Technical Report on the Lift Incident

on 25 October 2008

at Shin Nga House, Fu Shin Estate, Tai Po

Electrical and Mechanical Services Department

5 December 2008

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Introduction

In the evening of 25 October 2008, at around 7:21pm, a lift without passenger of number L32 at Shin Nga House, Fu Shin Estate, Tai Po fell to the ground floor level. Damages were found at the lift car. In addition, 7 out of the 8 suspension ropes were broken and found lying on top of the lift car as shown in Figure 1.

Figure 1 – Lift No.L32 car top and suspension ropes.

2. There was no injury or casualty resulting from the incident.

Background

3. The lift was manufactured and installed in 1986 for the Housing Authority by KONE Elevator (HK) Ltd (KONE), a Registered Lift Contractor registered under the Lifts and Escalators (Safety) Ordinance (LESO), Chapter 327 of the Laws of Hong Kong. The lift is driven by an electric motor with rated speed at 2.5 metre per second (m/s) and rated load at 1,250kg. It served the 35-storey building with stops at every 3 floor interval (namely G/F, 2/F, 5/F, 8/F …. 35/F). From 1986 to January 2008, the lift was under the management and control of the Housing Authority and was not within the jurisdiction of the LESO. From 1 February 2008, the

management of the lift was transferred to the Incorporated Owners of the Fu Shin Estate, and as a result, the lift came under the control of LESO.

4. The maintenance of the lift was provided by KONE since 1986 till July 2008. The last periodic examination of the lift was conducted by a Registered Lift Engineer (RLE) of KONE on 5 January 2008, and the lift was certified to be in a safe working condition. On 1 August 2008, the maintenance responsibility of the lift was taken over by ThyssenKrupp Elevator (HK) Ltd (ThyssenKrupp), another Registered Lift Contractor. On 18 August 2008, a RLE of ThyssenKrupp conducted a periodic examination of the lift and confirmed the lift was in safe working order.

Components of the Lift

5. The layout of the lift is shown in Figure 2. The lift and its counterweight were driven by the electric motor in a double wrap 2:1 ratio roping system. The 8 suspension ropes were working in tandem, each had its own individual traction groove in all the pulleys. The rope ends were fixed to the floor of the lift machine room at the top of the lift shaft. There was a set of compensating ropes connecting the bottom of the lift car to the bottom of the counterweight. The overspeed governor, a device to detect overspeed operation of the lift car, was installed on the floor of the machine room next to the drive motor. The vertical movement of the lift was guided by two guide rails on both sides of the lift car. In the event of overspeeding, the overspeed governor would activate the safety gear at the lift car, which would bring the lift car to a stop by gripping the guide rails and holding the car there. At the bottom of the lift shaft, there were two hydraulic buffers providing a cushion to stop the lift and counterweight when they overrun their bottom limits of travel.

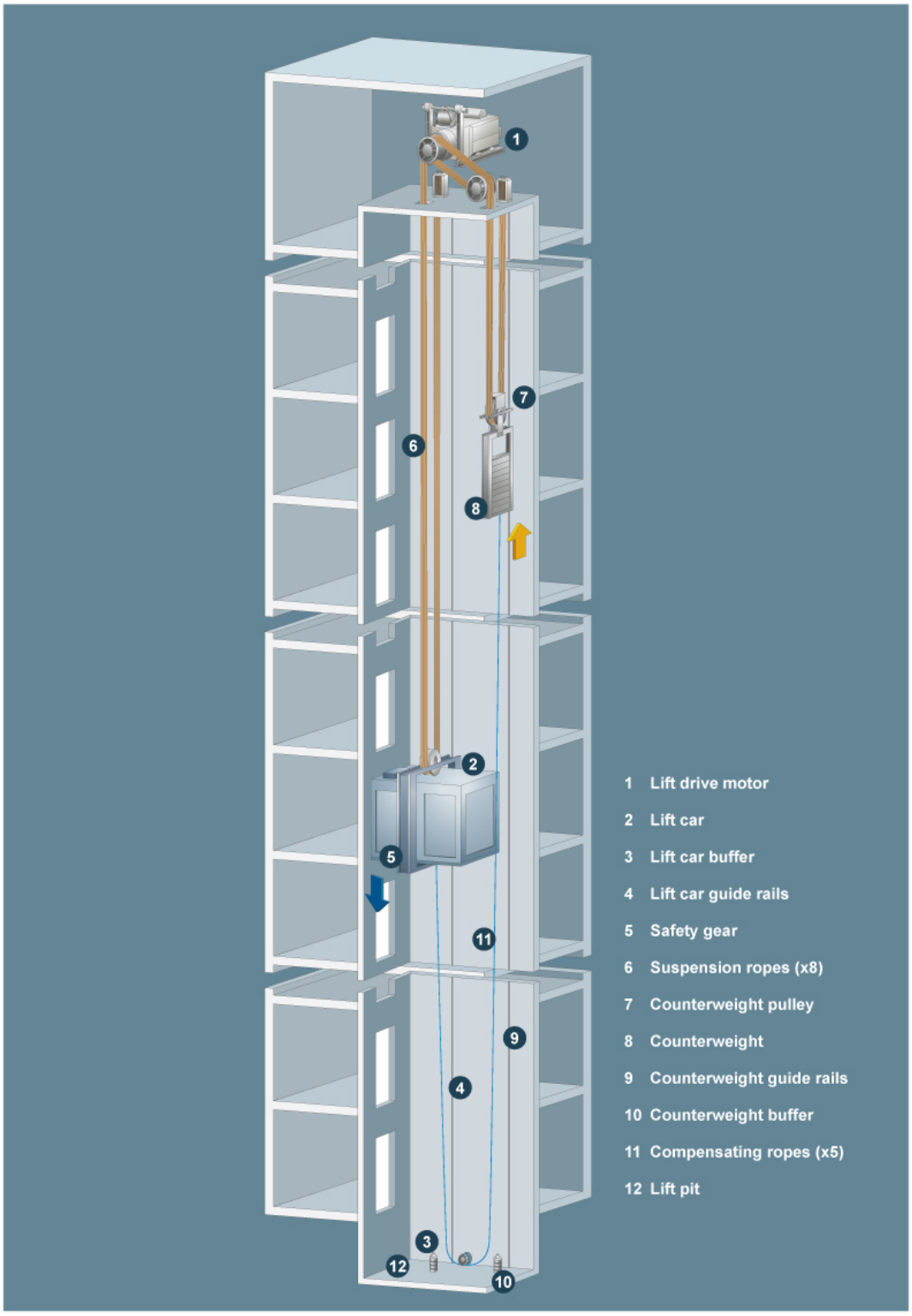


Figure 2 – Layout of Lift L32.

Approach of the Investigation

6. The approach adopted by EMSD in conducting the investigation is outlined as follows:

6.1 Analyse relevant records collected during the investigation, in particular the examination reports by the RLE, the Closed Circuit Television (CCTV) footage of the lift interior before the incident;

6.2 Interview maintenance staff of ThyssenKrupp, duty staff of the building managing company and the residents in Fu Shin Estate;

6.3 Inspect, check and analyse the lift components, including the damaged suspension ropes, overspeed governor, safety gear and electrical system;

6.4 Conduct site measurements and desk-top analysis to simulate the movements of the lift car, the suspension ropes and counterweight during the incident.

6.5 Arrange for laboratory examinations of the key lift components namely suspension ropes, overspeed governor, safety gear, pulley and bearings by the City University of Hong Kong and Public Works Central Laboratory.

Observations and Findings

7. The video footage captured from the estate management's CCTV system and the information provided by residents revealed the following operation of the lift shortly before the incident :

7.1 At 7:18:56pm, a teenage girl entered the lift on the 32nd floor. The lift then descended to the 17th floor where a man entered the lift at 7:19:26pm.

7.2 The lift descended to the 14^{th} floor where the girl left the lift car at 7:19:43pm. The lift continued to descend to ground floor where the man left the lift car at 7:20:18pm.

7.3 The empty lift ascended to the 14th floor; door opened at 7:21:13pm and door closed at 7:21:23pm. The video recording stopped at 7:21:30pm.

8. Visual inspection on the components of the lift after the incident revealed that:

8.1 Seven out of eight suspension ropes were found broken. Five ropes were found broken at position around 1.1 to 1.2 metres from the anchored points on the counterweight side. The other 2 ropes were broken at around 2 to 2.5 metres from the anchored points (see Figure 3 in Appendix A.)

8.2 The overspeed governor in the machine room was damaged. (see Figure 4 in Appendix A) The 2 'I-beams' supporting the lift motor inside the machine room were deformed. (see Figure 5A and 5B in Appendix A.) The bracket of the counterweight pulley was found with grease marks and scratches resulting from contact with moving ropes and the pulley. (see Figure 6A and 6B in Appendix A.)

8.3 The suspension ropes passed through the floor of the machine room to the lift shaft through openings in the concrete slab. There were new abrasion marks on the side of the concrete slab. (see Figure 7 in Appendix A.)

8.4 The counterweight pulley was found lying on the top of the counterweight and the bearing of the counterweight pulley was found broken lying on the floor of the lift pit. (Figure 8 in Appendix A shows the damaged bearing.)

8.5 The two guide rails were found to have scratch marks starting from 10th floor down to the ground floor. (see Figure 9 in Appendix A.)

8.6 The safety gear was found having scratch marks on both surfaces, see Figure 10 in Appendix A.

8.7 The top counterweight rail bracket was found deformed. (see Figure 11 in Appendix A.)

Results of the Laboratory Examinations

9. All the eight suspension ropes of the lift were tested for tensile strength at the Public Works Central Laboratory. The test results showed that the tensile strength (66kN each) of all the suspension ropes complied with the manufacturer's technical specification (60kN each) and in line with the requirements laid down in international standards.

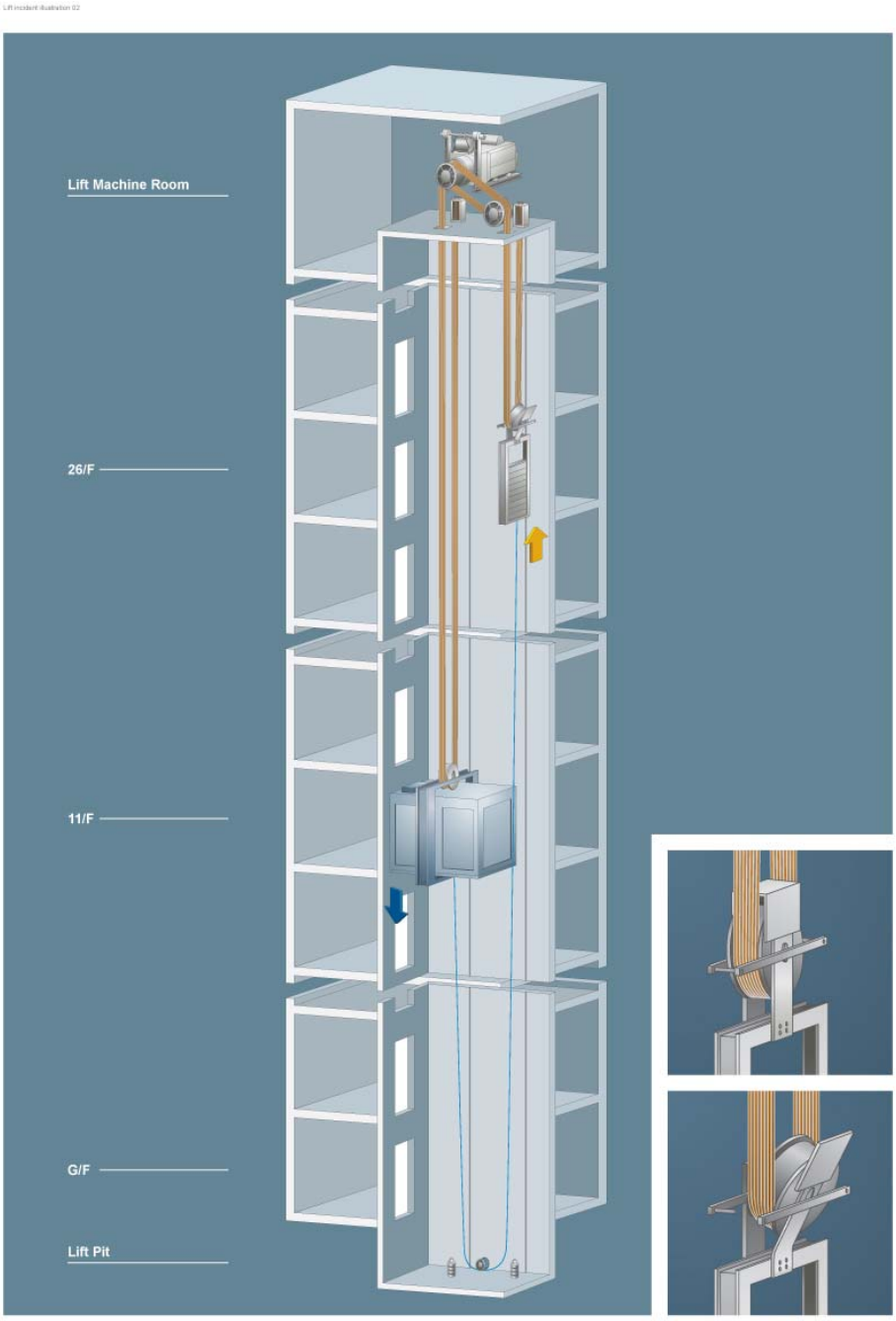
10. The 7 sets of broken suspension ropes were examined by City University of Hong Kong (CityU). The examination revealed that the fracture surfaces generally had the characteristics of overstressing tensile failure.

11. The pulley shaft and bearing of the counterweight were also examined by CityU. Corrosion was found at the inner surfaces, bearing balls and contact surface between the bearing and the shaft.

Scenario of the Incident

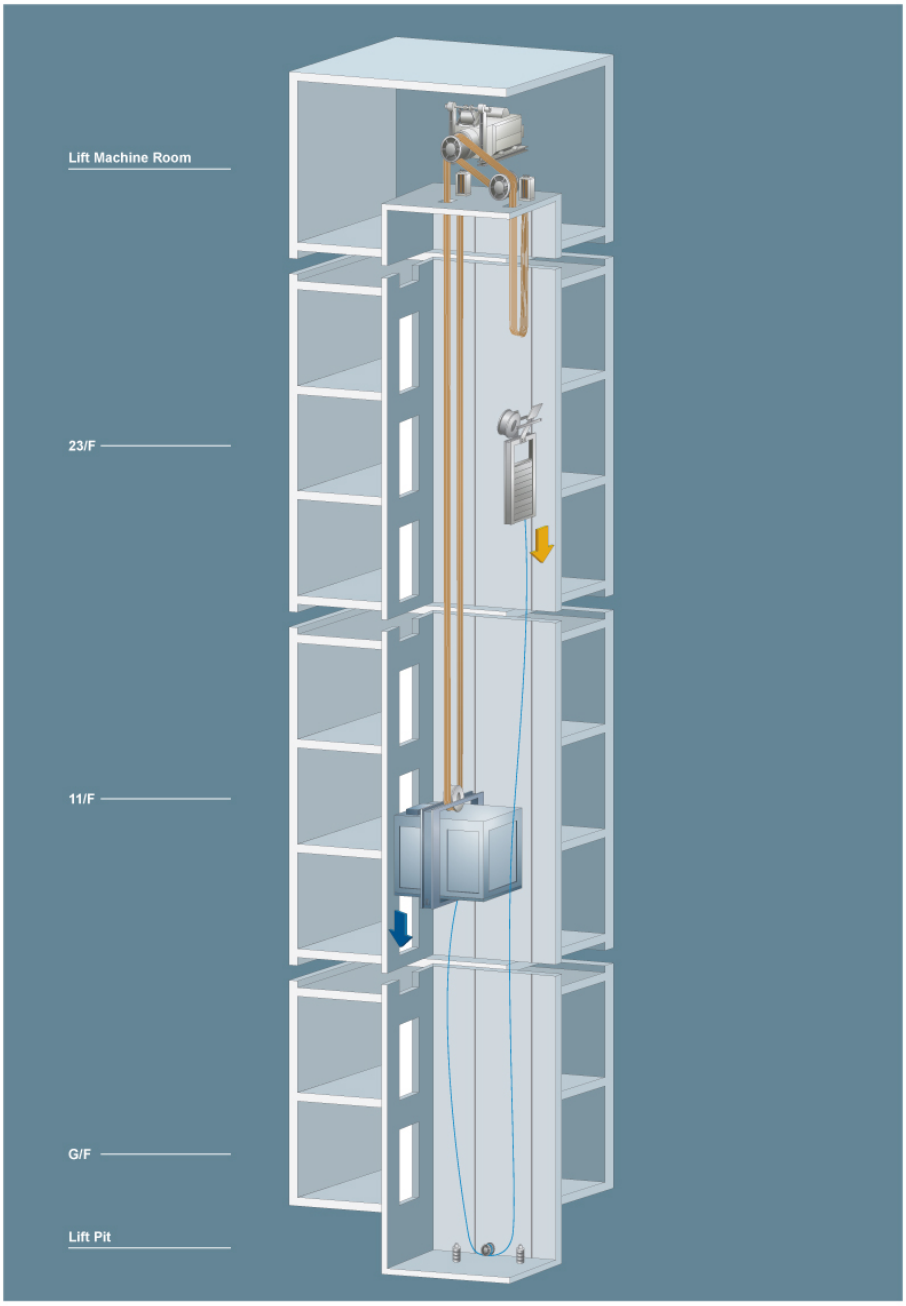
12. Based on the findings of the investigation, the possible scenario of the incident is as follows: -

12.1 When the lift descended from the 14th floor to ground floor at around 7:21pm, the lift counterweight ascended upward to the 21st floor. The corroded inner race of the counterweight pulley bearing fractured, causing the bearing balls coming loose from the bearing track. As a result, as shown in Sketch 1, one side of the pulley shaft lost support and consequently, the pulley tilted upward by the pull of the suspension ropes. The tilting also caused the pulley to come into contact with the counterweight bracket and exert pressure on it, causing one of the "arms" deformed. When one end of the shaft could no longer be retained by the bracket, the suspension ropes completely dislodged from the pulley.



Sketch 1 – Dislodgement of the suspension ropes from counterweight pulley.

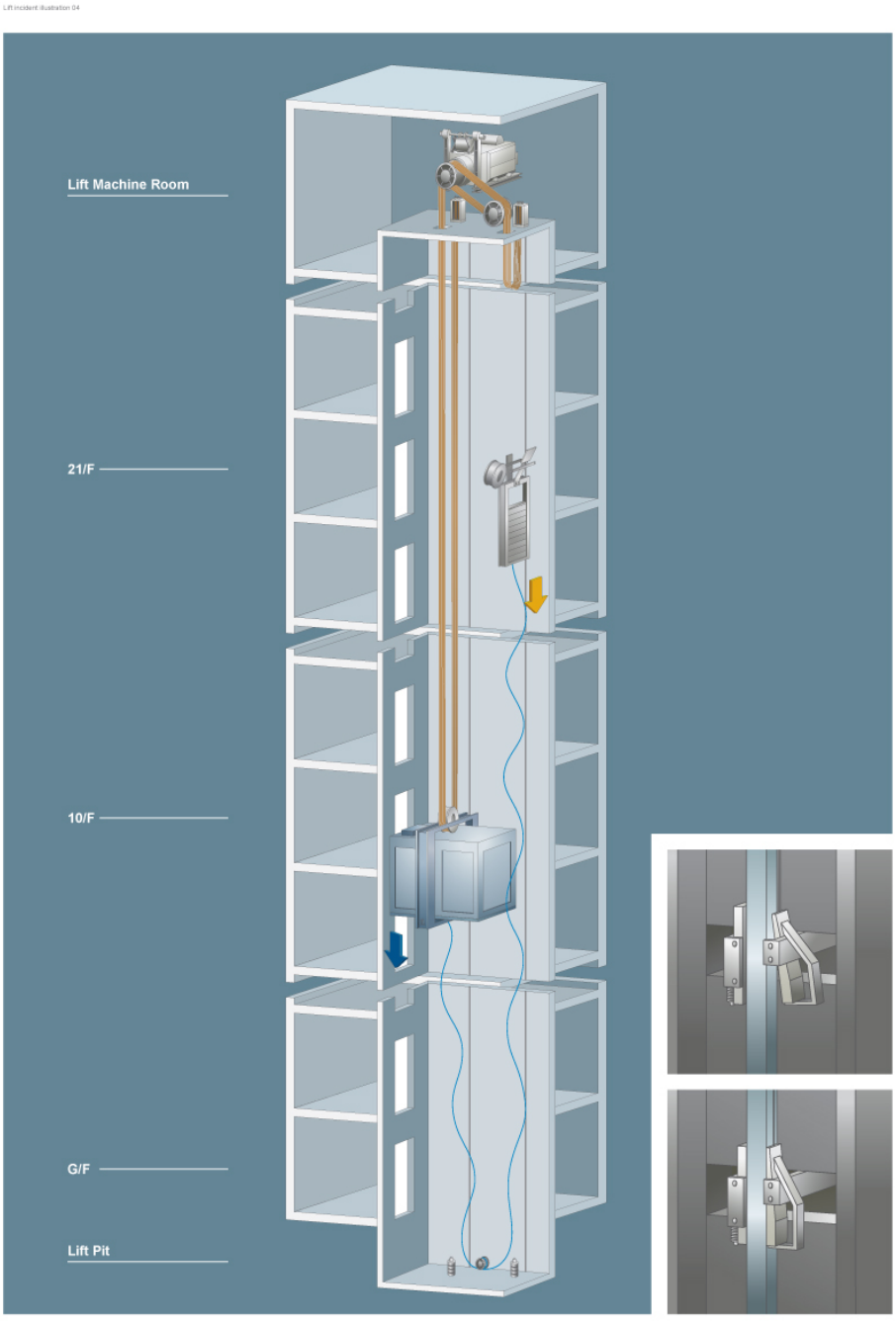
12.2 As shown in Sketch 2, due to the dislodgement of the suspension ropes, the counterweight was set free and slid down under gravity along the counterweight guide rails towards the bottom of the lift shaft. The counterweight pulley also detached from the bracket and fell under gravity. Without the counterweight, the lift car started descending and gaining momentum.



Sketch 2 – Lift Car and Counterweight slid under gravity.

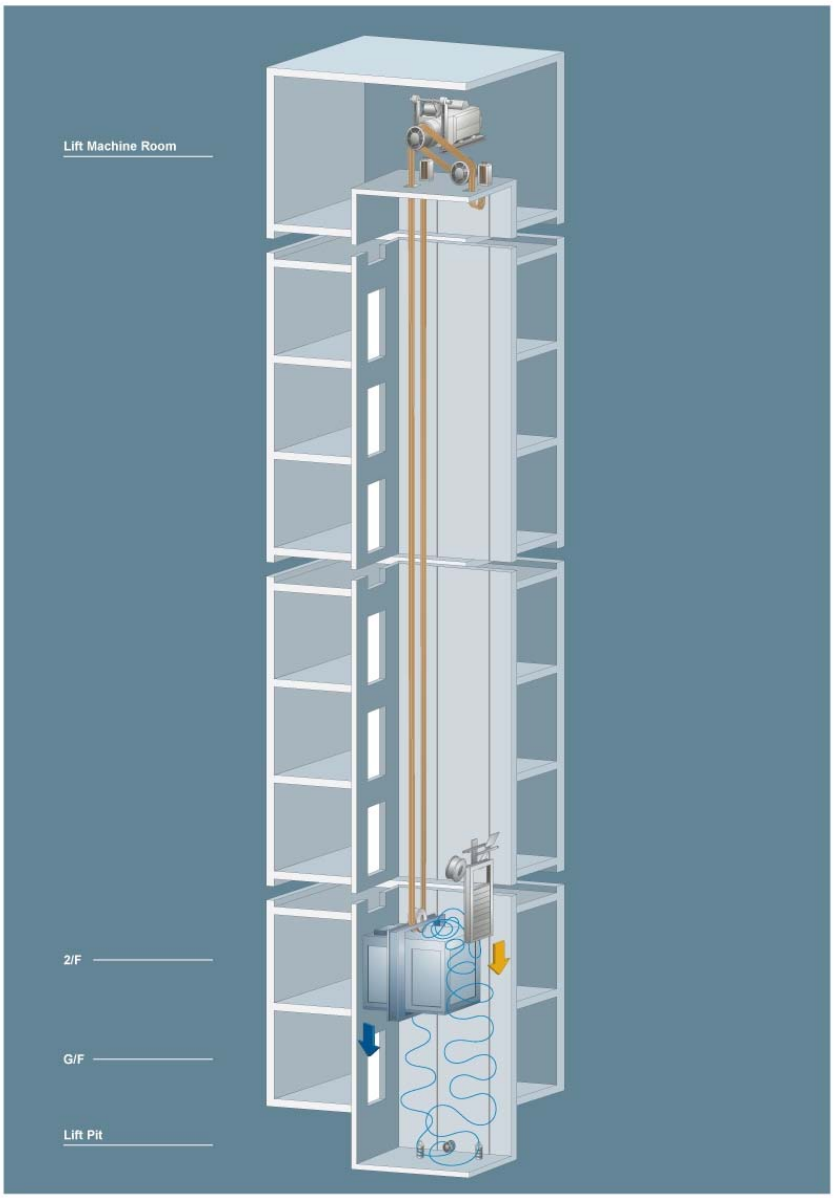
12.3 Accelerating above the rated speed, the overspeed governor activated its electrical switch stopping the lift motor operation and applying the motor brake. Because the suspension ropes were not in tight contact with the motor pulleys, there was not sufficient friction and the motor brake was not effective to stop the descending of the lift car. As shown in Sketch 3, the lift car continued to accelerate,

the overspeed governor activated the safety gear of the lift at around the 10th floor, and slowed down the lift car. The safety gear, however, did not bring the lift car to a stationary position.



Sketch 3 – Lift car safety gear activated and slowed the lift car.

12.4 In the meantime, the counterweight also slid down along the guide rails. Because of the limited space between the lift car and counterweight, (a horizontal clearance of about 65mm only), it is suspected that the compensating ropes (5 in number and each of 16 mm diameter) connected to the bottom of the counterweight became tangled on the top and the side of the lift car. As the counterweight was accelerating under gravity, the counterweight and the tangled



Sketch 4 – Counterweight and the tangled compensating ropes forced the lift car into the lift pit.

compensating ropes exert extra loading on the lift car. The load imposed by the descending counterweight and the tangled compensating ropes forced the lift car to travel further downwards overshooting the ground floor level into the lift pit, see Sketch 4.

12.5 When the lift car overshot the ground floor level into the lift pit, seven out of the eight suspension ropes became taut, while one rope came out of the diverter pulley and was not tight. Five suspension ropes were pulled against the concrete floor slab of the lift motor room whilst two suspension ropes were pulled against the counterweight rail bracket at the top of the lift shaft. The resultant force due to the fall of the counterweight and the lift car exceeded the tensile strength of the ropes, and broke these seven ropes, see Sketch 5. The remaining one rope which was loose was not broken.

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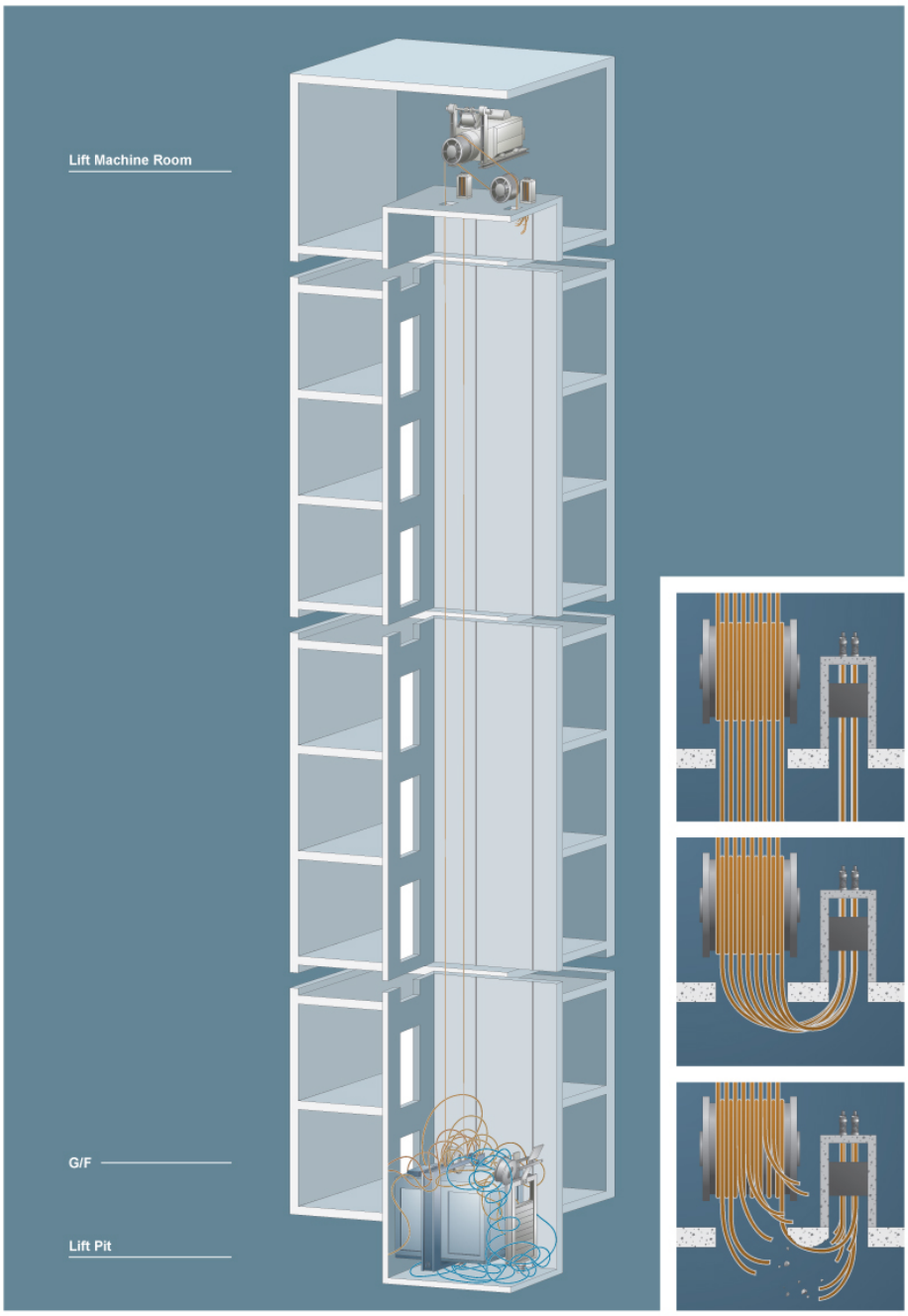

Sketch 5 – The resultant force due to the fall of the counterweight and the lift car broke the suspension ropes.

Measures to prevent recurrence of similar incident

13. During the periodic maintenance and periodic examination of the lift, the Registered Lift Contractors and Registered Lift Engineers shall strictly follow the manufacturers' recommendations and the technical requirements for the

maintenance of lift components as stipulated in the Code of Practice, and ensure that key components are in good working conditions including:-

a) all drums, sheaves, pulleys and bearings;
b) overspeed governor, safety gear, guide rail and guide shoe of the lift car and counterweight; and
c) suspension ropes, compensating ropes/chains and their anchorages.

Actions by EMSD

14. EMSD will step up inspection to enhance monitoring of the performance of Registered Lift Contractors and Registered Lift Engineers to ensure all technical and legal requirements are observed and complied with.

15. EMSD will enhance the content of the Code of Practice in conjunction with the trade to facilitate maintenance and examination to the key components of lifts.

Electrical & Mechanical Services Department

5 December 2008

Appendix A – Photos

Figure 3 - Broken suspension ropes found in Lift Motor Room.

Figure 4 – Damaged lift overspeed governor.

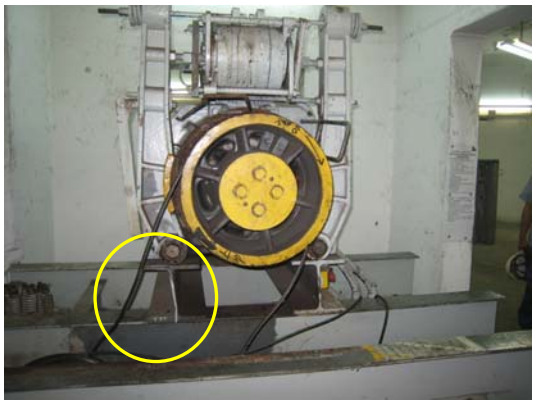

Figure 5A – I-beams of lift motor were deformed.

Figure 5B – Close-up view of the deformed I-beam.

Figure 6A – Rope markings on counterweight pulley bracket.

Figure 6B – Close-up view of the rope marks and pulley scratch mark on counterweight pulley bracket.

Figure 7 – Concrete slab with new abrasion marks.

Figure 8 – Damaged counterweight pulley bearing.

Figure 9 – Intermittent scratch marks on guide rail.

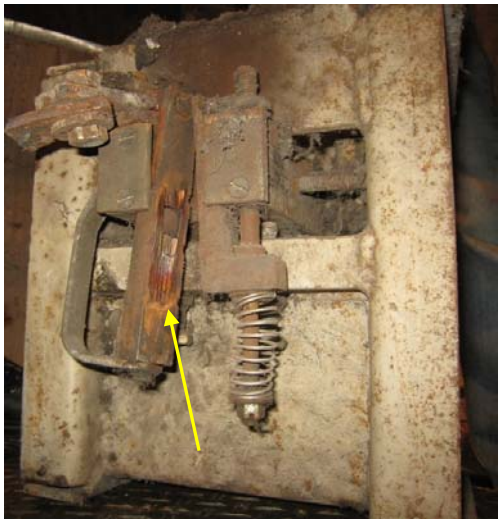

Figure 10 – Fresh scratch marks on the safety gear.

Figure 11 – Deformation of counterweight rail bracket (on the right hand side when looking into the lift shaft from 35/F landing)