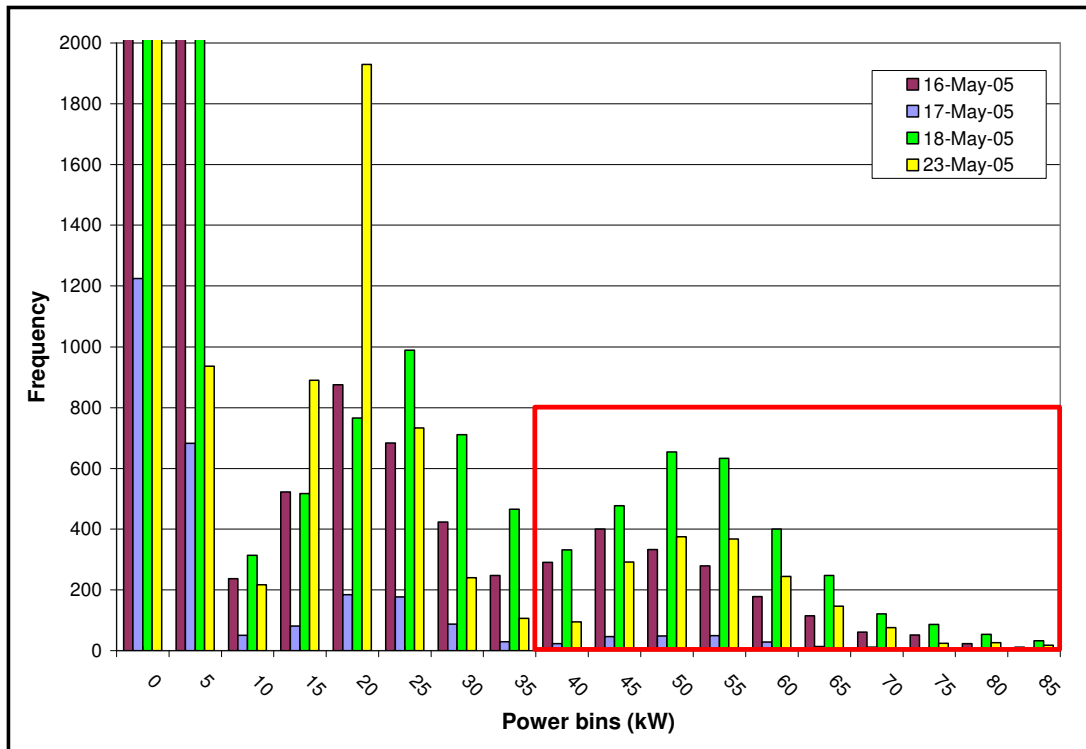


Figure M.2-23: Histogram for power consumed by a RH traction motor.

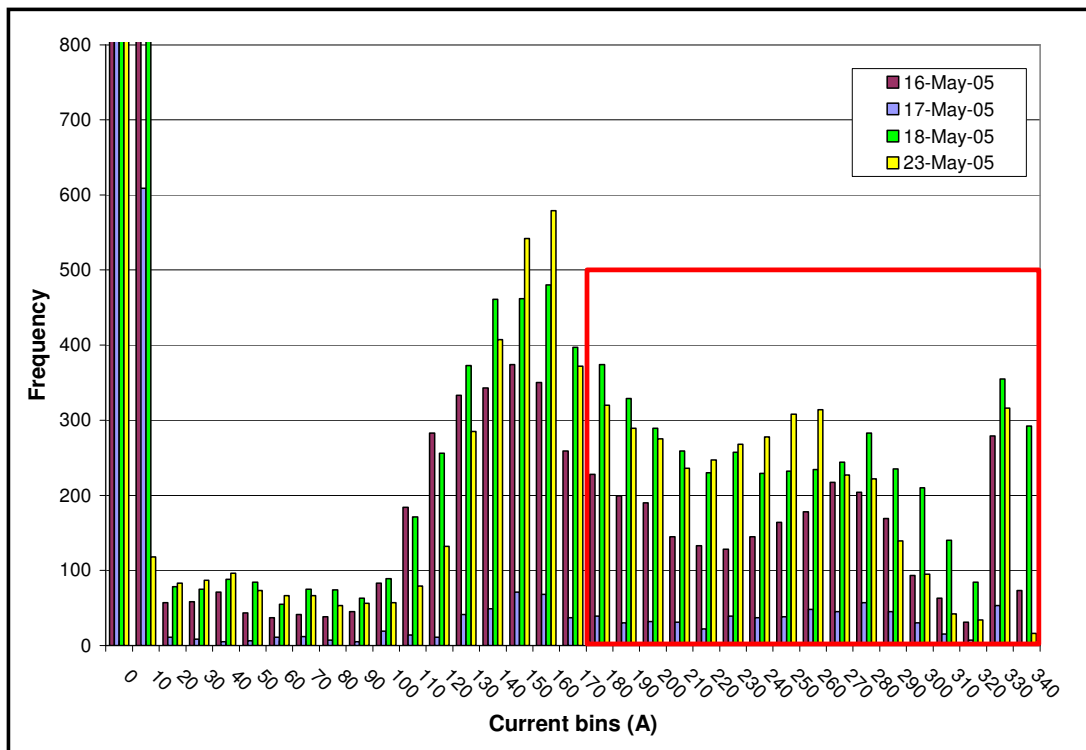


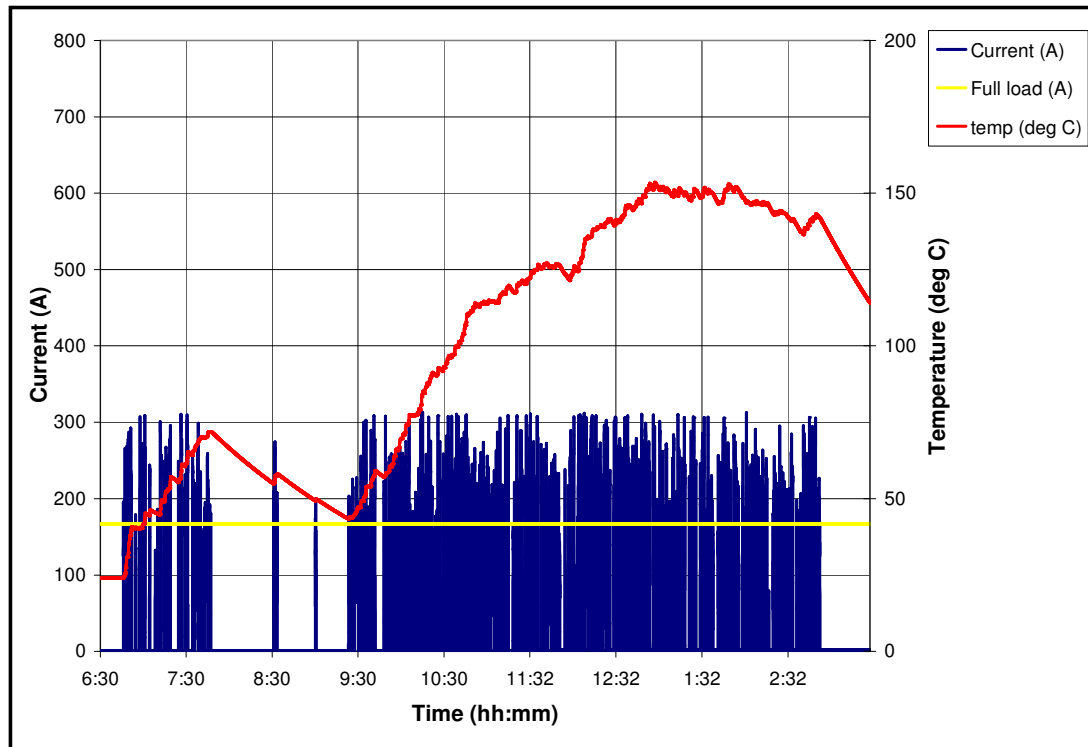
Figure M.2-24: Histogram for current consumed by a RH traction motor.

M.3 THERMAL CAPACITY

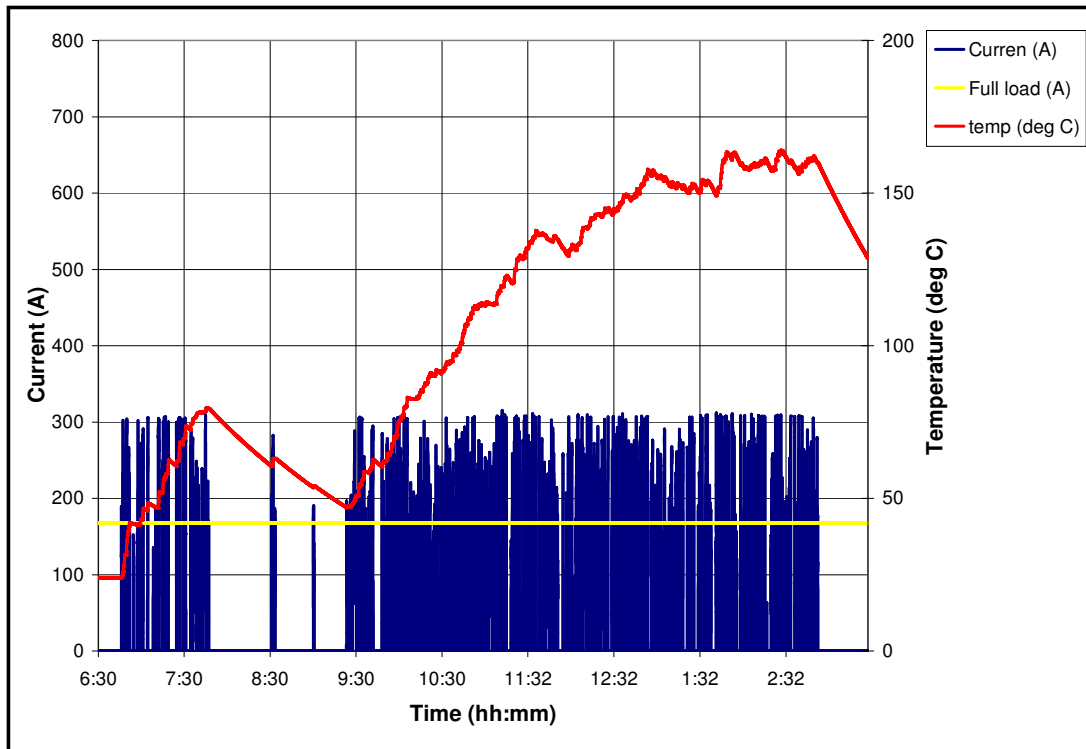
The next section focuses on the temperature of the windings of the traction motors. Each graph shows the temperature of the motor, the load current and rated full load current of the motor. The morning shifts and afternoon shifts are separated as well as the measurements made at the different sections. The thermal time constant is 40 minutes for the 37 kW motor and 45 minutes for the 50 kW motor.

M.3.1 SECTION 21

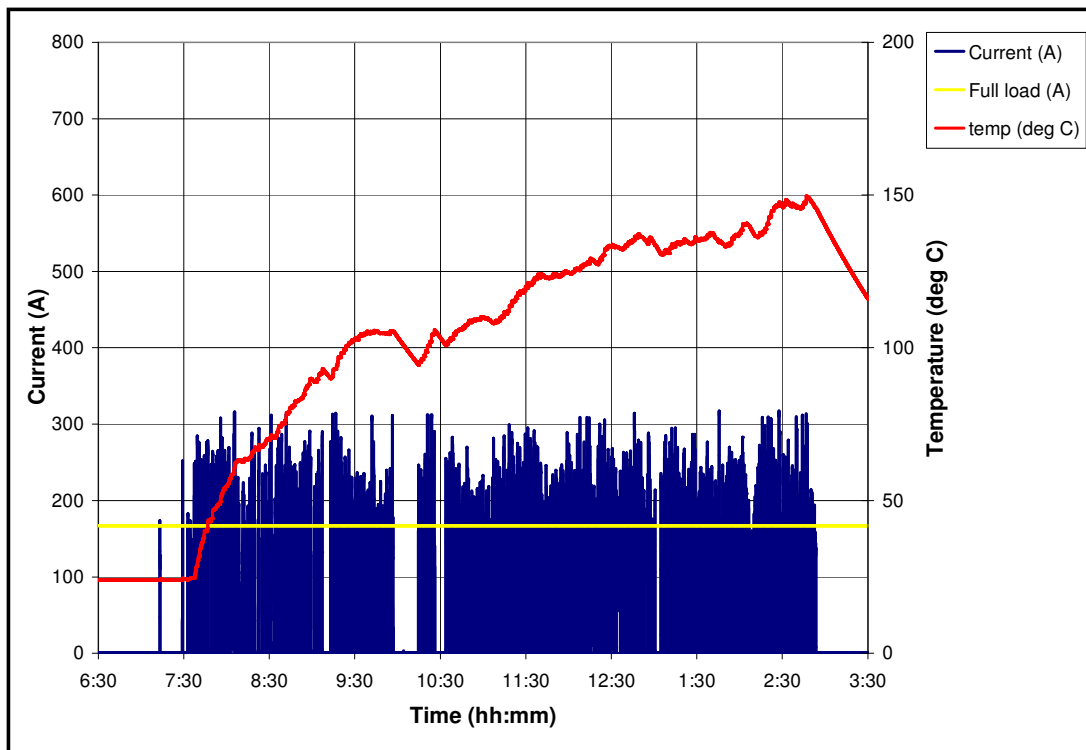
M.3.1.1 Morning shifts



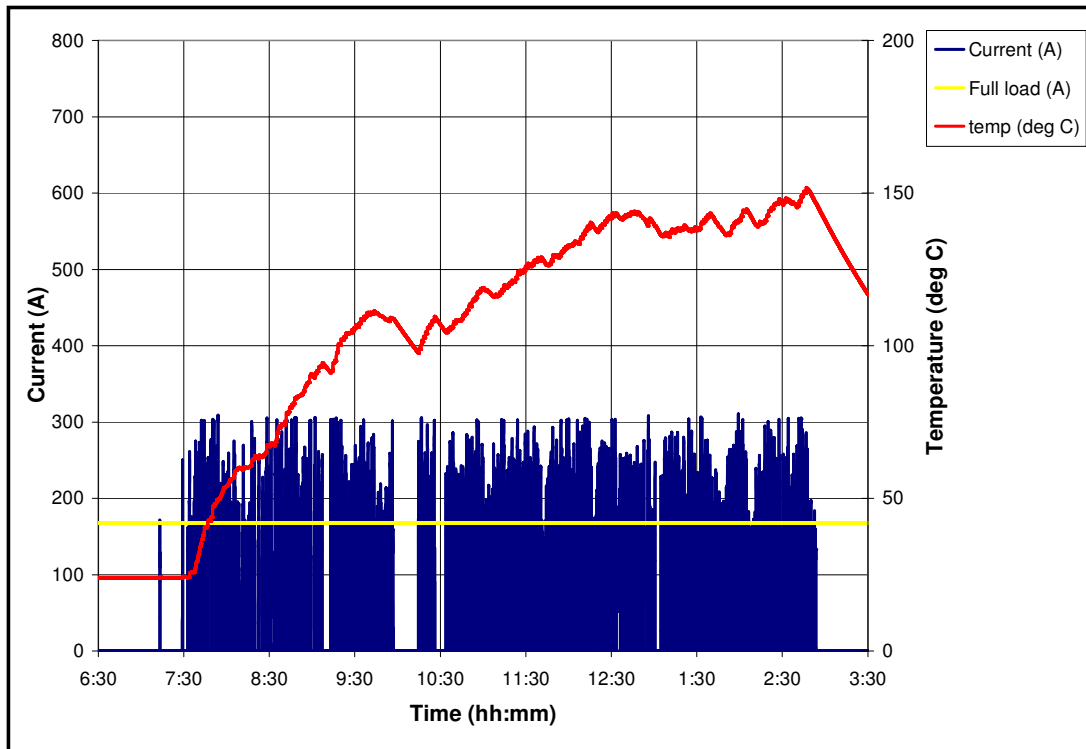
**Figure M.3-1: Load current and motor temperature for a LH traction motor
– 10 June 2005.**



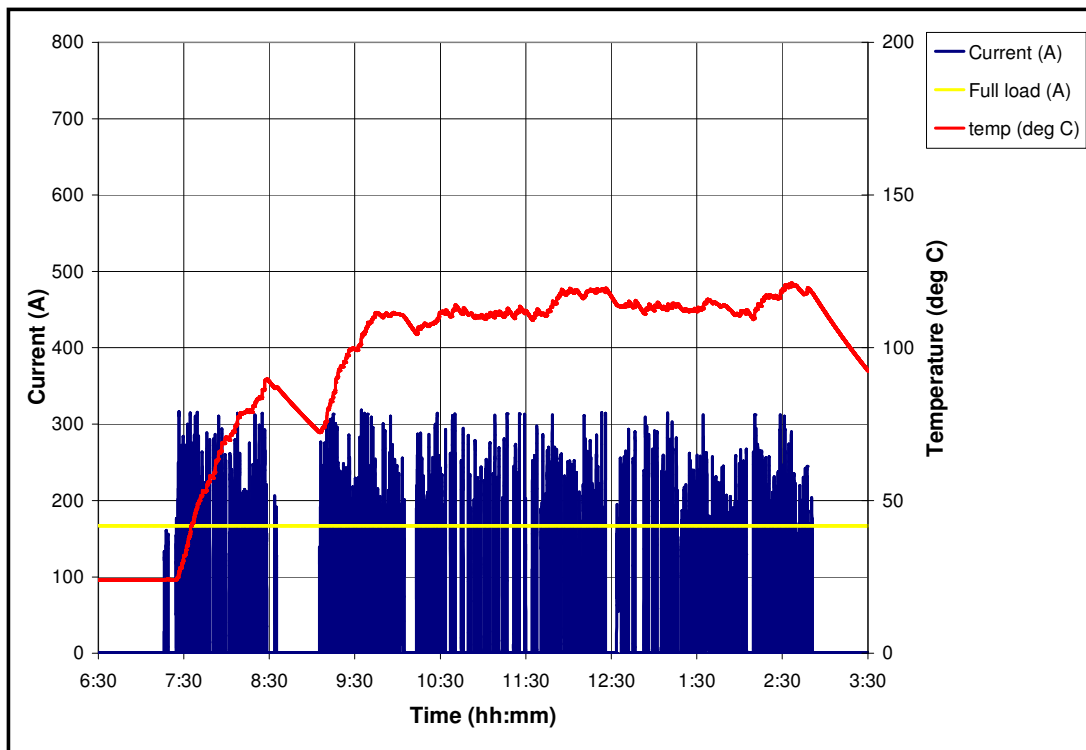
**Figure M.3-2: Load current and motor temperature for a RH traction motor
– 10 June 2005.**



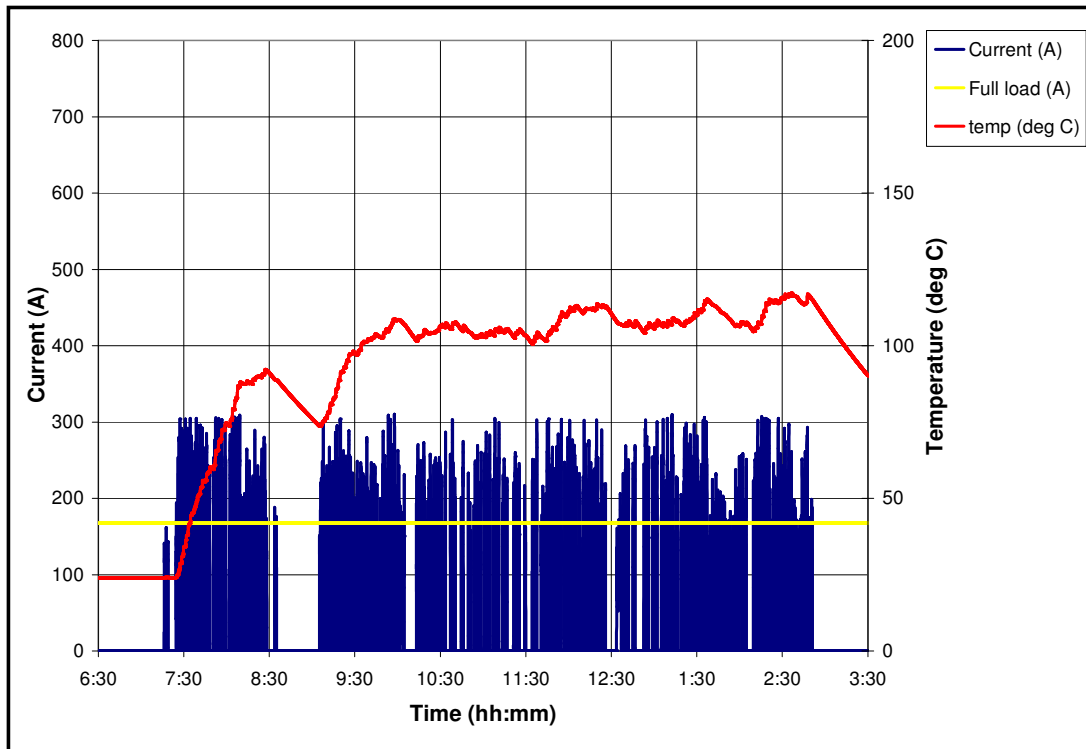
**Figure M.3-3: Load current and motor temperature for a LH traction motor
– 13 June 2005.**



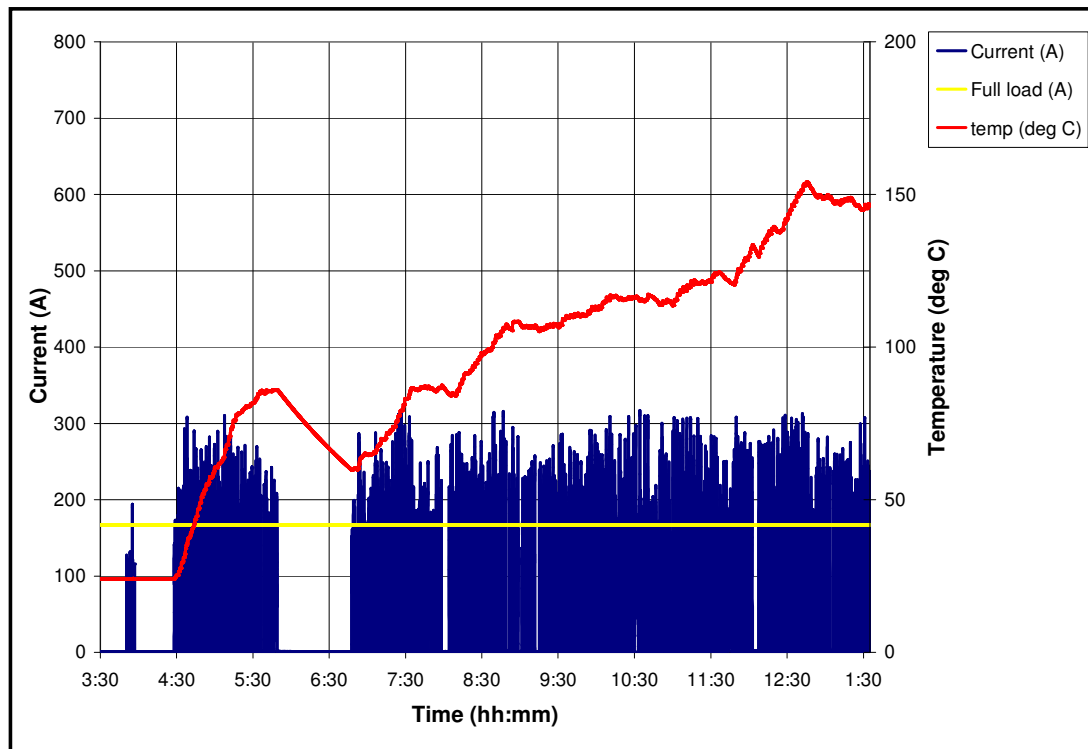
**Figure M.3-4: Load current and motor temperature for a RH traction motor
– 13 June 2005.**



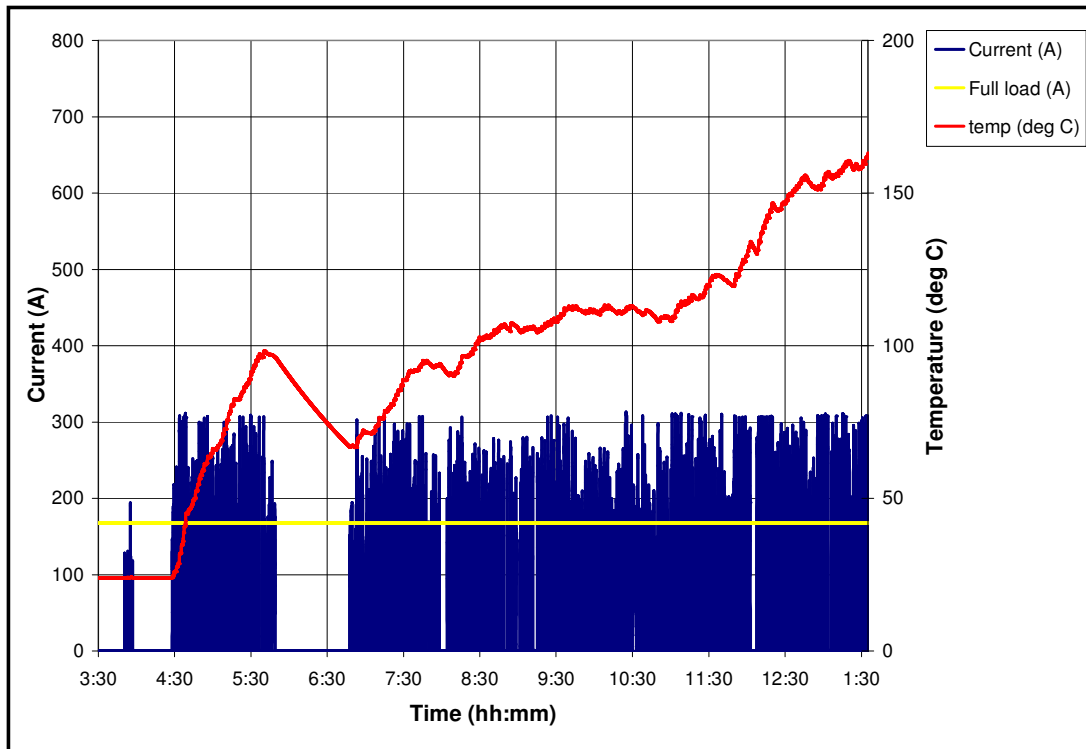
**Figure M.3-5: Load current and motor temperature for a LH traction motor
– 14 June 2005.**



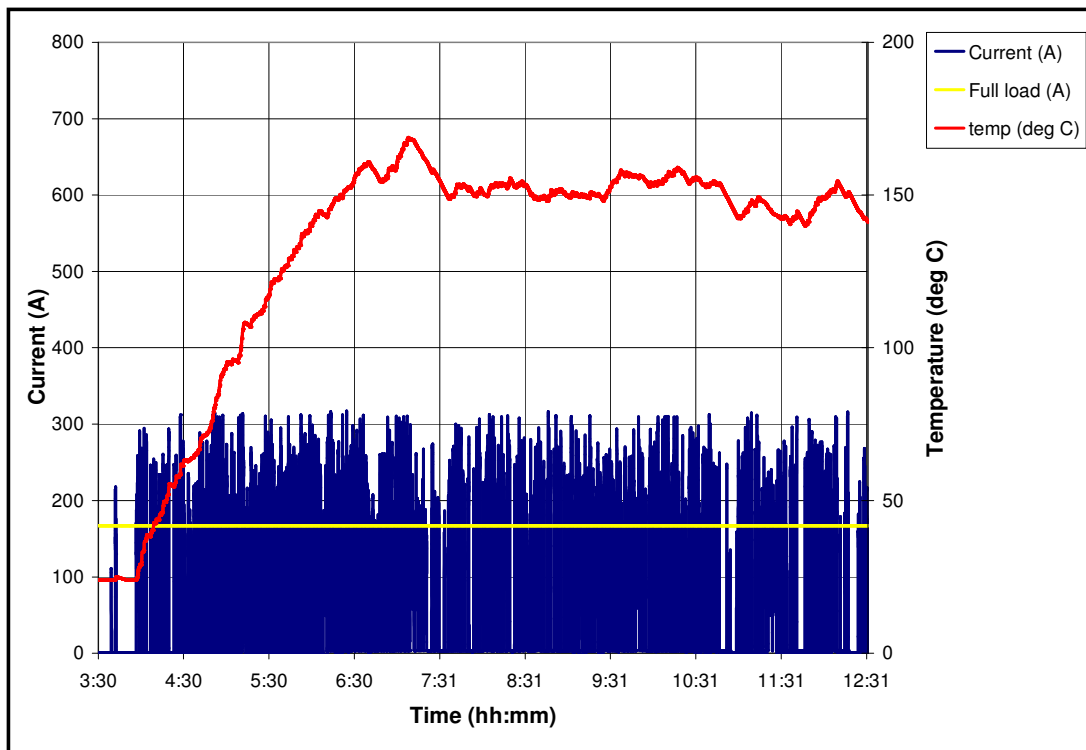
M.3.1.2 Afternoon shifts



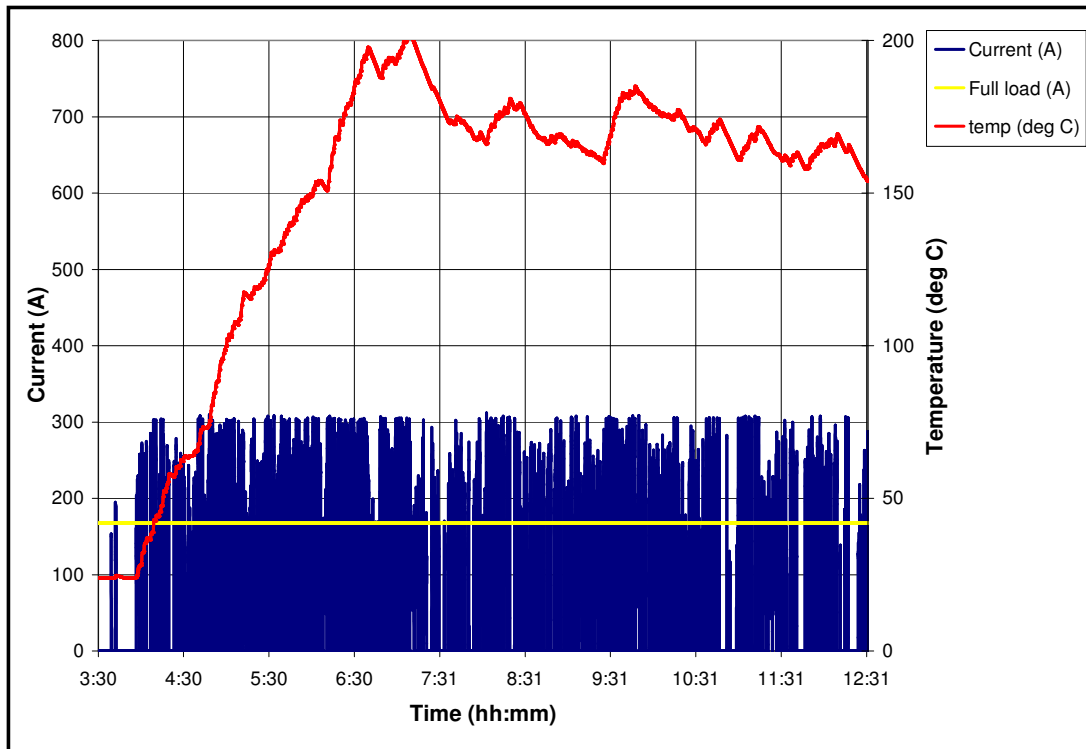
**Figure M.3-7: Load current and motor temperature for a LH traction motor
– 10 June 2005.**



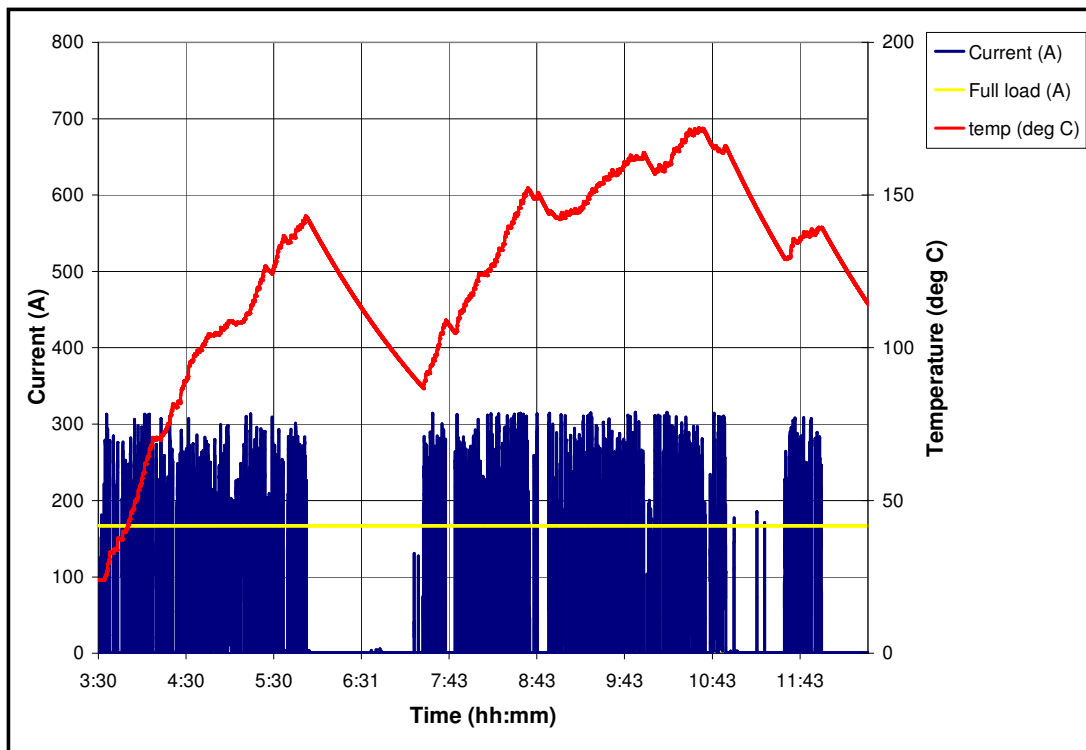
**Figure M.3-8: Load current and motor temperature for a RH traction motor
– 10 June 2005.**



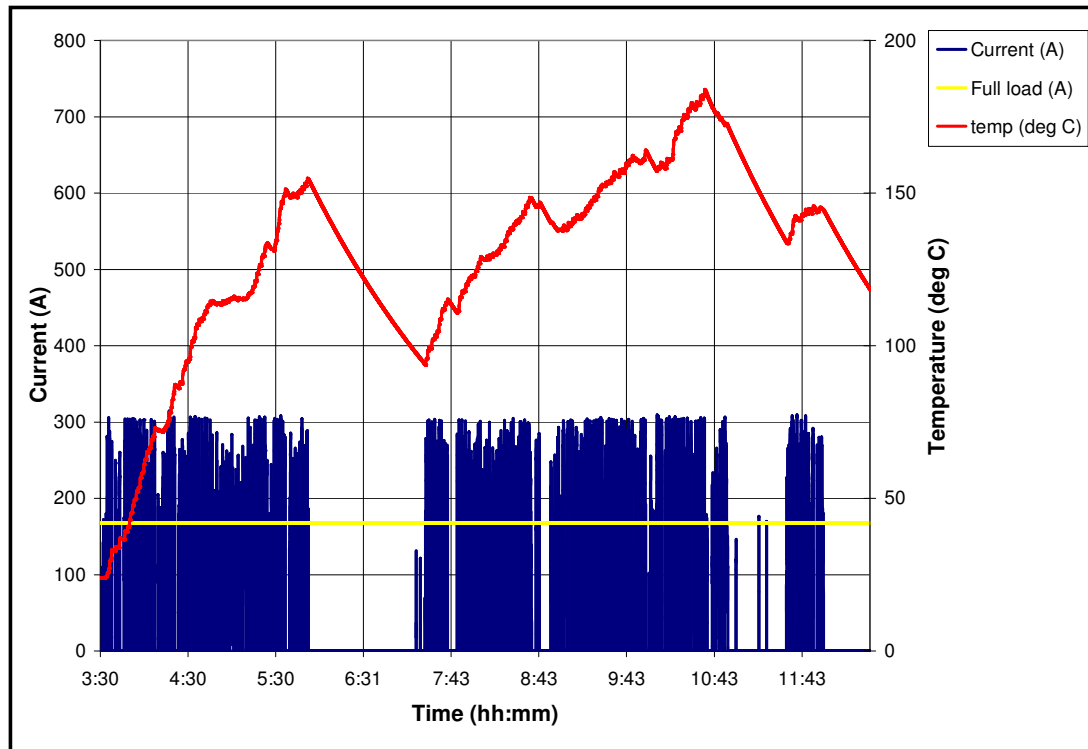
**Figure M.3-9: Load current and motor temperature for a LH traction motor
– 13 June 2005.**



**Figure M.3-10: Load current and motor temperature for a RH traction motor
– 13 June 2005.**



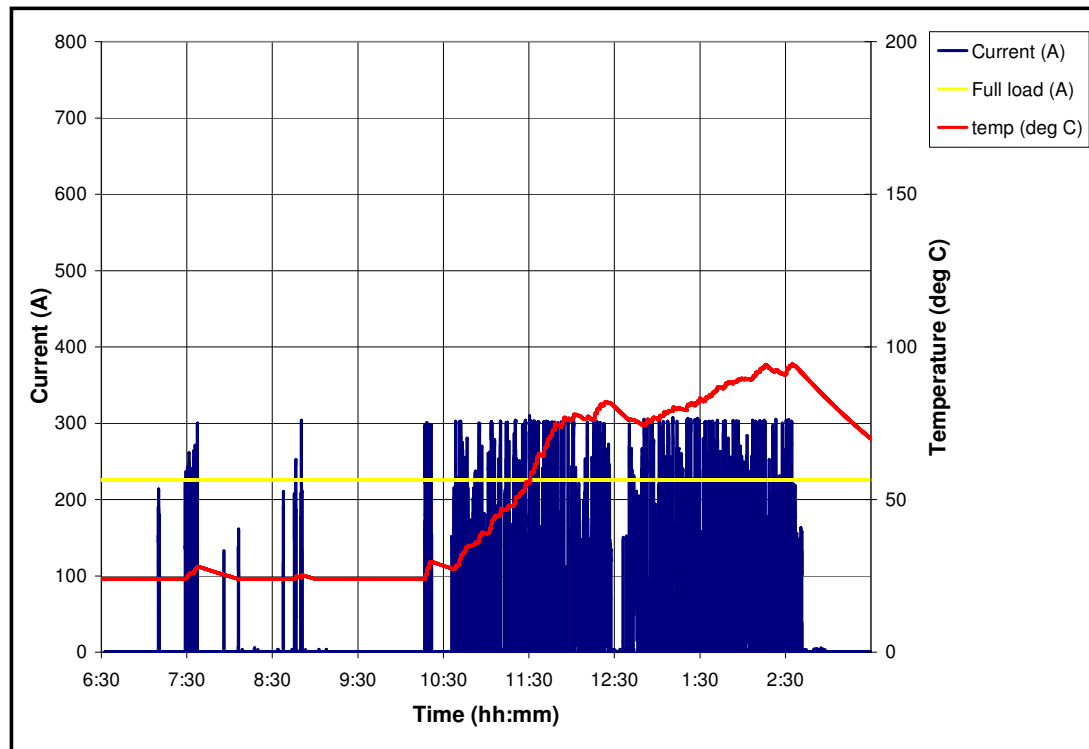
**Figure M.3-11: Load current and motor temperature for a LH traction motor
– 14 June 2005.**



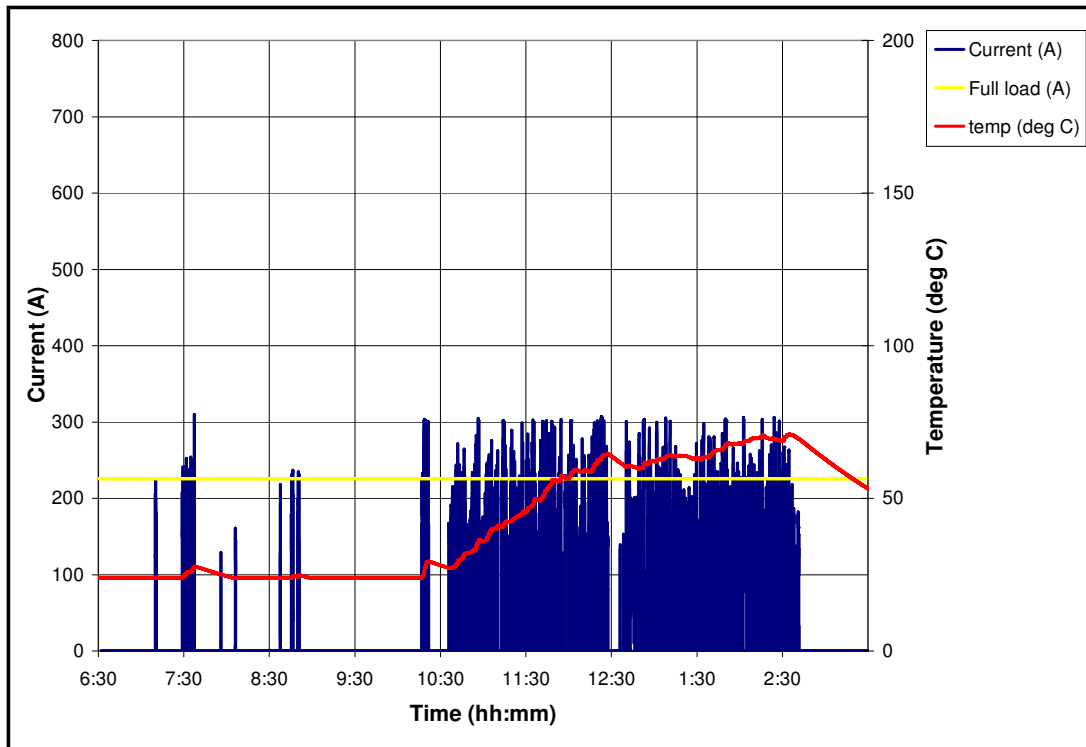
**Figure M.3-12: Load current and motor temperature for a RH traction motor
– 14 June 2005.**

M.3.2 SECTION 51

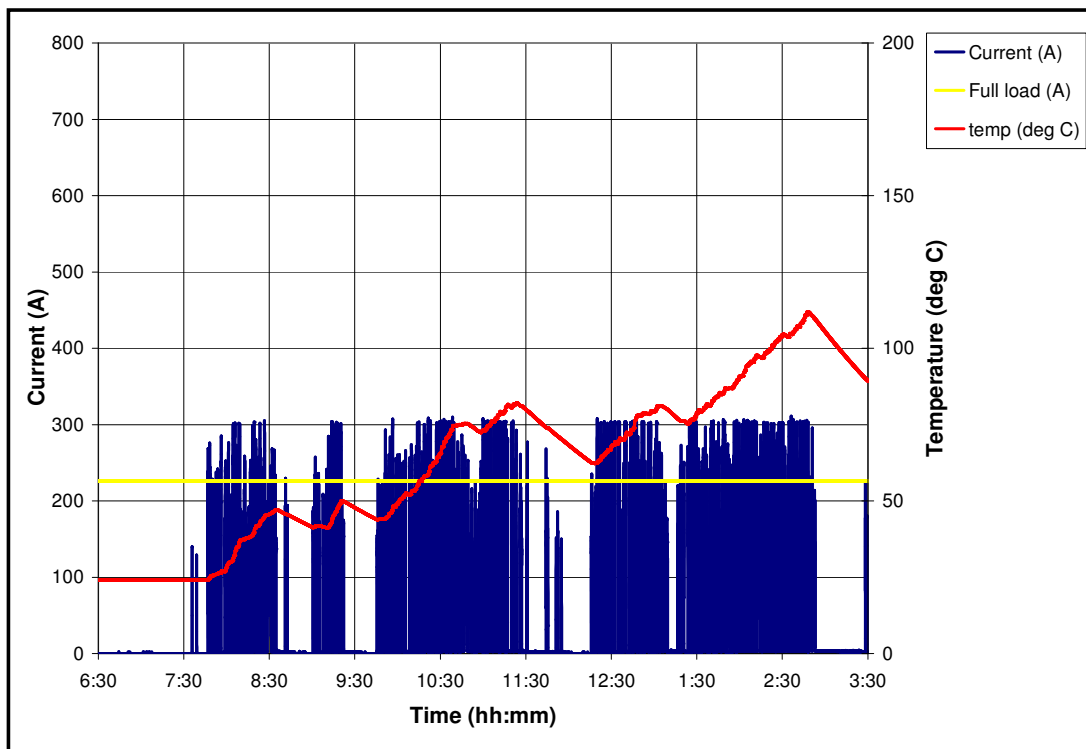
M.3.2.1 Morning shifts



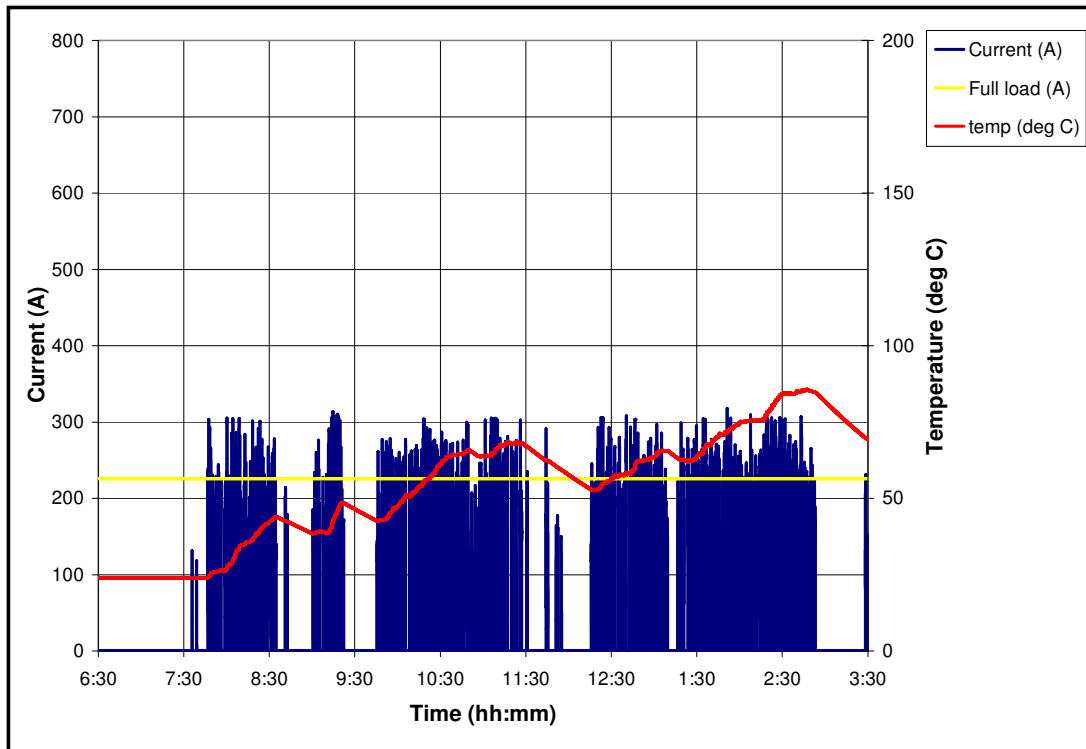
**Figure M.3-13: Load current and motor temperature for a LH traction motor
– 29 June 2005.**



**Figure M.3-14: Load current and motor temperature for a RH traction motor
– 29 June 2005.**

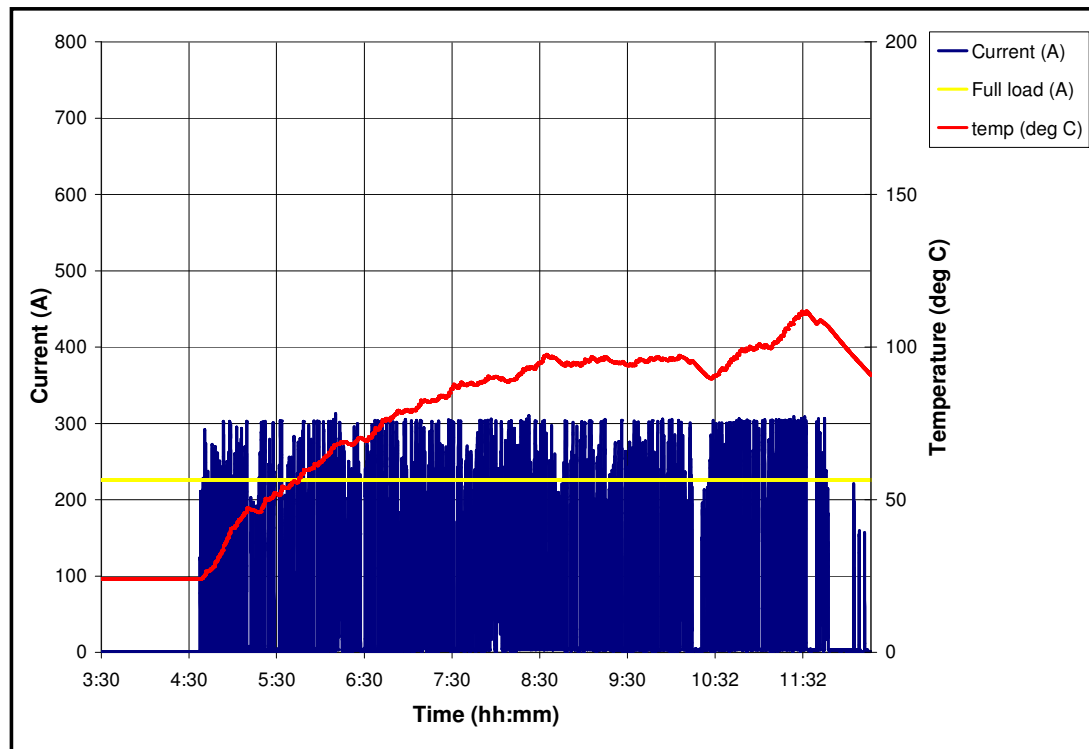


**Figure M.3-15: Load current and motor temperature for a LH traction motor
– 30 June 2005.**

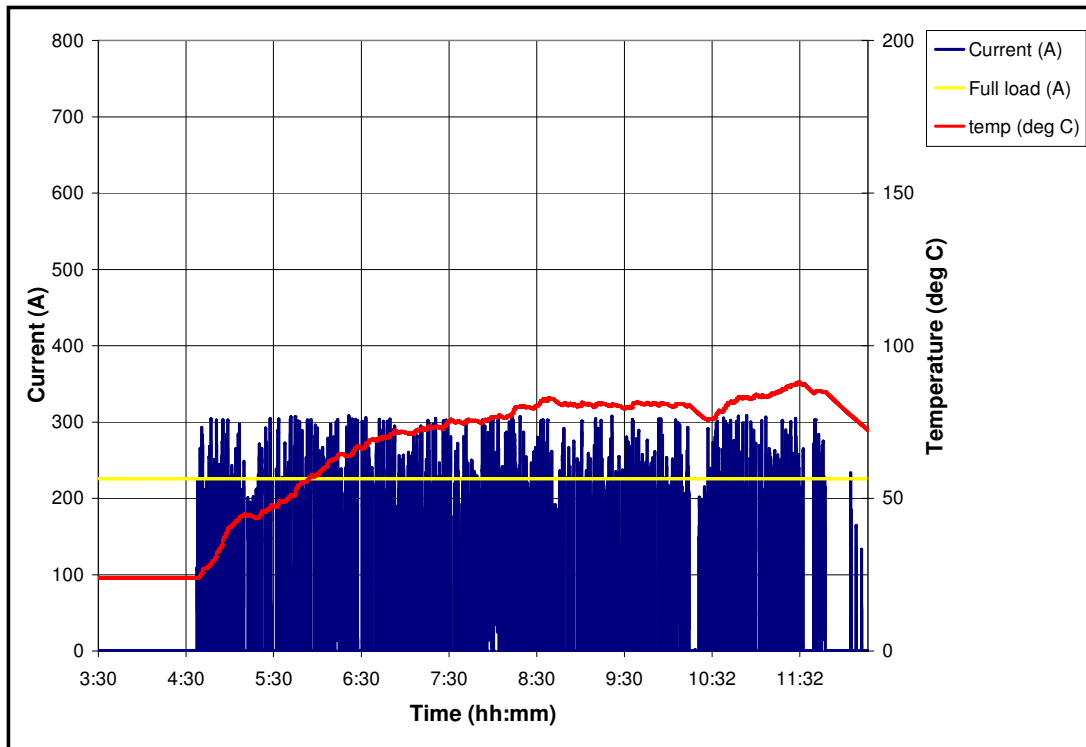


**Figure M.3-16: Load current and motor temperature for a RH traction motor
– 30 June 2005.**

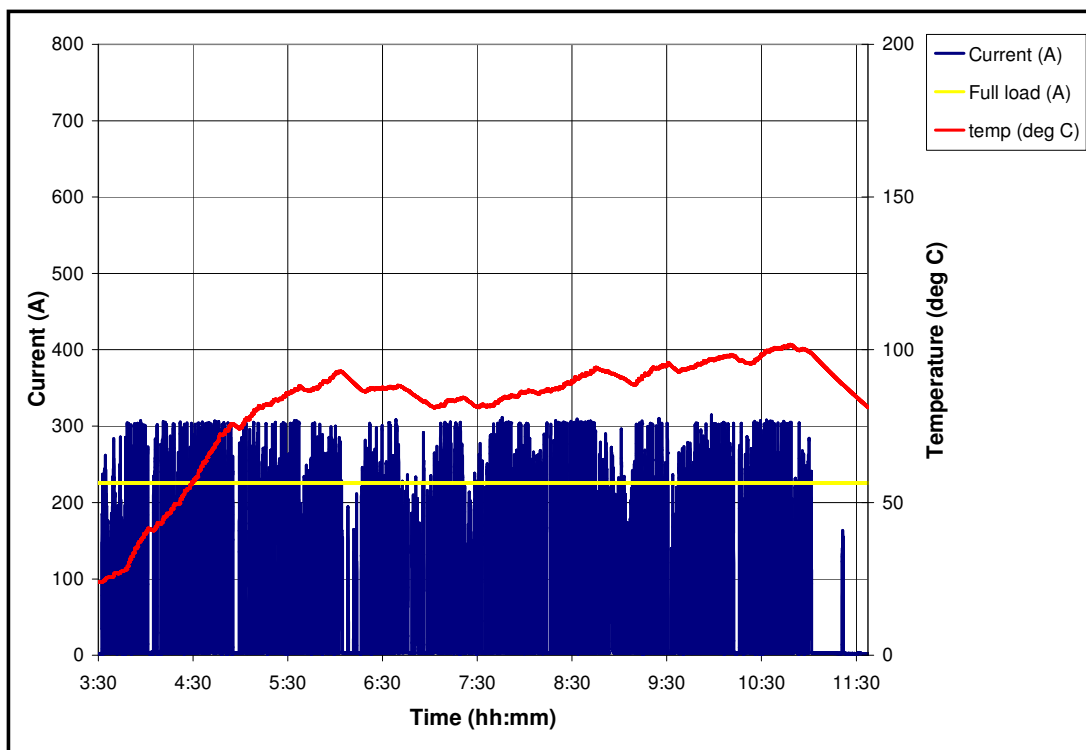
M.3.2.2 Afternoon shifts



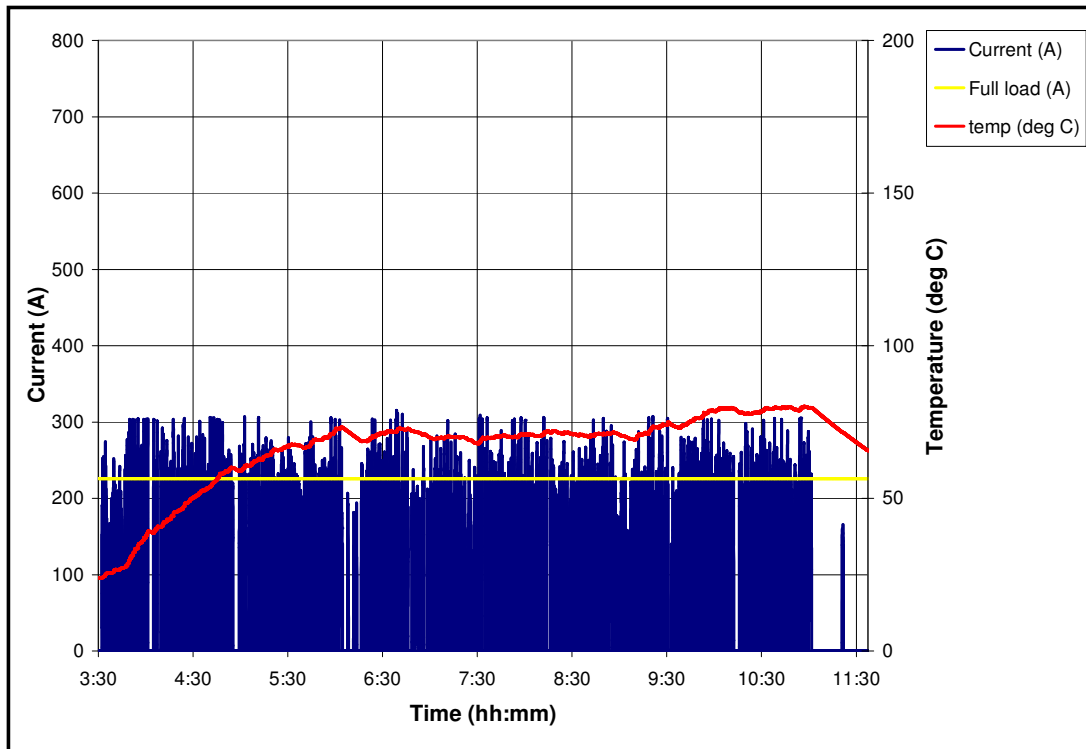
**Figure M.3-17: Load current and motor temperature for a LH traction motor
– 29 June 2005.**



**Figure M.3-18: Load current and motor temperature for a RH traction motor
– 29 June 2005.**



**Figure M.3-19: Load current and motor temperature for a LH traction motor
– 30 June 2005.**



**Figure M.3-20: Load current and motor temperature for a RH traction motor
– 30 June 2005.**