NOTES ON ELEVATOR SYSTEMS

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Disclaimer

1 Electrohydraulic Lifts

Pascal's law of fluid dynamics states: "Pressure applied to continuous fluid at any point is transmitted undiminished through fluid in all directions." It is this basic principle which operates electrohydraulic lifts. An electrohydraulic lift consists of an electric motor and a pump unit. The electric motor drives the pump which moves the oil through a hose connected to a cylinder. The oil pressure generated by the pump acts on the ram in the cylinder. The lift car which is attached to the top of the ram moves as the ram moves upwards. The electric motor is not required on descend. A "Down" valve is opened to allow the oil to flow back to the tank for the lift downwards movement.

The main components in an electrohydraulic lift include:

- A **tank unit** which consists of a motor, a screw pump and a valve unit. The motor and the pump are immersed in the oil whereas the valve unit is installed externally on the top of the tank.
- A **cylinder and ram unit**. The ram moves within the cylinder which acts as protection to the ram's uniform smooth finish. A cylinder head is attached to the cylinder with clamping rings. Other parts include:
  - split guide rings (prevent sideways movement of the ram);
  - ram seal (prevent leakage of oil past the cylinder head);
  - scraper ring (prevent scoring of the ram by removing foreign substance before ram returns to the cylinder);
  - bleed screw (for removing air in the hydraulic system); and
  - 0-ring (provide seal between cylinder head and cylinder).
- A **controller** which the operates the valves and control the directions of the car.

There are 3 basic lift car arrangements:

- **Direct Acting** - The cylinder is placed inside a caisson which is embedded in the ground. The ram is then attached to the bottom and normally at the centre of the car frame. Bore is required for the installation of the caisson. There is no real benefit of having direct acting arrangement. However some argue that this arrangement is suitable for lifting heavy load.
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- **Side Acting** - This is the most popular arrangement. The cylinder unit sits at the bottom of the lift pit against a side wall. Guide rails are required to guide the ram in a vertical plane. The ram is attached to the top of the car frame.

- **Rope hydraulic** - This arrangement is used to increase the speed of the lift by using a 2:1 roping ratio. The cylinder installation is similar to that of side acting except that a sheave is attached to the top of the ram. Ropes are passed over the sheave with one end attached to the pit and the other end to a safety gear under the car. The safety gear can be operated by the slack rope method or a governor. When the ropes become slack, the rope springs force the suspension pins downwards to operate a safety switch. Further movement of the pins will operate the safety gear through a mechanical linkage.

**Valve Unit**
The valve unit controls the lift operation - acceleration, deceleration and directions. It consists of 3 chambers - the pump chamber, the high pressure chamber, and the low pressure chamber. The pump chamber contains a by-pass valve and a pump relief valve. The high pressure chamber contains a check valve, a main down valve and a down levelling valve. The low pressure chamber is connected to the tank by a return pipe. The functions of the valves are:

- **By-pass Valve** - This valve permits the oil to pass from the pump chamber to the low pressure chamber until the working pressure is built up. When this valve is closed, the pressure in the pump chamber is built up and pushes the check valve open.

- **Pump Relief Valve** - If the pressure in the pump chamber built up beyond the preset limit, this valve will open.

- **Check Valve** - When closed, this valve maintains the pressure in the high pressure chamber and keeps the lift in position.

- **Main Down Valve** - A down command will open a solenoid which in turn will open the main down valve. This actions permit the oil to flow from the high pressure chamber to the low pressure chamber and cause the lift to move downwards.

- **Down Levelling Valve** - At floor level, the pump is cut off. However the kinetic energy causes the lift to move past the floor. A solenoid will energise and open a down levelling valve which allows the lift to settle back to the floor level under a controlled condition.

- **Door Lock Valve** - This is a solenoid operated valve located between the cylinder and the manual lowering valve. With the car door open, the solenoid will de-energise and close the valve. This action prevents the lift from moving downwards.

- **Manual Lowering Valve** - This valve allows the oil to flow from the high pressure chamber to the lower pressure chamber and lowers the lift manually.

**Statutory Requirements**
Electrohydraulic lifts are covers under the Australian Standard Lift Code AS1735 Part 3. Some of the requirements are:
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- **Pump Relief Valve** - Each pump shall have a relief valve and located between the pump and the check valve. This valve shall operate at not more than 125% of the pump working pressure and with sufficient size to pass the maximum rated capacity of the pump without raising the pressure by more than 20% above the valve open pressure.

- **Flow Restriction Valve** - This valve shall be electrically operated and installed as close as possible to the cylinder. The valve shall be set to operate at not more than 30% above the lift full-load down speed. When operated, the valve shall restrict the full-load down speed of the lift to 0.05 m/s.

- **Manual Lowering Valve** - This valve shall allow the lift to be lowered manually at not more than 0.2 m/s.

- **Anti-creep Device** - Anti-creep device shall be provided to prevent the lift car from sinking more than 150 mm from the landing.

2 Escalators

Escalators are moving stairs which transport passengers from one landing to another. The drive unit is an electric motor with a sprocket to drive the main shaft. The drive unit is located in the upper truss extension and may be fitted with an overspeed governor. The main drive shaft has sprockets at each end of the axle to drive the step chains. A third sprocket on the main shaft is used to drive the hand rail friction newel wheel.

Escalators in Australia must be designed to the Australian Standard Lift Code AS1735 Part 5. The major requirements under the Code are:

- The angle of inclination shall be not more than 30 degrees.
- The rated speed shall be not more than 0.75 m/s.
- The width of step treads shall be between 400 mm and 1050 mm. The depth shall be not less than 400 mm. The rise shall not exceed 215 mm.
- The width between balustrade (measured 685 mm from the step) shall be between 600 mm and 1370 mm.
- Rated load (kg) = 0.27 * Width between balustrade (mm) * Horizontal distance between upper and lower combplate teeth (m).
- The clearance between the step and the adjacent skirting shall be not more than 4.75 mm. The sum of clearances on both sides shall be not more than 6.35 mm.
- The distance between the combplate teeth and the treads shall be between 2.4 mm and 4 mm.
- Demarcation lines in bright yellow shall be provided on the steps - two lines parallel to the skirting; one line adjacent to the projecting edge.
- Two green fluorescent lamps shall be provided within the step-band at each end and not more than 400 mm from the combplate.
- Lighting on the step shall be not less than 75 lux.
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Safety devices are provided in each escalator to protect the public and maintenance personnel. The safety devices include:

- Key-operated start switches.
- Emergency Stop buttons.
- Speed governor.
- Reverse phase protection.
- Pit stop switches.
- Broken main drive chain switch.
- Broken step chain switch (or tension carriage switch)
- Handrail entry switches.
- Combplate switches.
- Step sag monitors
- Skirt pressure switches.
- Ceiling guards.

Escalator Inspection

The following activities should be carried out during routine inspection:

- Ride on the escalator. Check for noise, vibration, uneven or wavy motion. Uneven or wavy motion indicates slackness in the drive chain.
- Check the start key switches and emergency stop buttons.
- Check the handrail tension. With the escalator running, stand on the landing and held on the handrail with both hands. The handrail should afford a slight slip.
- Check the combplate clearances and look for broken teeth.
- Check the clearance between the steps and skirting.
- Clean rubbish and dirt from the steps.
- Clean pits.
- Lubricate the drive chains.
- Check the handrail and steps lighting.
- Check the brake operation.
- Check safety switches.

3. Electrical Requirements for Lifts

The lift supply mains shall comply with Australian Standard AS3000 Wiring Rules.

The main supply to the lift installation should be one of the following types:

- Metal-insulated metal sheathed cables (MIMS).
- Polymeric cables.
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- Cables installed in a fire-rated enclosure and protected against mechanical damage.
- Cables in underground location.

The supply to the lift main switch shall be taken from the supply side of the building main switch. However if the lift installation is in a separate building the supply to the lift may be taken from the supply side of that building main switch.

The supply mains shall be earthed at the main switchboard and at the lift switch board.

The circuit breaker at the main switch board should be clearly identified. The circuit breaker in the machine room shall be installed adjacent to and on the lock-side of the door.

The maximum demand of the lift motors can be calculated by using the following formula:

- 125% of full load current for the largest motor.
- 75% of full load current for the next largest motor.
- 50% of full load current for the remaining motors.

As lift motors are subject to short-time overload currents the current rating of the lift circuit breaker may be 1.5 to 2.5 times greater than the current-carrying capacity of the conductors.

Luminaires in the machine room shall be of protective type. At least two luminaires shall be provided. The Lift Code specifies the lighting level to be 110 lux at the floor level and on the controller. At least one general purpose outlet (GPO) shall be provided in the machine room. For major installations, lighting and GPO may be provided by lift contractors so that the position of luminaires can be arranged to suit the equipment layout. The light switches shall be on the lock-side of the lift machine room door.

The illumination for the internal car lighting, measured at car sill, shall be not less than 50 lux (AS1735 Part 12 Clause 23.25.2). AS1735 Part 12 Clause 10.2 specifies 100 lux at car sill when measured with the car and landing doors open. The Interior Lighting Code AS1680 specifies 160 lux for the lobbies. The designer should satisfy all the requirements.

Lighting in the lift well and pit is required. Such lighting is more effectively carried out by lift contractors.

Lighting for the access route between the nearest lift lobby and the machine room shall be controlled by 2-way switches; one at the lobby and one outside the machine room. Alternatively, 24-hour or photocell-controlled lighting can be provided. The minimum lighting level for the access route is 75 lux.

Where an emergency generator is provided for the lift operation during normal supply failure, the electrical contractor shall provide two 240 volt signals, to indicate: (i) normal supply and (ii) emergency supply, to the lift machine room.
Where a Building Management and Control System is provided consideration should be given to connect the following signals to the system:

- Normal power
- Emergency power.
- Lift in Service
- Lift under independent service.
- Lift failed.
- Lift alarm.
- Machine room high temperature alarm.

A telephone is required in the lift car. A telephone line should be provided and terminated in the machine room at a final distribution frame. The telephone line should be Dual Tone Multi-frequency type and fitted with line isolation units. The line should be barred from International Subscriber Dialling (ISD) and Subscriber Trunk Dialling (STD). A separate line is required for each lift. If a PABX is operated 24 hours, a PABX extension in lieu of the telephone line is acceptable. Hand-free self-dialling phones are recommended.

 Thermal alarms may be provided in the machine room and at the top of the lift well. The alarms should be of dry head type. A wet sprinkler with a temperature rating of not less than 100 degree C may be install in the lift well.

4. Ventilation to Lift Machine Room

The Lift Code requires the temperature in the machine room to be kept within 8 degree Celsius of the shade temperature of the outdoor surroundings. The temperature should not exceed 38 degrees Celsius for more than 30 days a year or exceed 40 degrees Celsius for more than 20 days a year. For a single 2-landing installation, natural ventilation may be sufficient. Mechanical ventilation should be provided for all other installations. The ventilation fan should be controlled by a thermostat which is set to operate the fan at 24 degrees Celsius and the alarm at 43 degrees Celsius.

Heat load (kw) from the lift drives in the machine room can be obtained from the Lift Engineer. With the kw rating the mechanical engineer can calculate the type and size of the ventilation fan required.

**Example for Design of Ventilation**

Heat load from machine, e.g. 5 kw per DC gearless drive
For 5 lifts, total heat load = 25,000 w
Design for temperature rise of 6 degree Celsius in the machine room
Air flow of ventilation fan (litres/s)
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= Heat Load / (Temp Rise * 1.213)
= 25,000/ (6 * 1,213)
= 3,435 litres/s

*1.213 is the conversion factor.

5. Lifts for Persons with Limited Mobility

Besides passenger lifts the following equipment may be suitable for persons with limited mobility:

- Low-rise platform lifts (AS1735 Part 14)
- Lifts for Restricted use (AS1735 Parts 15 and 16)

Disclaimer

This document is intended for ongoing sharing of information between lift researchers, consultants, manufacturers, contractors and other interested parties and is based on the author's personal knowledge at the time of publication. No responsibility of any kind for any injury, death, loss, damage or delay however caused resulting from the use of the recommendations can be accepted by the Department of Public Works and Services, the author or others involved in its publication.

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