Measuring the Heat from Hydraulic Lifts

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INTRODUCTION

George Floth Consulting Engineers was asked to investigate a hydraulic lift installation that was overheating in summer. This is a description of the methods used.

Figure 1 shows that energy flows in several ways in a hydraulic lift motor room. Figure 2 shows the general arrangement of the installation.

MEASUREMENTS

The power input was measured at the lift circuit breaker, using an Elite Pro logger.

- Power (kw) was recorded at 3 second intervals and converted to kWh by multiplying by 3/3600.
- The logger memory allowed 28 hours of recording.
- The 3 second interval clearly showed the number of motor starts and also relevelling. *See Figure 3*

Clip on current transformers and voltage probes allow recording without interfering with the lift.

Temperatures (°C) were recorded using ACR smart reader loggers.

- Ventilation air entering the lift motor room (LMR)
- Ventilation air leaving the LMR
- Oil in the tank
- Air in the centre of the LMR, for lift mechanic comfort

If more sensors had been available, a more complete picture would have been obtained by also recording the temperature of the air into and our of the oil cooler, and in the lift shaft.

The air velocity (m/s) through and the areas (m²) of inlet grille to LMR were also measured.

We had an enthusiastic maintenance contractor so recordings were made over 3 days.

- Day 1 with flexible ducts from the air intake of the LMR to the oil cooler
- Day 2 with flexible ducts as for day 1, plus flexible ducts to near the exhaust fans
- Day 3 no ducts

The ducts made little difference; probably this was because the oil cooler fans were not rated for the extra static pressure imposed by the ducts, so air flow reduced.

CALCULATIONS

A formula for heat flow is

$Q = CM\Delta T$

Q = heat (kj)
C = Specific heat (kj / kg °C)
M = Mass (kg)
ΔT = Temperature change

Also 1 kjoule = 1 kwatt/sec or 3600 kj = 1 kWh

$kWh = C \times d \times v\ \Delta T / 3600$

d = density (kg / l)
v = volume (l)

Heat removed from the LMR by ventilation in 1 hour

$kWh_{LMR} = 1.213 \times \text{air flow (l/s)} \times \Delta T_{LM} \times 10^{-3}$ **1**

ΔT_{LM} = Outlet air temperature - Inlet air temperature

Air flow (l/s) = grille area (m^2) x velocity (m/s) x 10^3

Heat added to oil in 1 hour

kWh_{oil} = 2.08 kj / kg °C x 0.89 kg / l x v(l) x ΔT(°C) / 3600
= 0.514 x v(l) x ΔT x 10^{-3} **2**

Heat added to LMR air in 1 hour

kWh_{LA} = 1.025 kj / kg x 0.845 10^{-3} kg/l x v m^3 x 10^3 x ΔT / 3600
= 0.866 x volume of LMR(m^3) x ΔT / 3600 **3**

A handout from a seminar presented by Dave Hydraulic Lifts a few years ago included 2 equations below.

Heat loss to lift shaft in 1 hour

kWh_{SL} = Jack area(m^2) x ΔTs (°C) x 3 x 10^{-3} **4**

ΔTs = Oil temperature - shaft air temperature

Jack Area = (D_C x π x L_C+ Dc x π x L_R x 0.5) x 10^{-6}
Dc = diameter of cylinder D_R = diameter of room
Lc = length of cylinder L_R = stroke of room

Heat loss from oil tank in 1 hour

kWh_{OT} = Tank Surface Area (m^2) x ΔT_T x 8 x 10^{-3} **5**

ΔT_T = Oil temperature - LMR air temperature

The wide variation in lift motor room construction and surrounds may require some mechanical engineering imput to calculate loses through the fabric of the lift motor room and heat stored in fabric of the motor room. However, if the motor room has fire rated walls with a ventilated car park (or similar) outside, these losses can be neglected as they will be offset by heat gains from the lift controls.

RESULTS

The results are shown graphically for 1 day in figure 4.

Maximum up trips / hour ≈ 40
Maximum energy input / hour ≈ 7 kWh x 2

Heat removed by LMR ventilation ≈ 4 kWh in 1 hour

CONCLUSIONS

A combination of measurements and calculations (as shown in figure 1) allows the heat flow in a hydraulic lift motor to be analysed.

Heat exchangers should be located so they discharge as directly as possible to outside the motor room. If the motor room ventilation system is designed to cope with a 8°C temperature rise and the additional heat from the oil cooler raises the temperature of the discharging air to 16°C above the inlet temperature, twice as much heat will be removed from the room;if this hot air discharged to outside the temperature in the room will therefore be much closer to the outside air.

The lift motor room ventilation system should move more air through the room than the oil cooler is discharging.

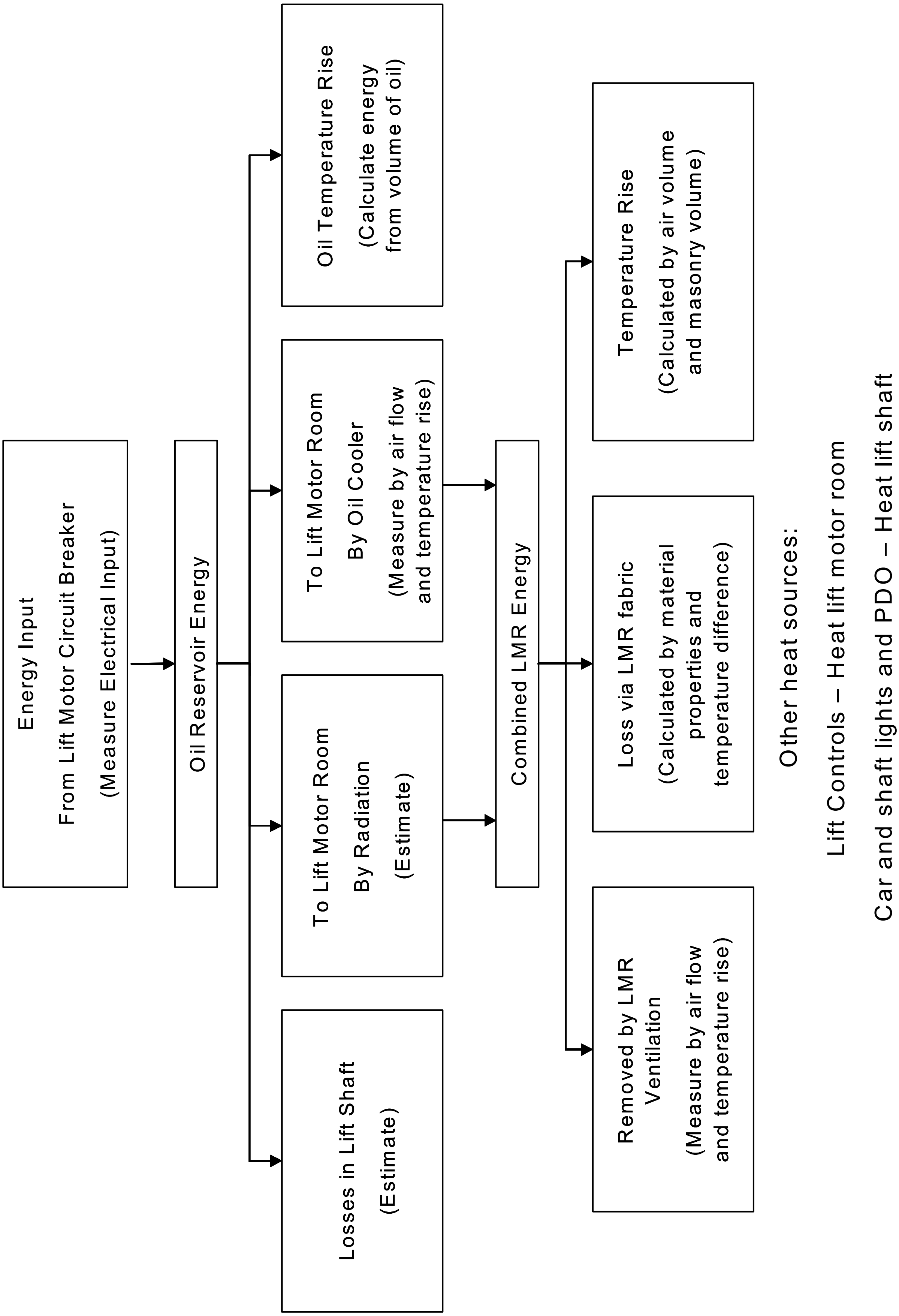
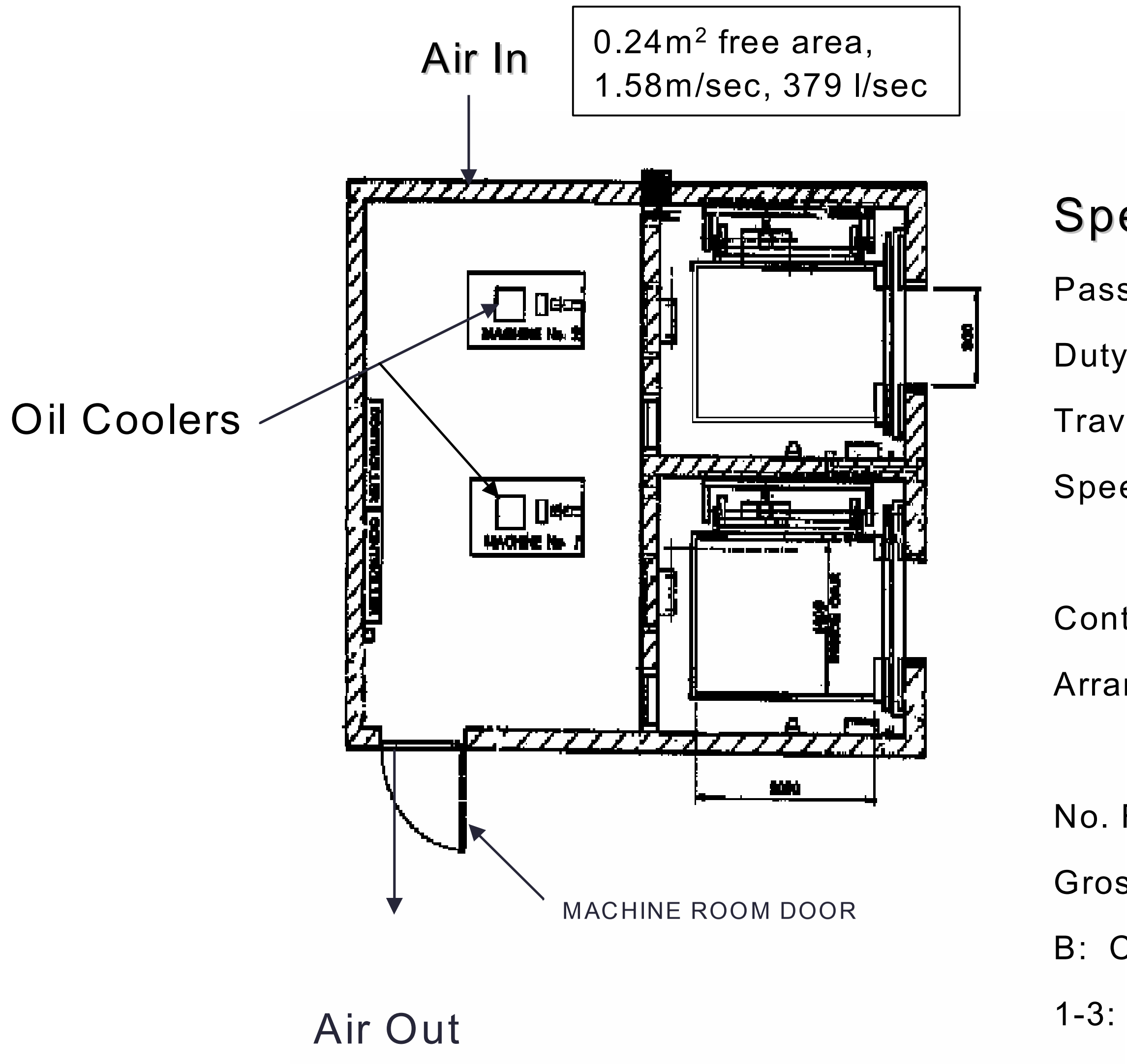


Figure 1 Energy Flow Hydraulic Lift Motor Room



Specification:

Passengers:	17
Duty:	1156 kg
Travel:	24.599m
Speed:	0.8 m /sec UP
	1.0m /sec DN
Control:	Duplex
Arrangement:	Roped Cantilever Hydraulic
No. Floors:	9
Gross Load:	2086 kg
B: Car Park	G: Lobby and Dining
1-3: Aged Hostel	4-6: Self Care
7: Roof	

Figure 2 Machine Room and Well Plan

Date/Time	kW	kWh	Start	Trip
21/04/04 8:37:06	0	0	0	0
21/04/04 8:37:09	0	0	0	0
21/04/04 8:37:12	41.553	0.0346275	1	0
21/04/04 8:37:15	0	0	0	0
21/04/04 8:37:18	42.129	0.0351075	1	0
21/04/04 8:37:21	47.883	0.0399025	1	0
21/04/04 8:37:24	48.816	0.04068	1	0
21/04/04 8:37:27	37.425	0.0311875	1	1
21/04/04 8:37:30	0	0	0	0
21/04/04 8:37:33	0	0	0	0
21/04/04 8:37:36	0	0	0	0
21/04/04 8:37:39	0	0	0	0
21/04/04 8:37:42	0	0	0	0

Figure 3 **Spreadsheet of Input Power and Calculated Energy**

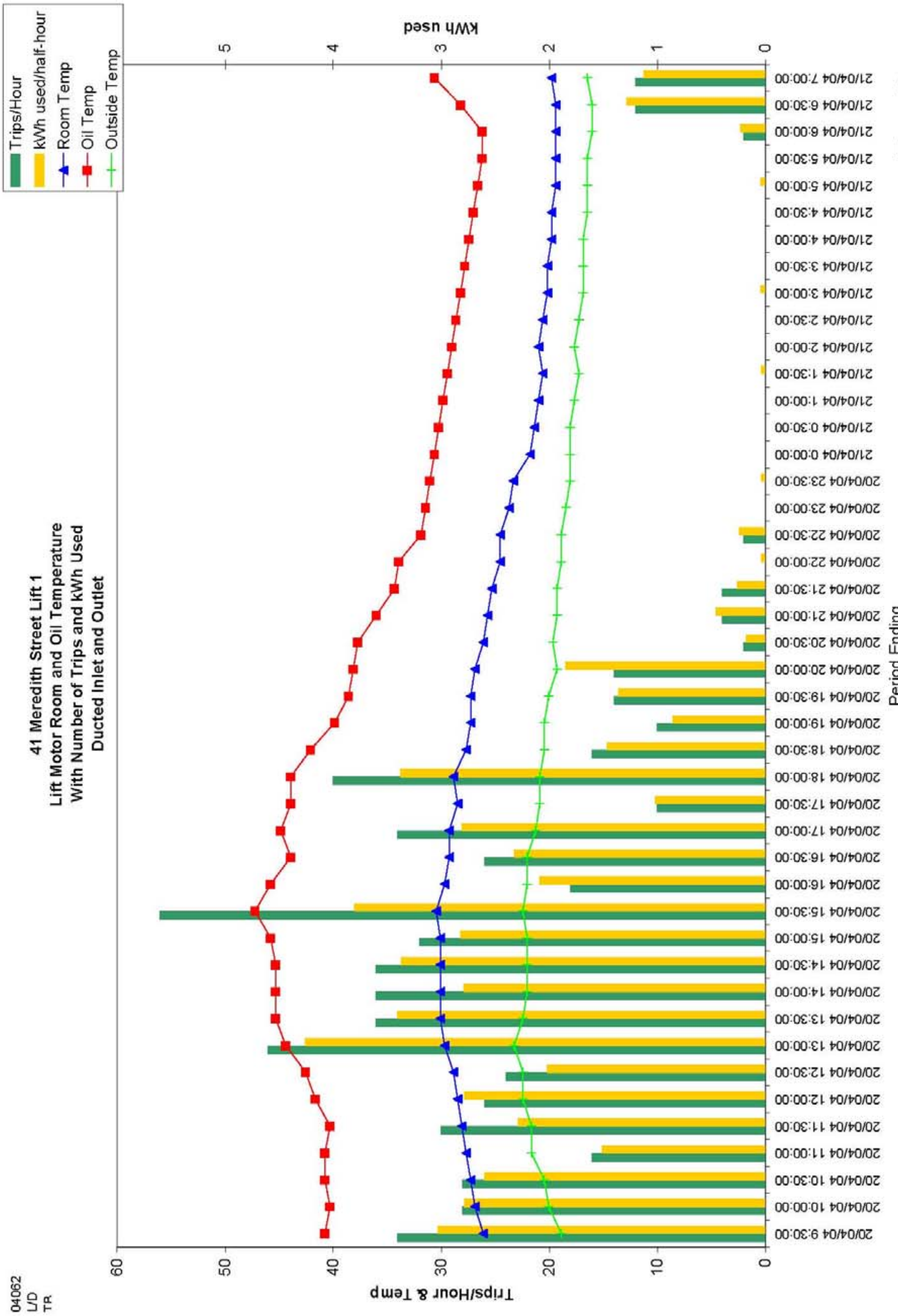


Figure 4 Results