Symposium on the Lift and Escalator Technologies

The Reliance on Testing for Modernised Lifts

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INTRODUCTION

When a lift is nearing the end of its working life then it is usually time for a modernisation, this will encompass upgrading several major components of the lift system with newer and more efficient components than before. These are usually lighter in weight and smaller than previous equipment due to the technological advancements that have been made over the years, they are also easier to obtain. This is mainly due to the introduction of the Lifts Directive [1] and subsequent Lift regulations [2] that came into force July 1999; this opened the flood gates for all member states to be able to trade effectively and safely due to the conformance procedures and subsequent CE marking that can be enacted by law. This has further been reinforced by the latest Machinery Regulations [3] with its 'intended use' certificate of incorporation.

Unfortunately this system of compliance is not considered when using the modernisation model for lifts and subsequently a great deal of reliance is left down to the test procedures adopted, but do the test procedures cover all eventualities and leave the lift totally safe to use? Furthermore which test procedure do we adopt?

All of the components chosen for the modernisation have the appropriate CE mark but collectively when placed as a complete system do not afford the same seal of approval, this is due to there being no legislative requirements for the system calculations to be performed, furthermore the simple action of weighing the car and counterweight does not always take place.

This research intends to highlight the issues by following three modernisations from start to finish with a view towards testing to see if there are any obvious frailties that come to light. If there is no car weight or it has been guessed then the knock on effects filter through to most of the major components, traction calculations, emergency braking decelerations and safety gear decelerations and sliding distances all of which are fundamental calculations carried out for a 'new' installation are affected, but none of these are recorded or asked for on a test sheet. Without the back up of conformity procedures for a modernisation the test procedure and recording should be such that these calculations *must* have been carried out before the test or it *cannot* be completed and placed back into service.

METHODOLOGY

The methodology to achieve the main aim and objectives of this dissertation has been to research the 'new lift' conformity assessment procedures within the Lifts Directive [1] and subsequent Lift Regulations [2] and current codes and standards, which in turn back up the final test results against the modernisation guidelines and test procedures.

This can be shown by following through to completion the modernisation of a lift at;

The Brunel Shopping Centre Swindon Bay 14 lift3A Goods lift.

The following on site tests were carried out with the test engineer and the findings recorded.

- Traction tests as set out within BS 8486-1:2007 section 5.4 [4]
- Balancing of the car at 50% achieved through half of the rated load placed within the car and the current readings taken from the VVVF drive at the halfway point in both the up and down directions as the car is running. Weight is then added or taken away from the car accordingly until the readings are the same in both directions, the amount of weight that has

been taken out or added will be the required amount removed or added to the counterweight accordingly.

- Brake tests as in BS8486-1:2007[4]

The actual angle of wrap was measured on site using a tape measure and calculated.
The calculations for traction using Euler's formula as from Janovsky [5] and BS EN 81-1:1998 + A3:2009[6]. The calculations do not take into account the inertia of the diverters or machine and are calculated with 125% rated load and with the car near the lowest floor.
Acknowledgement that all of the relevant data has been supplied by the third party specialists who specify the tolerances for the 'intended use' and certificate of incorporation and of the maintenance company who supplied test data and information of the modernisation.
Only one scenario is included in this review and the findings require further research.

RESULTS

By looking at The Brunel Shopping Centre Swindon Bay 14 lift3A Goods lift the following data can be ascertained:

Brunel Centre Specification of Motor Details from Sassi

INSTALLATION		**GEAR**	
Type of roping	1:1	Quantity	1
Car Speed[m/s]	0.64	Type	MB95
Duty Load[Kg]	3000	Traction sheave position	To be defined
Car Weight[Kg]	3300	Ratio	1/58
Car Travel[m]	9	Traction Sheave Ø[mm]	650
Ropes weight[Kg]	50	Ropes no. x Ø[mm]	6 16
Counterweight [Kg] (%)	4800	Angle groove[◦] U	30
Comp Chains[Kg] (%)		Angle undercut groove[◦]	87
Shaft Efficiency[%]	80	Pitch of grooves[mm]	21
Machine	TOP	Brake voltage DC	185
Type of diverters	On	Flywheel	
Number of diverters	1	MAX static load[Kg]	12000
Out of balance load [Kg]	1,582	MAX out of balance[Kg]	1,648
Static load[Kg]	11,150	Sync traction speed	0.59
Minimum alfa angle[◦]	156		
Diverter Ø[mm]	650	**MOTOR**	Ziehl Abegg
Acceleration[m/s^2]		Frame size	VFD200L-4
Electric cable mass[Kg]		Power[kW asyncr]	23
Ropes breaking load[Kg]		Poles	4
		RPM	1100
		Voltage [V]	400
		Frequency [Hz]	38
		Regulation	VVVFClosedlo
		Sts./h.	240
		Running current	49
		Starting current	96

Table 1.

The car weight had been estimated and not correctly weighed *before* and *after* the modernisation, the actual weight of the new car was found to be 2700 kg some 600 kg lighter than estimated.

The original diverter had been kept and is positioned within the shaft on the steelwork, the new raft with the new machine positioned above in the motor room. The actual on site angle of wrap was 133^0 instead of the suggested minimum of 156^0.

By looking at the above information and what is actually fitted on site we can carry out some basic calculations to back up the test procedure findings. Firstly the Critical Traction Ratio can be calculated at the minimum angle of wrap as suggested, also with what is actually onsite and with the varying weights given against actual. The calculations do not take into account the inertia of the diverters or machine. Eulers Critical Traction ratio as shown in EN 81-1+A3:2009[6] and used in Janovsky [5].

$$\frac{T1}{T2} < e^{f \times \alpha}. \qquad (1)$$

Eq 1.

f = friction factor;
α = angle of wrap of the ropes on the traction sheave in radians;
$T1$, $T2$ = forces in the portion of the ropes situated at either side of the traction sheave.

Ratio of tensions for suggested and actual

T1 Suggested	69663.75	T2 Suggested	47088
T1 Actual	63777.75	T2 Actual	41202
T1/T2 Actual	**1.547929**	T1/T2 suggested	**1.479438**

Table 2.

Showing Critical Traction ratio for suggested and actual

Traction condition	Coefficient of friction μ	Friction Factor f	Angle of suggested wrap (156^0) α	Critical traction ratio(suggested) $e^{f\alpha}$	Angle of actual wrap (133^0) α	Actual Critical traction ratio $e^{f\alpha}$
Normal Loading	0.10	0.19	2.72	**1.66**	2.33	**1.54**
Emergency Braking	0.09	0.17	2.72	**1.61**	2.33	**1.50**

Table 3.

DISCUSSION

What can be seen from Table 2 is the discrepancy for the weight of the car has led to an increase in the ratio of tensions between actual and suggested. This would not have had an impact solely on its own in this case. By looking at Table 3 Critical Traction ratio (suggested) at the angle of wrap of 156^0 Euler's formula would still hold true for both instances, however coupled with the decrease in the actual angle of wrap to 133^0 has led to the figure for normal loading to be equal to the actual T1/T2 ratio so in essence Euler's formula holds true although with any increase in acceleration traction will be lost as the emergency braking figure shows. In reality the lift passed the test procedures prescribed and some two years later traction was being lost under the emergency scenario. Many factors could have an influence on this, the groove angle would only need to increase by a couple of degrees to decrease the friction factor to make the formulae untrue, therefore wear on the sheave due to set up or poor manufacture could have contributed over the two year period tipping the balance. Whilst testing the lift the angle of wrap would not have been asked for to check or stipulated neither for the weight of car, the test sheet adopted was BS5655:10[7], these calculations, angles and weights should have been carried out and set up before installation. This immediately highlights how critical these factors are even with the 25% redundancy that is built in to the calculation. It also highlights that even after the unit has been tested for traction it has in reality 'papered over the cracks' that the modernisation relies on the testing process to prove the system is safe, rather than backing up the calculations of the desired new system, however this still does not specify how close the ratio becomes before we need to increase the angle of wrap or change the type of groove and angle or undercut to account for wear and tear of the system. The installation company embarked to rectify this issue by installing an additional diverter under the raft to increase the angle of wrap to 180^0 this being the easiest and most practical solution; however this would decrease the life of the ropes due to the reverse bends. The unit was again tested to ensure traction is not lost using the Dynamic Braking test as laid out in BS 8486-1:2007 section 5.4[4]. However the new calculation was never carried out with the new figures and the braking force of the brake never checked.

CONCLUSION

Although the majority of companies embarking on a modernisation of a lift would indeed carry out the fundamental task of weighing the car before modernising and calculating the weight of the sum of the components to be added to ensure the correct figures for calculating traction, there are a lot that do not. The above project is a prime example where estimates and assumptions are made and not checked and although on this occasion the test procedure adopted did result in traction not being lost at time of test some two years later that was not the case.

There are already enough safety codes and standards that give guidance on how to successfully achieve a safe and reliable lift system from a major modernisation; however these are just guidance and not legally binding which results in the reliance on testing procedures again and again. But the test procedures themselves, although comprehensive, do not fully cater for a major modernisation as yet and could be improved to force those that 'do not' to '*do*'.

REFERENCES

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[5] Janovsky, L. (1999) *Elevator Mechanical Design.* 3rd Edition. U.S. Edward Brothers Inc

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