Technical Investigation Report on Lift Incident

at 478-480 King's Road, North Point, Hong Kong

Electrical and Mechanical Services Department
July 2013

CONTENTS

Executive Summary

On 2 March 2013, the lift No. 5 at 478-480 King's Road, North Point, carrying seven passengers, dropped into the bottom of the lift shaft when the lift car ascended from the ground floor and reached the first floor, causing injuries to all seven passengers inside. It was found that all the four suspension ropes were broken, and the safety gears were not activated to stop the lift from falling.

The Electrical and Mechanical Services Department (EMSD) had completed the technical investigation with the assistance of independent experts engaged to find out how the incident occurred. The investigation revealed that this was a rare incident. All the four suspension ropes were broken at almost the same time when the lift car ascended from the ground floor and reached the first floor. The lift car then started to fall but the safety gears were not activated to stop or decelerate the lift even though the falling speed had exceeded the activation speed of the overspeed governor.

The investigation findings indicated that the suspension ropes broke at between 12.5 m to 13.5 m from the fixing points at the lift car. The failure of the suspension ropes was due to insufficient lubrication for a prolonged period of time. This had caused abrasive wear between and within the strands of the suspension ropes. Moreover, excessive wear between the suspension ropes and the traction sheave was observed. These had resulted in the reduction of rope diameter and the breakage of individual wires in the strands, hence reducing the strength of the suspension ropes. Prior to the failure, the four suspension ropes had deteriorated severely to similar extent, with serious wear and rouging, so that the ropes failed at more or less the same time.

The investigation revealed that the pawl of the overspeed governor had failed to engage onto the teeth of the ratchet wheel during the incident when the activation speed of the overspeed governor was reached. The investigation further revealed that improper connection of the deformed tension spring and rust on the pin of the pawl were attributable to the unsuccessful engagement of the pawl and ratchet wheel, thus causing the failure to activate the overspeed governor. Therefore, the safety gears of the lift were not activated by the overspeed governor to stop the lift from falling.

Technical Investigation Report on Lift Incident
at 478-480 King's Road, North Point, Hong Kong on 2 March 2013

1. Objectives

1.1 This report presents the results of the technical investigation conducted by the Electrical and Mechanical Services Department ("EMSD") on the lift incident occurred at 478-480 King's Road, North Point, Hong Kong on 2 March 2013.

2. Background of the Incident

2.1 EMSD received an incident report from the call centre of the Fire Services Department at around 8:23 pm on 2 March 2013 involving the trapping of seven passengers inside lift No. 5 at 478-480 King's Road, North Point, Hong Kong ("the lift"). All seven passengers were rescued by firemen and admitted to hospitals. EMSD staff arrived at the scene at about 9:15 pm on the same day to carry out an investigation into the cause of the incident.

2.2 The investigation revealed that all four suspension ropes of the lift were broken, and the safety gears of the lift were not operated to hold the lift car on the guide rails. The lift car dropped from 1/F to the bottom of the lift shaft, injuring all seven passengers.

3. Regulatory Control over Lift Safety

3.1 Regulation regime

The Lifts and Escalators Ordinance (Cap 618) (the "Ordinance") provides the statutory framework to ensure lift safety in Hong Kong. Under the Ordinance, only registered lift contractors, registered lift engineers and registered workers are qualified to carry out lift works, including construction, installation and maintenance services. The responsible person for a lift is required to ensure that the lift and all its associated equipment or machinery are kept in a proper state of repair and in safe working order. The responsible person shall arrange a registered lift contractor to carry out periodic maintenance at an interval not exceeding a month. The responsible person shall also engage a registered lift engineer to carry out periodic examination for the lift at an interval not exceeding 12 months.

3.2 Audit inspection

EMSD, as the Registrar and regulatory authority, maintains registers for qualified lift contractors, engineers and workers, and monitors their performance to ensure that the services they provided meet the requirements stipulated in the Ordinance and Codes of Practice for Lift Works and Escalator Works (the "Code of Practice"). EMSD adopts a risk-based approach to conduct audit inspections to lift and escalator works to identify any non-compliance with the requirements of the Ordinance and Codes of Practice. Under the risk-based approach, lifts and escalators are selected for audit inspections taking into account the assessed risks in respect of age, type of installation, nature of works associated with installation, complaint, incident, change-over of maintenance contractor and past performance of the responsible registered contractors. On average, more than 9,000 audit inspections are conducted each year.

4. Technical Information of the Lift Involved in the Incident

4.1 The lift was driven by an alternating current two-speed (AC-2) geared machine, with a rated speed of 1.0 metre per second (m/s) and a rated load of 900 kg (or 12 persons), serving the G/F, 1/F, 2/F and 3/F of the building. The total travel of the lift was about 12 metres (m).

4.2 The lift was suspended by four suspension ropes, each with nominal diameter of 12 millimetres (mm). The lift adopted a side traction roping arrangement so that the traction machine of the lift was not placed directly above the lift well. Suspension ropes were diverted to the lift car and counterweight respectively using diverting pulleys. Figure 1 shows the arrangement of the traction machine/sheave and the diverting pulleys of the lift.

4.3 Technical details of the lift are summarized as follows:

Make	:	Mitsubishi
Type	:	Electric passenger lift
Drive Control	:	Alternating current two-speed electric motor
Door Control	:	Horizontal centre opening
Rated Speed	:	1.0 metre per second
Rated Load	:	900 kilograms
Rope Ratio	:	1 to 1 (machine on top with side traction)
Floors Served	:	G, 1, 2, 3/F
Year of Installation	:	1974
Date of Last Examination by Registered Lift Engineer	:	21 November 2012

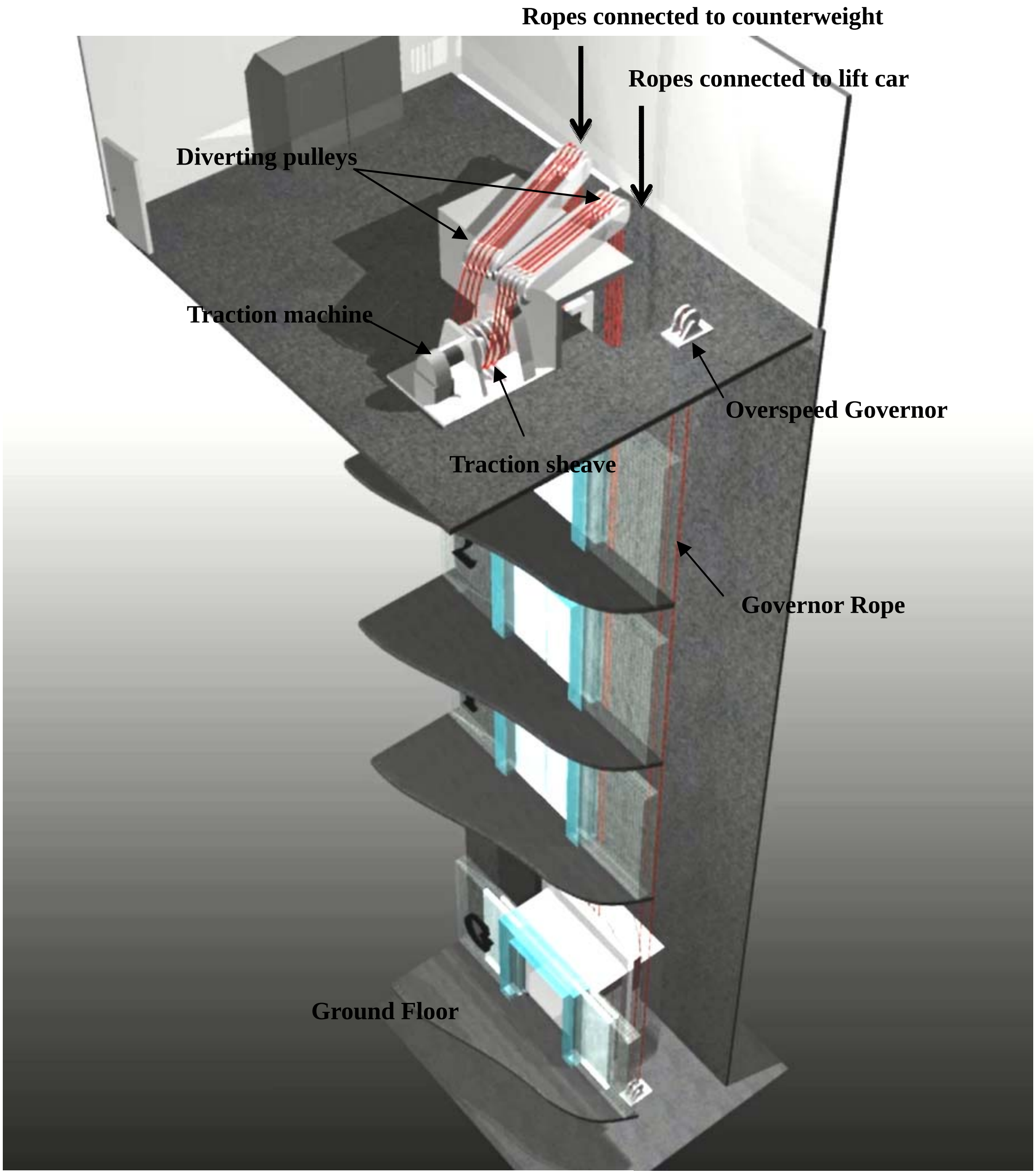


Figure 1 : Arrangement of the lift

5. Approach of Investigation

5.1 EMSD conducted the technical investigation with a view to identifying the causes leading to the incident. The approach of the investigation is outlined below:

(i) inspect, check and analyse the lift components that were involved in the incident, including the broken suspension ropes, machine brake, overspeed governor, safety gears, guide rails, traction sheave and buffer;

(ii) conduct the following tests and examinations with the assistance of independent experts :

- ➢ thorough examination of the broken suspension ropes and conduct tensile testing of the rope sections to assess the quality of the ropes;

- ➢ examine the critical components of the lift and conduct on site simulation tests to verify the functioning of the lift components including machine brake simulation test, activation speed test and pull-through test of the overspeed governor; and

- ➢ assess the impact speed of the lift car on the buffer during the incident.

(iii) interview and take statements from relevant personnel for collecting information related to the incident, including:

- ➢ five maintenance workers and two directors of Shineford Engineering Limited ("Shineford");
- ➢ registered lift engineer who carried out statutory annual examination of the lift on 21 November 2012;
- ➢ workers who replaced the suspension ropes of the lift in September 2010;
- ➢ seven passengers who were involved in the incident;
- ➢ two responsible persons for the lift; and
- ➢ representatives of the occupants on 1/F and 2/F of the building.

(iv) review and analyse relevant records including logbook, maintenance records provided by Shineford, suspension ropes replacement records, test and examination report issued by the registered lift engineer, occurrence report submitted by Shineford. Records examined are listed in Appendix I.

6. Observations and Findings

<u>Possible causes of the incident</u>

6.1 According to the indication of the floor selector of the lift, the lift car was at a position near 1/F before falling of the lift car. According to the information provided by one of the lift passengers injured in the lift incident, the lift was ascending from the ground floor and had already reached the first floor before the incident.

6.2 Based on the on-site observation, it was found that the lift car plunged onto the spring buffer. The following possible causes could lead to such outcome:

(a) The lift machine brake failed and the lift car fell to the lift pit due to the weight of the lift car and passengers but the safety system did not function. The counterweight overshot upwards and then fell down. The impact force caused breakage of the ropes; or

(b) The ropes broke and the safety system failed to function.

<u>Lift machine brake</u>

6.3 The lift machine brake was designed to hold the lift. A brake test was carried out on site on 12 March 2013. The results showed that the machine brake was operating normally and there was no abnormal delay in its operation. The linings of the machine brake were also examined and found to be in a reasonably good condition. Thus, the plunging of the lift car was not caused by the failure of the lift machine brake as suggested in section 6.2(a) above.

<u>Suspension ropes</u>

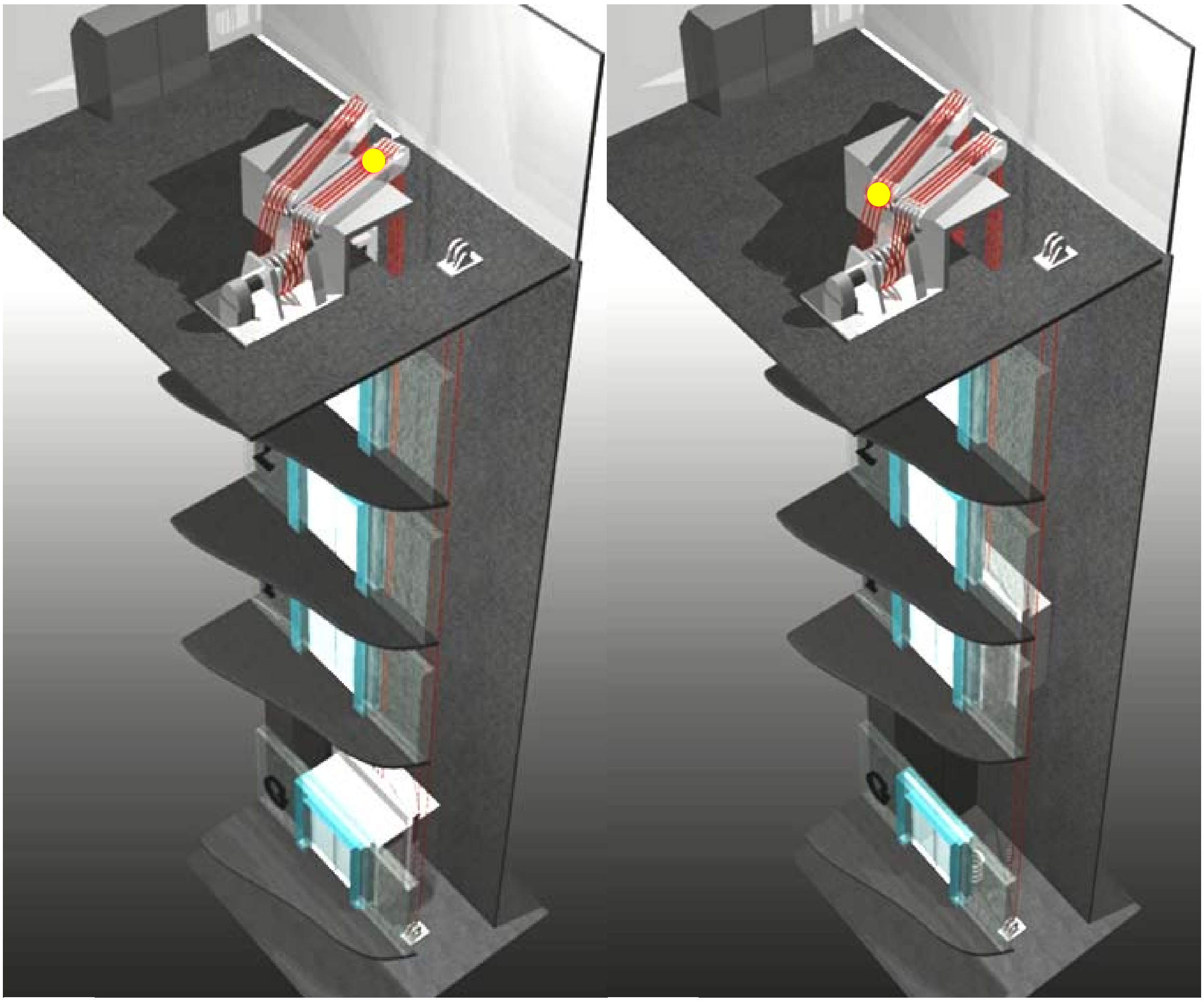
6.4 The four suspension ropes were found broken at positions between 12.5 m and 13.5 m from the fixing points at the lift car, corresponding to the point where the suspension ropes rest on the diverting pulleys when the lift was at G/F (refer to Figure 2). The G/F is the floor with the most frequent stops, thus the above sections of the suspension ropes should experience the largest loading and unloading pressure when the passengers enter and exit the lift car.

6.5 There are several possible causes of rope breakage including:

(a) Overloading;
(b) Inadequate strength of the ropes ;
(c) Stalling of lift car causing abrasion of ropes on running sheave; and
(d) Wear and tear leading to a reduction in tensile strength of the ropes.

Operating conditions

6.6 At the time of incident, there were only seven passengers in the lift car. The estimated weight is 455 kg. This was well below the rated load of 900kg of the lift, i.e. twelve passengers. Therefore, overloading as mentioned in section 6.5(a) was not the cause of rope breakage.



2a 2b

Figure 2 : A pictorial view to show the position of breaking points of the suspension ropes (yellow dot) corresponding to different positions of the lift car. The diagram on the left hand side (2a) shows the lift car on G/F. The diagram on the right hand side (2b) shows the lift car on 1/F.

Replacement of suspension ropes

6.7 The suspension ropes of the lift concerned were replaced by Shineford in September 2010. Based on the copies of suspension rope certificate and delivery order submitted by Shineford, the replacement ropes were manufactured by a rope manufacturer in Japan. Each rope was constructed by eight strands. Each strand contained nineteen wires (Please refer to section 1 of Appendix II). The nominal diameter of the ropes is 12 mm. The specifications of the ropes complied with that specified by the lift manufacturer. Besides, an identification ribbon for the ropes produced by this manufacturer was found in the fibre cores of the broken suspension ropes. The above findings together with the findings in section 6.15 indicate that the scenario suggested in section 6.5(b) was not the cause of the rope breakage.

Examination of suspension ropes

6.8 The suspension ropes were carefully examined by a lift expert. No sign of burnt mark was found indicating that rubbing between stationary ropes against a rotating traction sheave had not occurred. Therefore, the scenario as suggested in section 6.5(c) was not the cause of rope breakage.

6.9 The four suspension ropes were found broken at about the same position (i.e. near to the diverting pulleys). Visible wear and red iron oxide particles (also known as rouge) could be observed from the suspension ropes, in particular at sections close to the breakage points. Figure 3 shows the sectional view of a typical suspension rope of a lift.

6.10 At the very ends of failed strands in all ropes, only king wires and inner wires were found. The fibre cores and the outer wires were completely missing (refer to Figure 3a). Adjacent to the failed ends, the strands of the ropes opened up after failure. Detailed examination revealed that the fibre cores of the ropes could not be found in the suspension ropes until at some distance from the failed ends. It was suspected that movement of the wires had already cut the fibre cores into small pieces, which had escaped from the ropes when they broke (refer to Figure 3b). Besides, notches formed on the outer wires of the strands were observed and these indicated that abrasion had occurred between strands of the ropes (refer to Figure 3c).

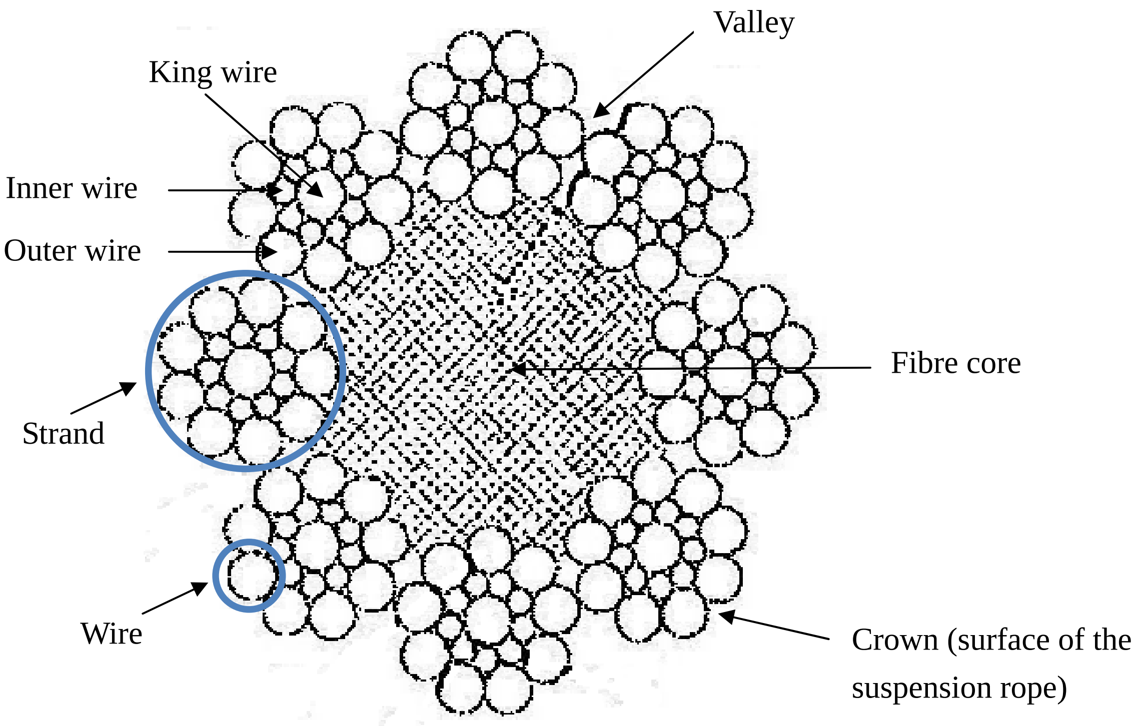


Figure 3 : Sectional view of a wire rope

Figure 3a : A closer view of the broken end of a suspension rope. Only inner wires and king wires remained.

Figure 3b : The fibre cores were missing in a short section next to the failed end of the rope.

Figure 3c : Notches formed due to abrasion between strands.

6.11 Away from the failed ends, the suspension ropes were relatively dry and rouge was observed in the valleys between strands along a substantial section of the suspension ropes. Moreover, wear was clearly visible along outer wires for most of the length of all ropes (refer to Figure 4).

Figure 4 : Wear of the rope along outer surface (crown wear) and red iron oxide particles (rouge) in the valleys between strands.

<u>Traction sheave</u>

6.12 The grooves of the traction sheave were examined. According to the design, an undercut is made to each groove so that the pressure between the suspension rope and the groove would be increased (see Figure 5). This feature helps to increase the friction between the ropes and the sheave to provide the traction required for effective operation of the lift.

6.13 The examination revealed that the four grooves in contact with the ropes were found to have worn down to the bottom of the undercut (see Figure 6). A traction sheave with this substantial groove wear would result in rope slip and hence extra abrasion of the rope as shown in Figure 4.

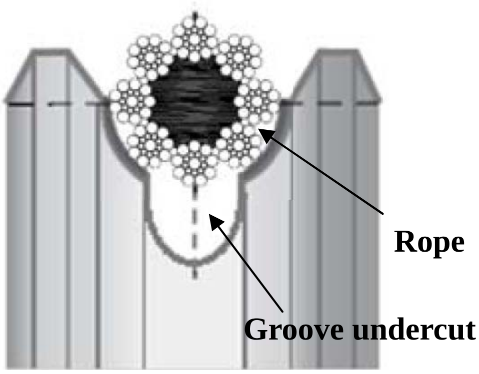


Figure 5 : Undercut of sheave groove

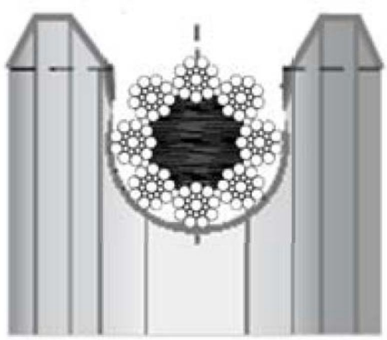


Figure 6 : Groove worn down to the bottom of the undercut

Tensile strength of the suspension ropes

6.14 The suspension ropes were subject to wear and tear thus leading to a reduction in tensile strength. Tensile tests on the ropes were carried out to assess the extent of reduction in strength. Eight of the test pieces were cut from the four broken suspension ropes. Three of them were cut from the position near the fixing points to the lift while the other five were cut from the ropes near to the failed ends.

6.15 The test samples cut from the ropes near to the fixed ends did not pass over the traction sheave, and hence were not subject to wear and tear. The average breaking load of the three test samples was found to be 69.8 kN (as compared to the breaking load of 58.8 kN specified on the certificate for the suspension ropes). The test results indicated that the strength of the suspension ropes at these sections complied with the requirement as indicated on the certificate. See also section 6.7.

6.16 With regard to the samples collected from the ropes near to the failed ends, the tests indicated the average strength of the five samples was 38.5 kN with a minimum of 23.7 kN for one of the samples. The test results indicated that the tensile strengths of these sections which were subject to substantial wear and tear during service had been significantly reduced to about 34% of its design strength. Further reduction in the tensile strength of the ropes at the failed ends was expected as they were the weakest points of the ropes.

Possible cause of rope breakage

6.17 From the results of the tensile tests and examination of the suspension ropes, it is obvious that the failure of the ropes was due to excessive wear and tear of the ropes. Due to insufficient lubrication for a prolonged period of time since their replacement in September 2010, the fibre core of the rope section had dried up and could not provide the strands with the necessary lubrication and radial support. The strands came in contact with each other causing abrasive wear between and within strands. These had resulted in significant reduction in the strength of the suspension ropes. Immediately before the failure, the four suspension ropes had deteriorated severely to a similar extent. The remaining strength of the ropes could no longer support the weight of the lift car with passengers inside combined with the dynamic loads when the lift stopped on 1/F. The ropes failed at almost the same time.

Overspeed governor and safety gears

6.18 The overspeed governor and safety gears of the lift are designed to come into operation when the speed of the lift exceeds the specified limit. The safety gears on the lift car would be activated to hold the lift car onto the guide rails, thus leaving clamping marks on the guide rail surfaces. Close examination of the guide rails revealed that the guide rails were clear of any clamping marks. The findings showed that the safety gears were not activated during the incident.

6.19 The followings are possible causes of the non-operation of the safety gears:

(a) The falling speed had not reached the designed level to activate the overspeed governor and safety gears; or
(b) The overspeed governor and/or safety gears did not operate even when the activation speed was reached.

Falling speed of the lift car

6.20 The breakage of the suspension ropes and non-operation of the safety gears led to the plunging of the lift car into the lift pit. Figure 7 shows the deformation of the bottom part of the lift car supporting frame ("bottom frame"). The deformation of the bottom frame was caused by the impact of the lift car to the spring buffer in the lift pit.

Figure 7 : Outlook of the deformed lift car bottom frame.

Impact speed estimation

6.21 The impact speed of the falling lift car was analysed. The impact speed of the lift car loaded with seven passengers should be above 2.7 m/s. This speed was well above the activation speed (1.4 m/s) of the overspeed governor of the lift. The analysis shows that overspeed governor should have been activated before the lift car reached the buffer.

Testing of the overspeed governor

6.22 During the on-site inspection immediately after the incident on 2 March 2013, the electrical switch of the overspeed governor was found activated. Besides, the pawl of the overspeed governor was released and had come close to the valley between two teeth of the ratchet wheel. However, it was not fully engaged with the ratchet wheel. These indicated that the overspeed governor had already reached its activation speed.

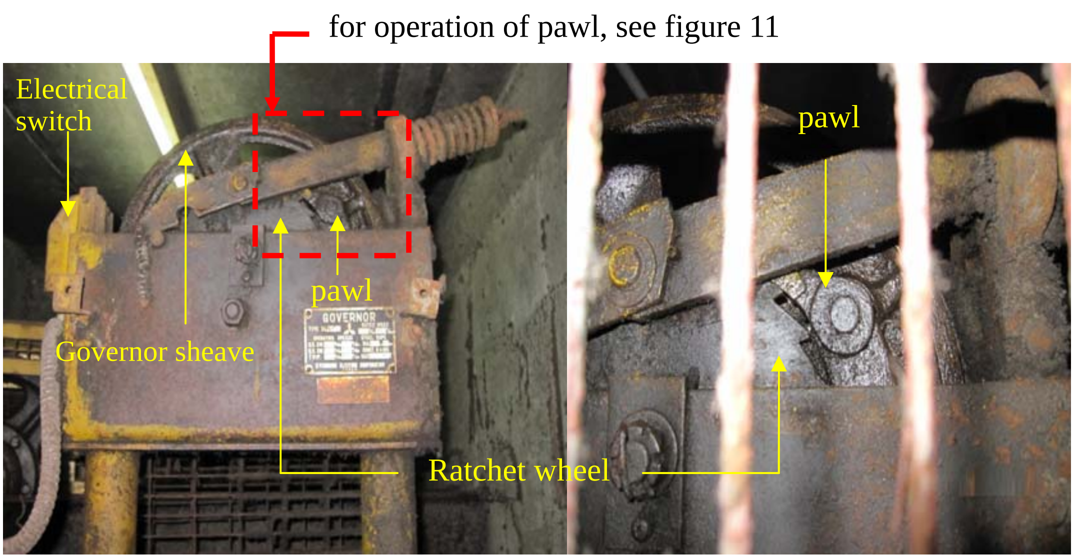


Figure 8 : Overspeed governor of the lift. The Figure on the left shows that the pawl of the overspeed governor had been released and came close to the valley between two teeth of the ratchet wheel.

6.23 Another test was conducted to verify if the activation speed of the overspeed governor was correctly set. The test was conducted by driving the overspeed governor sheave with a variable speed tool when the governor rope was detached from the governor sheave. (see also Figure 9) Test results showed that the activation speeds (1.3 m/s for activating the electrical switch and 1.4 m/s for activating the safety gears) were in line with the speeds shown on the data plate of the overspeed governor and were in compliance with the requirements specified in the Code of Practice on the Design and Construction of Lifts and Escalators issued by the Electrical and Mechanical Services Department.

Figure 9 : Governor activation speed test arrangement – governor sheave being driven by a variable speed tool

6.24 Although the activation speed of the overspeed governor was correctly set, it was noticed that a gap was found between the governor rope and the shoe of the governor, signifying that the governor rope was not gripped by the shoe in the incident. (refer to Figure 10)

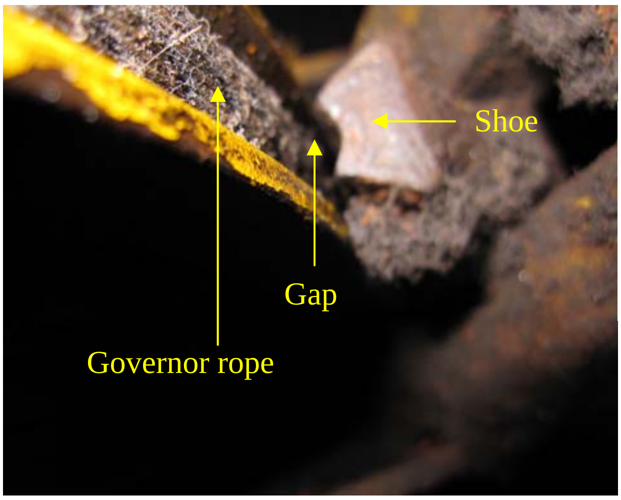


Figure 10 : Gap between the shoe of the governor and the governor rope, indicating no gripping of the governor rope by the shoe in the incident.

6.25 It was mentioned in section 6.22 that, after the incident, the pawl of the overspeed governor was released and had come close to the valley between two teeth of the ratchet wheel but was not in the fully engaged position. Due to the failure of engagement of the pawl with the ratchet wheel, the subsequent mechanism to activate the safety gears could not be operated to prevent the lift car from falling down.

The pawl

6.26 The pawl of the overspeed governor was spring-loaded to ensure its engagement with the ratchet wheel when the latch was released. The operation of the pawl and ratchet wheel is shown in Figure 11. It was found that the tension spring of the pawl was not properly connected to the pawl and the connection end of the spring was deformed (see Figure 12).

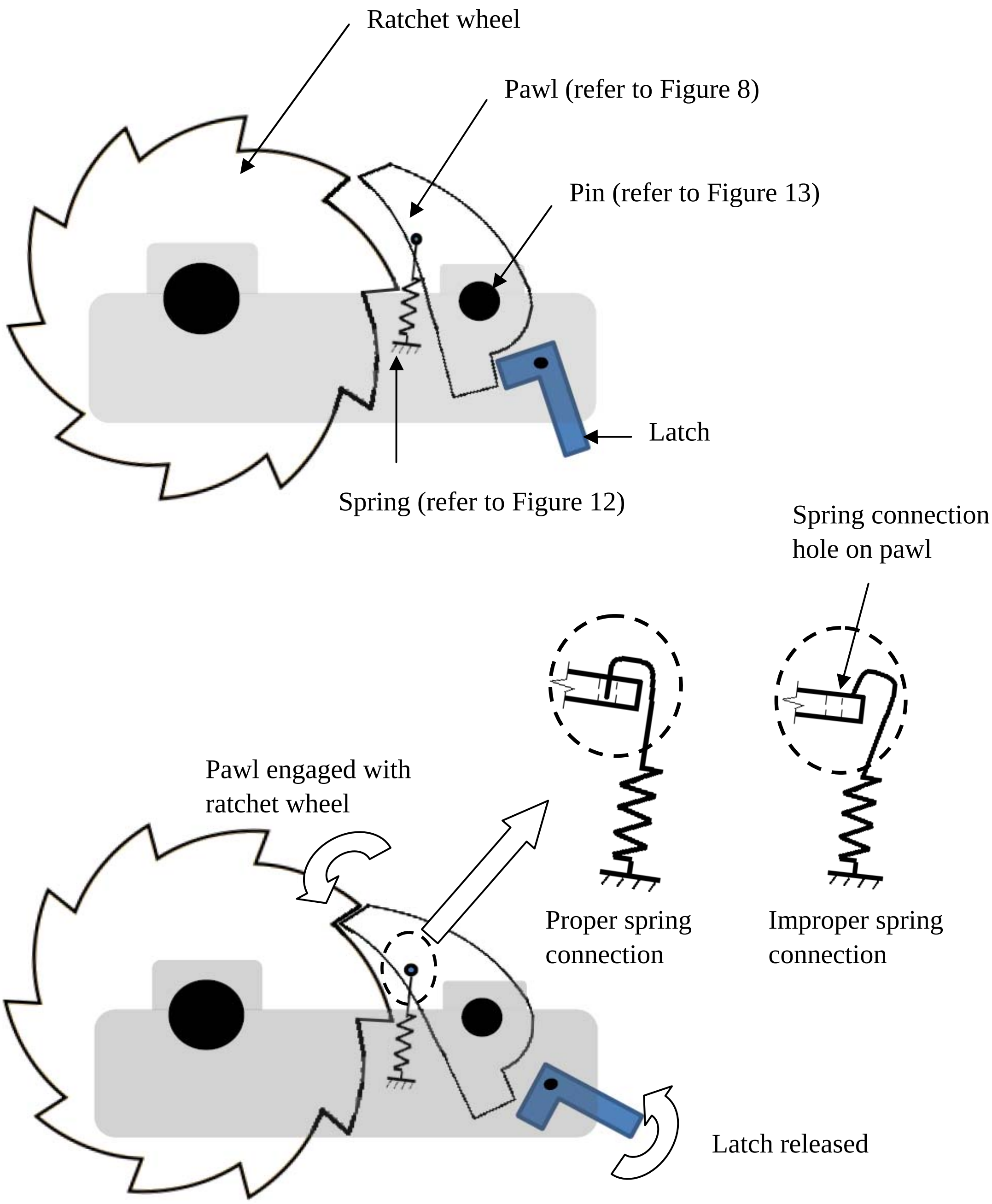


Figure 11 : Diagrams showing the operation of the pawl and ratchet wheel of the overspeed governor. The lower diagram shows the latch released and the pawl engaged with the ratchet wheel.

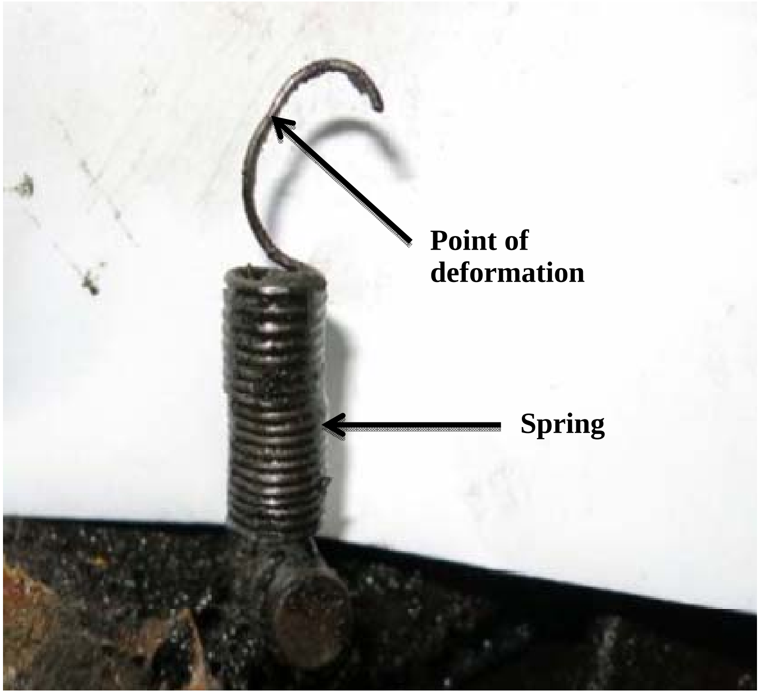


Figure 12 : Photo shows deformation of the spring end.

6.27 The pin (pivot joint) of the pawl was dismantled and examined. Rust was found on the surface of the pin. (see Figure 13). The rust would increase the friction of the pin and impair the swift response of the pawl of the overspeed governor.

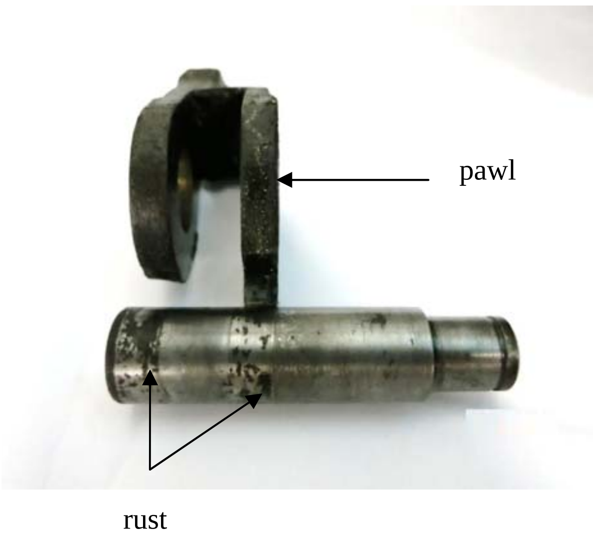


Figure 13 : Pin of the pawl of the overspeed governor.

Possible cause of failure of the safety system

6.28 Based on the observations mentioned in 6.22, the pawl of the overspeed governor failed to fully engage with the ratchet wheel during the incident despite that the activation speed of the overspeed governor had been reached and the latch of the pawl was released. The improper connection of the tension spring and the rust on the pin of the pawl were attributable to the unsuccessful engagement. Therefore, the ratchet wheel failed to bring the shoe of the governor gripping onto the governor rope and hence did not activate the safety gears.

7. Conclusions

Based on the findings of the investigation, the following conclusions are drawn:

7.1 All the four suspension ropes broke at almost the same time when the lift car, carrying seven passengers, was ascending from G/F and reached 1/F. The lift car then started to fall but the safety gears were not activated to stop or decelerate the lift car despite the falling speed of it had exceeded the activation speed of the overspeed governor.

7.2 The suspension rope breakage was primarily due to wear and tear caused by insufficient lubrication to the suspension ropes for a prolonged period of time, and this had led to excessive wear and rouging being formed on the suspension ropes prior to the incident. The strength of the ropes had been substantially reduced which caused all the suspension ropes to break in the incident.

7.3 The overspeed governor failed to activate the operation of the safety gears to stop the lift car. Despite that the activation speed was reached, the pawl of the overspeed governor failed to engage with the ratchet wheel during the incident, rendering it unable to activate the safety gears of the lift. The improper connection of the tension spring of the pawl and the rusty pin of the pawl were attributable to such unsuccessful engagement.

8. Measures to Step up Regulatory Control on Lift Safety

8.1 Subsequent to the lift incident, EMSD had taken immediate action to inspect all the lifts maintained by Shineford within three days immediately after the incidents, ensuring the safe working order of these lifts.

8.2 On satisfying that Shineford had failed to carry out the lift works properly and safely, the Director of Electrical and Mechanical Services, in the capacity of the Registrar under the Lifts and Escalators Ordinance, exercised the power under the Ordinance to suspend Shineford's registration as a registered lift contractor for six months commencing 1 May 2013.

8.3 EMSD had reminded all registered lift contractors to strictly observe the Code of Practice's requirements in conducting lift maintenance. EMSD had also stepped up inspection of lifts maintained by registered lift contractors with relatively low performance rating in the Contractors' Performance Rating (CPR) Scheme.

8.4 Taking into account the findings of this investigation, EMSD had stepped up the monitoring of registered lift contractors, including the following :

i. More inspections would be accorded to the lifts maintained by registered contractors with relatively low performance rating in the CPR Scheme. EMSD would also increase the frequency of audit visits to registered contractors with low CPR ranking.

ii. As suspension ropes are the essential component of a lift, the registered contractors/engineers would be required to submit detailed inspection reports of the ropes after the annual examinations of lifts.

iii. Separately, the CPR Scheme would be critically reviewed with a view to rationalizing the Scheme to reflect the performance of registered contractors.

8.5 To facilitate responsible persons to better understand their duties and responsibilities under the Ordinance, EMSD would step up publicity and public education by arranging more seminars for responsible persons to enhance their knowledge on daily management of lift and entering maintenance contracts with registered lift contractors.

Appendix I
List of Documents Inspected during the Investigation

1. Delivery order and quotation for replacement of hoisting ropes of the lift No. 5 (lift involved in the incident) dated 8 September 2010 issued by Shineford to lift owner
2. “Periodic maintenance report” of Shineford for lift No. 5, 6, 7 at 480 King’s Road between March 2012 and February 2013
3. Circuit diagram of lift no. 5 kept in the machine room
4. Logbook for lift No. 5, 6, 7
5. Safety certificate issued by the registered lift engineer for the periodic examination of lift no. 5 carried out on 21 November 2012
6. “Lift Examination Record” of Shineford for the periodic examination of lift no. 5 carried out on 21 November 2012
7. “Items for Periodic Maintenance of Lifts” of Shineford (standard chart)
8. “Notification of Lift Incident” – Form LE27 dated 4 March 2013 submitted by Shineford on behalf of the responsible persons for the lift
9. Investigation report submitted by Shineford
10. Training records of the staff/workers of Shineford
11. “Safety Handbook” dated 11 October 2007 issued by Shineford
12. “Works Instruction – Issue related to Periodic Safety Test of Lifts”, document no. V2-13 issued by Shineford
13. Technical information, manufacturer’s maintenance manual/schedule provided by the agent of the manufacturer of lift No. 5
14. Manufacturer’s Certificate of the suspension ropes for lift No. 5

Appendix II

Basic Structure of Lift

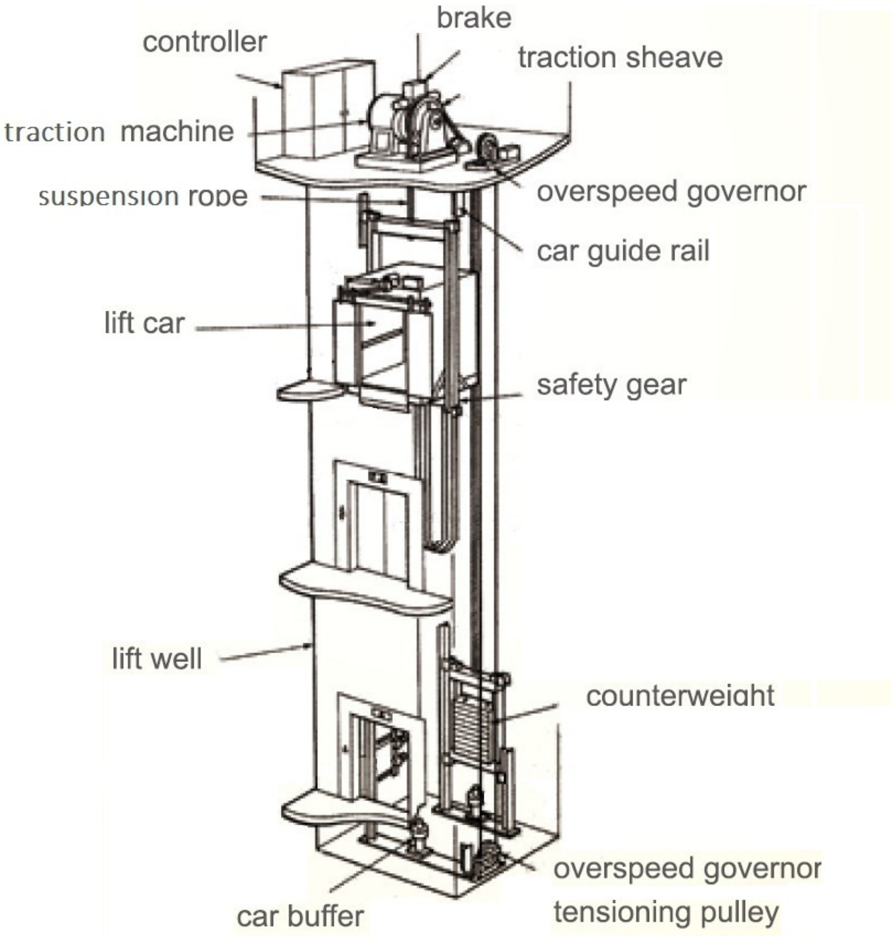
The basic structure of a lift consists of a vertical lift well in which the lift car is placed. Guide rails are installed inside the lift well, which restrict the lift car to move up and down in a controlled manner.

Multiple steel ropes (suspension ropes) are used to move the lift car, which are driven by the traction machine installed inside the machine room, usually located on the roof level. One end of these suspension ropes is connected to the lift car and the other end is connected to the counterweight for balancing. The weight of counterweight is generally determined by the weight of lift car plus 45% - 50% of the rated loading capacity. When the lift car moves, the counterweight will move in the opposite direction. The traction machine is fitted with a traction sheave, over which suspension ropes are laid. The suspension ropes are in contact with the grooves of the sheave and driven by means of friction between the contact surfaces. The suspension ropes and traction sheave are subject to wear and tear during lift operation, and have to be checked and replaced regularly.

The suspension ropes shall have a tensile grade corresponding to those specified in ISO 4344 or other relevant international standard. The safety factor (ratio between minimum breaking load and the maximum force in the rope) of the suspension rope shall be at least 12.

In spite of the high safety factors, suspension ropes should be replaced immediately when the rope has worn down by more than 10% of its diameter or the number of wire breaks is excessive in order to keep the lift in safe working order.

The traction machine is used to drive the traction sheave so as to raise or lower the lift car via suspension ropes. Traction lifts have a number of safety devices to maintain the lift car in a safe position in the event of equipment failure. Basic safety components include overspeed governor in the machine room, safety gears in the car, counterweight (if applicable) and buffer at the bottom of lift shaft. In case the lift car travels at a speed higher than the design speed (e.g. rope breakage or brake failure) , the overspeed governor will be activated which will in turn activate the safety gears for clamping onto the guide rails to stop the lift car and the counterweight from further movement. At the bottom of the lift well, a buffer is usually installed to damp down the final movement of the lift car. The above-mentioned safety components are detailed below.



Major Components of the lift

1. Suspension Ropes

Figure A shows a typical construction of a suspension rope similar to the ones involved in the incident. It was constructed by strands which wound spirally around a central core (fibre core) soaked with lubrication oil. Each strand is in turn made by steel wires wound around spirally. Figure B shows the sectional view of a suspension rope. The ability of the suspension ropes to bend over a sheave/pulley is due to sliding of wires and strands relative to each other.

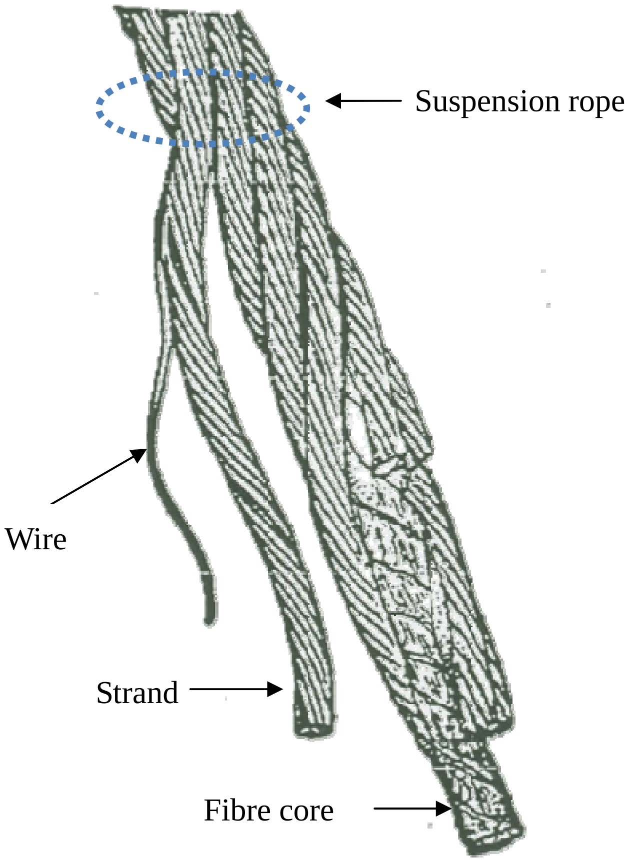


Figure A : Typical construction of a suspension rope

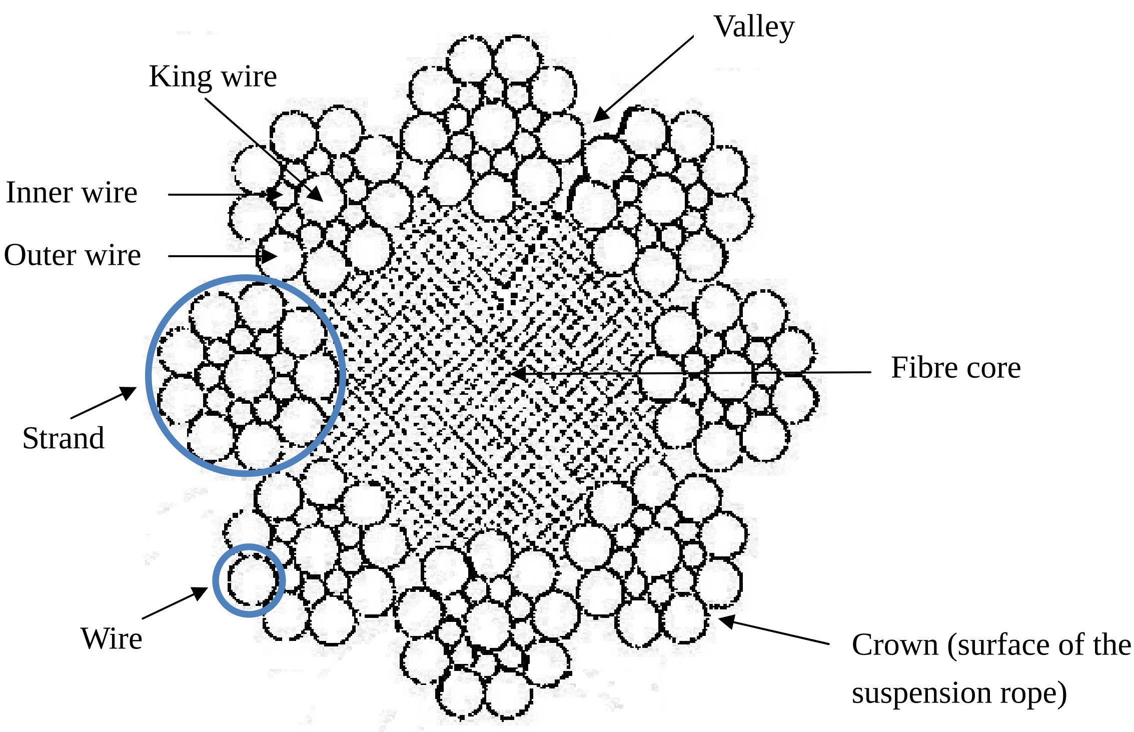


Figure B : Sectional view of a wire rope

Relative movements between wires, strands in the suspension ropes as well as that between the suspension ropes and the sheave/pulley cause wear of the suspension ropes as well as pulley/sheave. The wear causes reduction in rope diameter. Very small particles are torn away from the wire surface. The particles are very chemically active and are easily converted to iron oxide when exposed to oxygen. The iron oxide particles are very fine and red coloured and have been called rouge like red makeup.

Wear and tear of the suspension ropes can be minimized by proper lubrication. There is a need to maintain a supply of oil to the ropes by re-lubrication because the oil in the fibre core would be lost during service. Oil is squeezed out from the fibre core as it bends onto a pulley/sheave and drawn back into the fibre core by capillary action when the rope unbends off the pulley. A portion of the oil would be lost during the process. When the oil in the fibre core is too low or entirely lost, location at points of metal to metal contact would wear faster and create more rouge.

When rouging is found during routine maintenance, measures should be taken in order to avoid in-service rope breakage.

2. Overspeed Governor

The overspeed governor is essentially made of two pulleys connected to each other by a small rope located inside the lift shaft. The rope ends are connected to the safety gears located below the lift car. When the downward speed of the lift car reached the predetermined value (the activation speed), the overspeed governor would be activated to cut the power supply to the drive machine and to activate the safety gears to stop the lift car from further overspeeding or falling.

Figure C shows the typical arrangement of the overspeed governor system of the lift. The governor is located inside the lift machine room. It is provided with a governor rope passing round the governor sheave down to a tensioning pulley in the pit and back again to the governor sheave. The system is driven by the lift car to which the governor rope is attached at point.

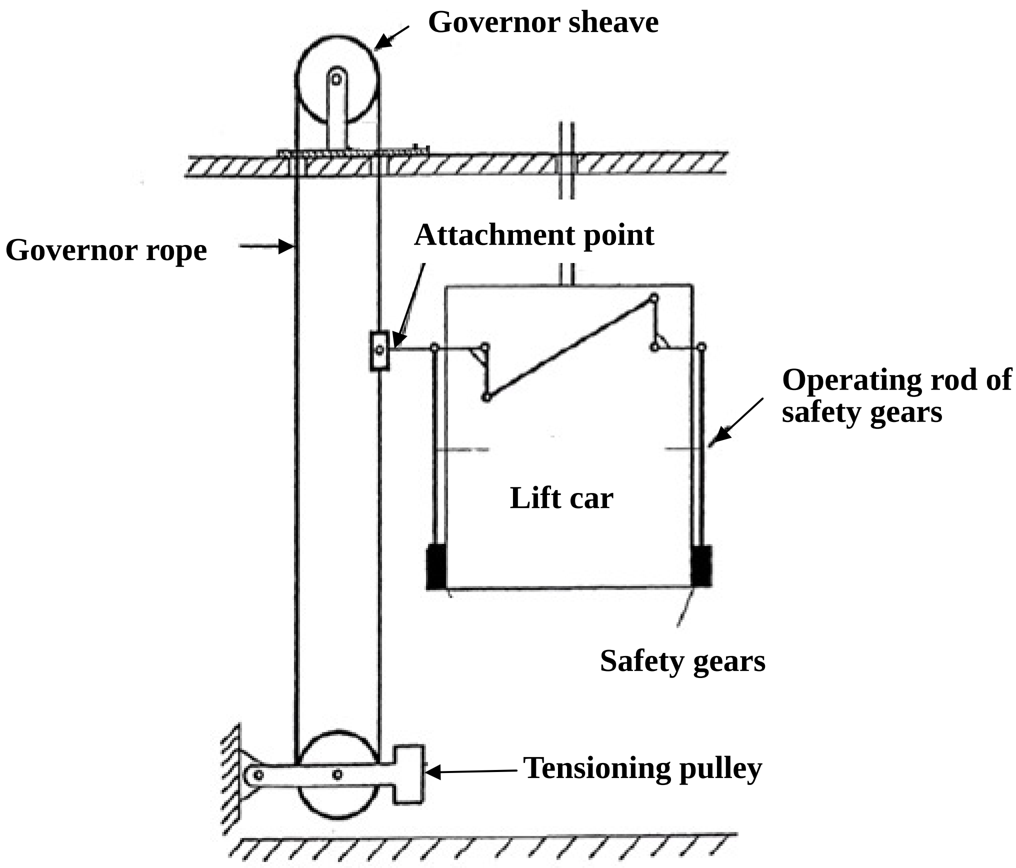


Figure C : Typical arrangement of overspeed governor system of lift

Figures D shows the construction of the overspeed governor involved in the incident. The overspeed governor is provided with two pivoted flyweights (1) which linked together by a rod (2) to ensure simultaneous movements of the flyweights and secured in position by helical spring (3). The governor sheave (4) rotates in a vertical plane. When the speed of the lift car reached the electrical activation speed, the flyweights are driven outwards due to centrifugal force to trip an electrical switch (5) to cut off the power supply to the lift machine. If the car speed continues to increase and attains the mechanical activation speed, further outward motion of the flyweights would trip a latching device that holds the spring loaded pawl (6) clear of the ratchet wheel (7). The ratchet wheel is stationary and independent of the rotation of the governor sheave during normal operation. The activation of the latching device releases the pawl of the overspeed governor and the tension spring ensures the lowering of the pawl. Further rotation of the governor sheave driven by rope traction makes the pawl fully engage with the ratchet wheel. The tension bar (8) connected to the ratchet wheel is then pulled in the direction that caused gripping of the governor rope by the shoe (9) of the governor.

1: Flyweight

2: Linking rod

3: Spring for flyweight

4: Governor sheave

5: Electrical switch

6: Pawl

7: Ratchet wheel

8: Tension bar

9: Shoe (friction pad)

10: Spring of pawl

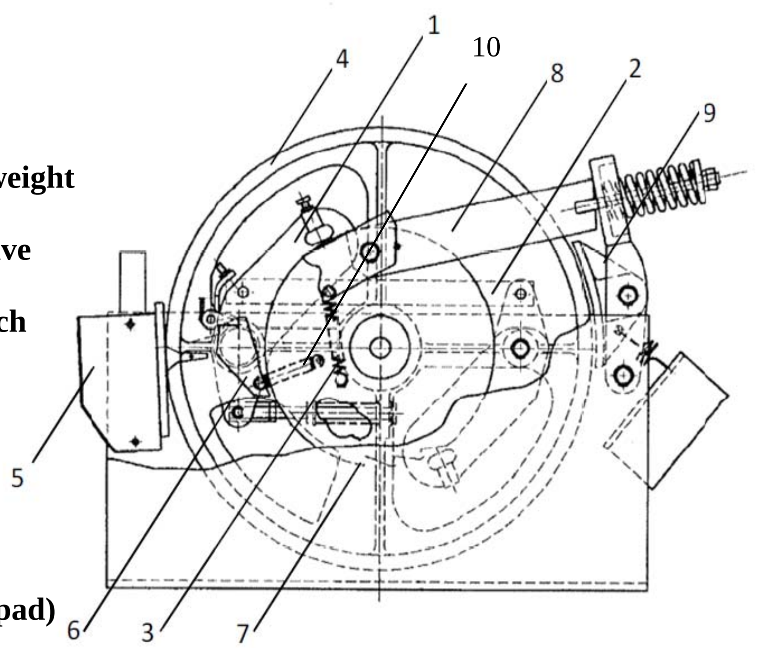
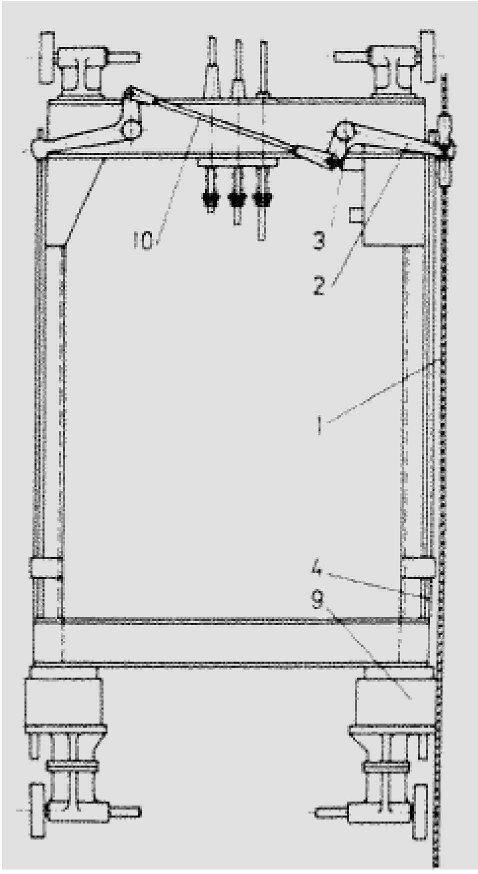


Figure D : Drawing of the overspeed governor of the lift

3. Safety Gears

Figure E shows the typical arrangement of the supporting frame of the lift car. The pair of safety gears (9) is mounted on the bottom of the supporting frame. When the governor rope (1) is gripped by the shoe of the overspeed governor, any further downward movement of the lift car will rotate the lever arm (2) on the pivoted point (3) and actuate a mechanism to operate the safety gears to clamp onto the guide rails. Linkage rod (10) ensures simultaneous operations of the safety gears. The design of the safety gears system for the lift involved in the incident was slightly different from that shown in Figure E in that the lever arms and linkage rod were mounted on the bottom of the supporting frame. Figure F shows the drawing of the bottom frame and safety gears of the lift involved in the incident.

Figure G shows the design of safety gears similar to the one involved in the incident. The assembly comprises two wedge-shaped gibs (1) moving on metal rollers (2) mounted in a casing (3) and running in the track of the jaw (4). When the safety gears are activated by the overspeed governor, the gibs are raised and brought into contact with the guide rail. Further downward movement of the lift car is prevented by the wedging action of the gibs on the guide rail.



1: Governor rope

2: Lever arm

3: Pivot point

4: Operating rod

9: Safety gears

10: Linkage rod

Figure E : Typical arrange of car frame

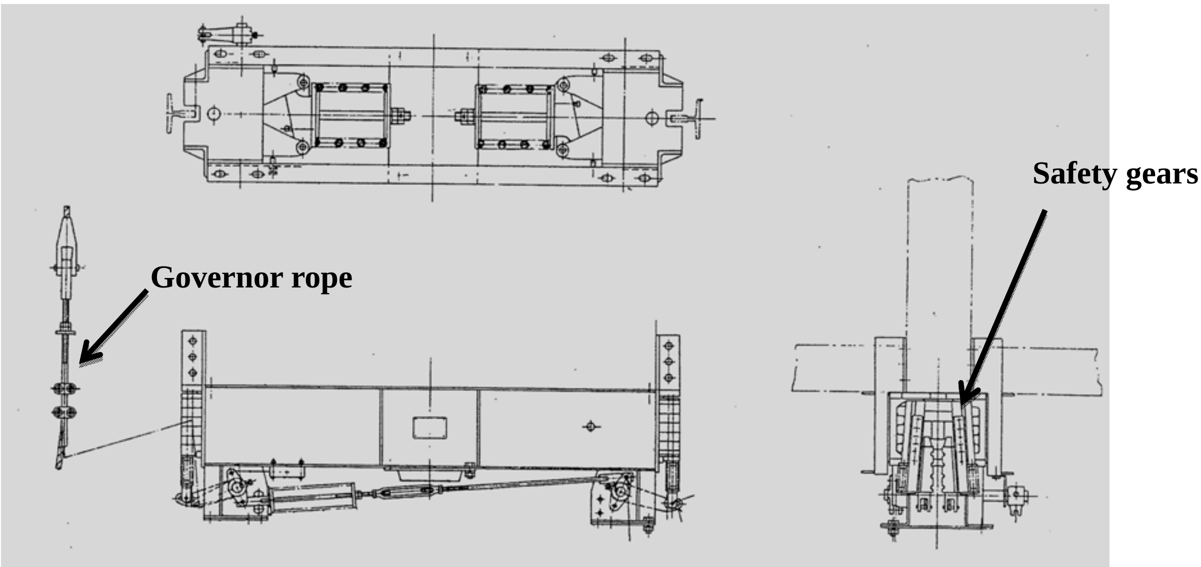


Figure F: Drawings for the bottom frame and safety gears for lift No. 5

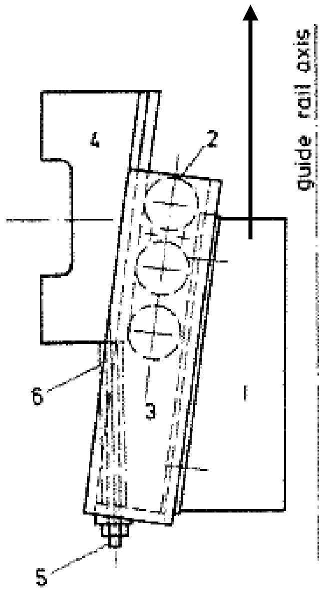


Figure G : Safety gears design

4. Buffer

A lift must be equipped with buffers located at the bottom limit of travel for both cars and counterweights to constitute the final emergency device. The buffers absorb the energy of impact of the lift car/counterweight overspeeding downwards but at a speed lower than the activation speed of the safety gears. Helical spring buffers of round section are installed at the lift pit for the car and counterweight of the lift involved in the incident. This type of buffer is called energy accumulation type buffer which may be used for a lift with rated speed not exceeding 1 m/s. For lift with rated speed above 1 m/s, buffer of energy dissipation type (oil buffer) must be used. Figure H shows a spring buffer used for the lift.

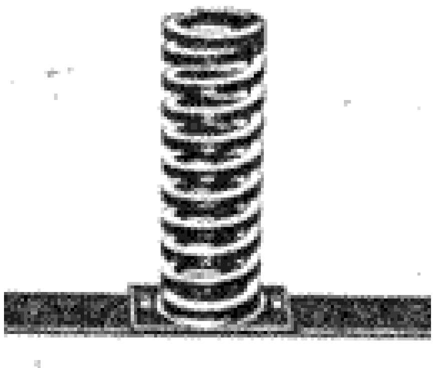


Figure H : Spring buffer of lift