MECH3422 Building Services Engineering I

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Lift and Escalators: Lift Traffic and Components

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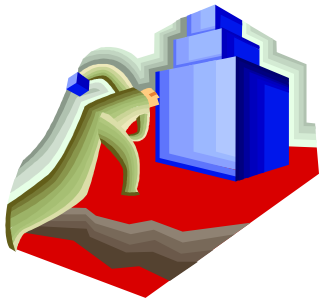
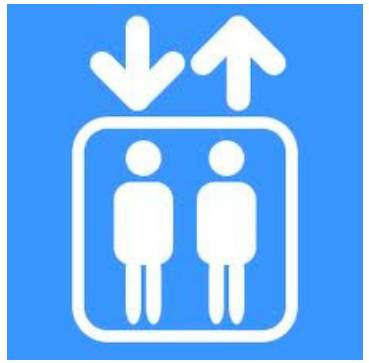
Contents

- Lift Traffic Analysis
- Advanced Traffic Planning
- Lift Components

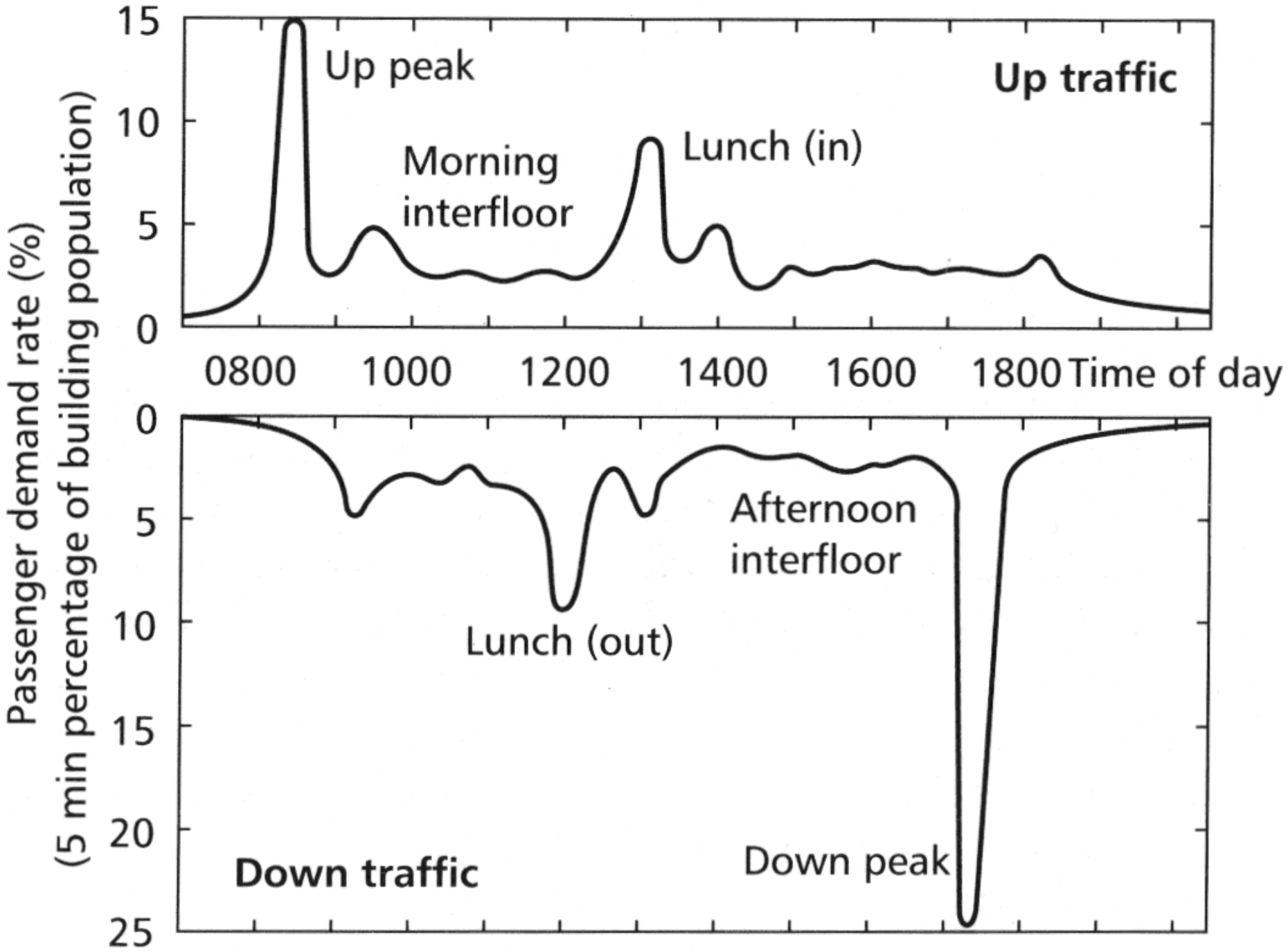
Lift Traffic Analysis



- Assessment of demand
  - Lift traffic patterns (e.g. in an office building)
    - Morning UP peak
    - Evening DOWN peak
    - Two-way traffic (lunch periods)
    - Interfloor traffic
    - Other considerations, e.g. ‘Flexitime’ attendance

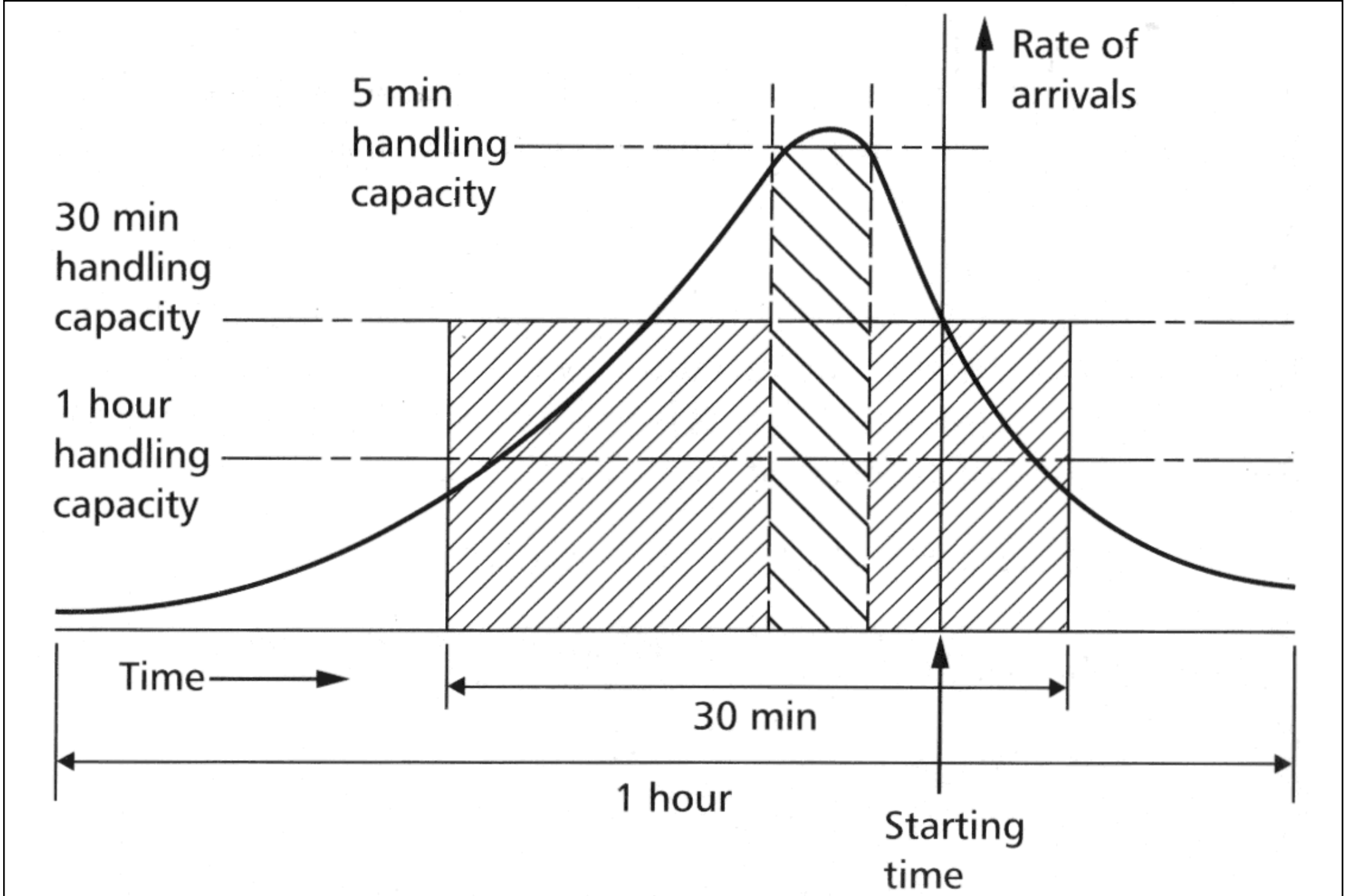


  - Estimation of population (occupant density)
  - Estimation of arrival rate



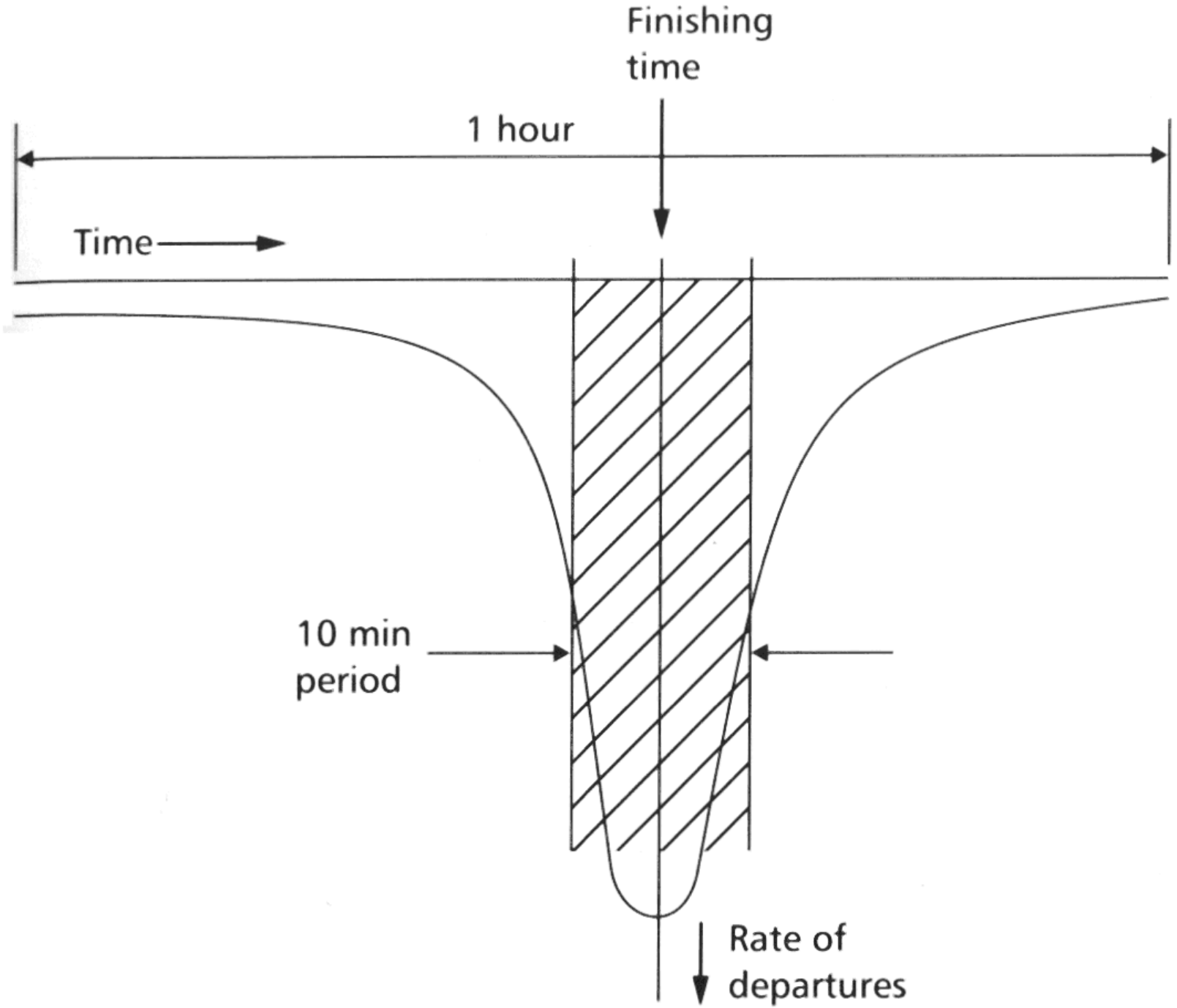
Traffic pattern in an office building

[Source: CIBSE Guide D]



Up peak traffic profile

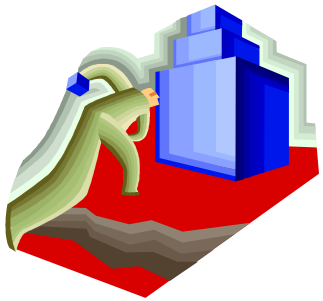
[Source: CIBSE Guide D]



Down peak traffic profile

[Source: CIBSE Guide D]

Lift Traffic Analysis



- Factors to be considered:
  - Population or no. of people who require lift service (based on building type)
  - Handling capacity or maximum flow rate required by the people (total no. of passengers handled during the peak period of the day
  - Interval or quality of service required (passenger waiting time of the various floors)

Estimation of population

Building type	Estimated population**
Hotel	1.5-1.9 persons/room
Flats	1.5-1.9 persons/bedroom
Hospital	3.0 persons/bedspace*
School	0.8-1.2 m^2 net area/pupil
Office (multiple tenancy): - Regular - Prestige	 10-12 m^2 net area/person 15-18 m^2 net area/person
Office (single tenancy): - Regular - Prestige	 8-10 m^2 net area/person 12-20 m^2 net area/person

* excluding patient

** Buildings in Hong Kong often have higher population density. May need to increase the number of people by 10-20%.

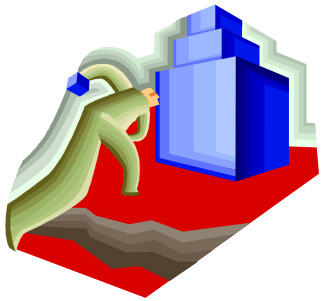
[Source: CIBSE Guide D]

Percentage arrival rates and up-peak intervals

Building type	Arrival rate (%)	Interval (sec)
Hotel	10-15	30-50
Flats	5-7	40-90
Hospital	8-10	30-50
School	15-25	30-50
Office (multiple tenancy):		
- Regular	11-15	25-30
- Prestige	15-17	20-25
Office (single tenancy):		
- Regular	15	25-30
- Prestige	15-17	20-25

[Source: CIBSE Guide D]

Lift Traffic Analysis



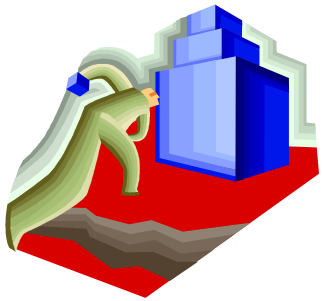
- Estimation of quality of service
  - Actual average passenger waiting time (AWT)
    - Time between the instant of passenger arrival until the instant of the actual arrival of the lift
    - Shorter the waiting time, better the service
    - But cannot be measured easily
  - Interval of car arrivals at the main terminal
    - Often taken to estimate the probable quality of service
    - A part of the evaluation of handling capacity
    - AWT ≈ 85% of the interval (assumed 80% car loading)

Probable quality of service in office buildings

Interval (sec)	Quality of service
≤ 20	Excellent
25	Very good
30	Good
40	Poor
≥ 50	Unsatisfactory

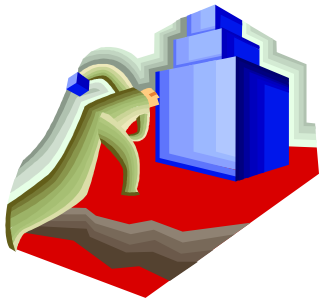
[Source: CIBSE Guide D]

Lift Traffic Analysis



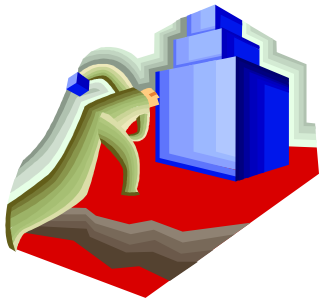
- Two methods of lift traffic analysis:
  - (1) Based on **classical formulae** & results
    - The worst 5-min period during morning up peak only
  - (2) Based on a **discrete digital simulation** of the building, its lifts and the passenger dynamics
    - Such as for down peak, two-way & interfloor traffic
- Need to work at early design stage with architect or planner, and the client to establish the lift system & its design criteria

Lift Traffic Analysis



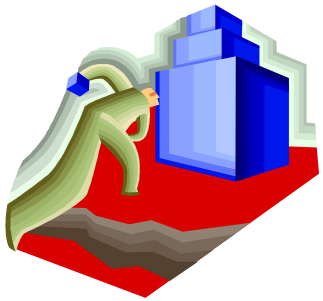
- Calculate up peak performance
  - Determine round trip time (RTT)
    - Time for a single lift to make a round trip
  - Select number of lifts (*L*)
  - Determine up peak interval (UPPINT)
    - Such as, <= 30 sec (good)
  - Determine up peak handling capacity (UPPHC)
    - During the worst 5-min (300 sec) of up peak

Lift Traffic Analysis



- $\mathrm{RTT} = 2\,H\,t_v + (S + 1)\,t_s + 2\,P\,t_p$
  - H = average highest call reversal floor
  - t_v = single floor transit time (s)
  - S = average no. of stops
  - t_s = time consumed when stopping (s)
  - P = average no. of passengers carried
  - t_p = passenger transfer time (s)
- $\mathrm{UPPINT} = \mathrm{RTT} / L$
- $\mathrm{UPPHC} = (300 \times L \times P) / \mathrm{RTT}$

Lift Traffic Analysis



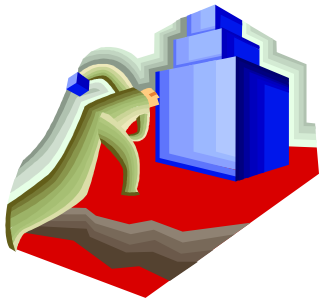
- Parameters in RTT equation
  - Average no. of passengers (P)
    - P = 0.8 x rate capacity of lift car
  - Average highest call reversal floor (H)

$$H = N - \sum_{i=1}^{N-1} \left(\frac{i}{N} \right)^{P}$$

  - Average no. of stops (S)

$$S = N \times \left(1 - \left(1 - \frac{1}{N} \right)^{P} \right)$$

Lift Traffic Analysis

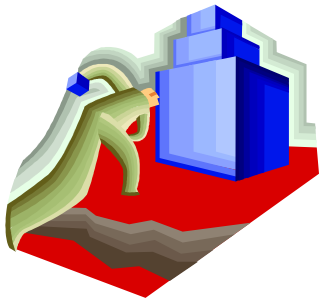


- Parameters in RTT equation (cont'd)
  - Single floor transit time, $t_v = d_f / v$
    - d_f = average interfloor distance (m)
    - v = contract (rated) speed (m/s)
    - For a lift serving an upper zone, an extra time to make the jump to/from the express zone to the main terminal must be added:

$$\text{RTT} = 2\,H\,t_v + (S+1)\,t_s + 2\,P\,t_p + [2\,H_e\,t_v]$$

    - H_e = number of average height floors passed through to reach the first served floor of the express zone

Lift Traffic Analysis

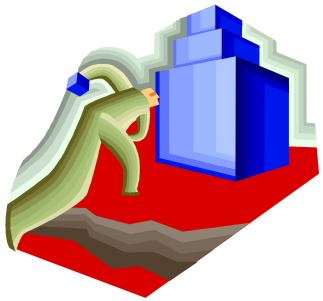


- Parameters in RTT equation (cont'd)
  - Time consumed when stopping

    $t_s = T - t_v = t_f(1) + t_c + t_o - t_v$

    - T = floor-to-floor cycle time (s)
    - $t_f(1)$ = single floor flight time (s)
    - t_c = door closing time (s)
    - t_o = door opening time (s)
  - Floor cycle time (T) has the most effect on RTT
    - Can be used to judge the quality of service
    - For a good system, T = 9 to 10 sec

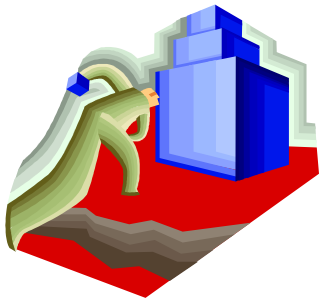
Lift Traffic Analysis



- Parameters in RTT equation (cont'd)
  - Passenger transfer time (t_p), vague to define. It depends on:
    - Shape of lift car
    - Size and type of car entrance
    - Environment (commercial, institutional, residential)
    - Type of passenger (age, gender, purpose, etc)

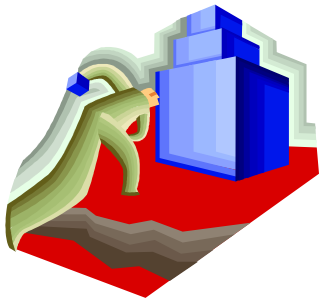
(See also: Lift traffic data and calculations [PDF]; Typical traffic calculation method and examples of traffic calculations (extracted from BS 5655-6:2011) [PDF])

Lift Traffic Analysis



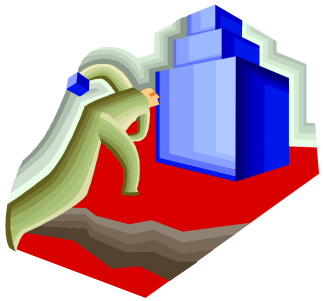
- Basic assumptions of RTT equation
  - Average no. of passengers
  - Passengers arrive uniformly in time
  - All floors equally populated
  - All cars load to 80%
  - Rated speed reached in a single floor jump and interfloor height are equal
  - Other operating time (like dwell time) ignored
  - Traffic controller is ‘ideal’

Lift Traffic Analysis



- Average passenger waiting time (AWT)
  - Average time an individual passenger waits at a floor before being able to board a lift
    - Not dependent solely on UPPINT
    - Also affected by the average car load and the arrival probability distribution function
  - Some design criteria for different traffic patterns have been derived empirically based on the simulation method (see *CIBSE Guide D*)

Lift Traffic Analysis



- Use of computer software
  - SIMPLE (suite of iterative balance method and other programs for lift and elevator design)
    - Run the software by "gosimple.bat" ("barney.zip")
  - ELEVATE (elevator traffic analysis and simulation software)
    - ELEVATE 7.0 demo version http://www.elevate.peters-research.com/pricelist.htm
  - KONE Quick Traffic (online)
    - http://toolbox.kone.com/media/mpb/frontpage_mpb/Quick%20Traffic.html

SIMPLE software

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**********************************************************************3
Welcome to Dr Gina Barney's lift programs.

All enquiries to PO Box 7, Sedbergh, Cumbria, LA10 5GE, UK.
Tel: +44(0)15396 20790  Fax: +44(0)15396 20578
Email: none  WEB: www.liftconsulting.org
Copyright Gina Barney: 1991-2002
caveat emptor

1  Iterative balance method
2  Lift traffic design
3  Lift traffic design with basements
4  Double deck design
5  Down peak estimate
6  Lift dynamics
0  Exit

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Your choice ?
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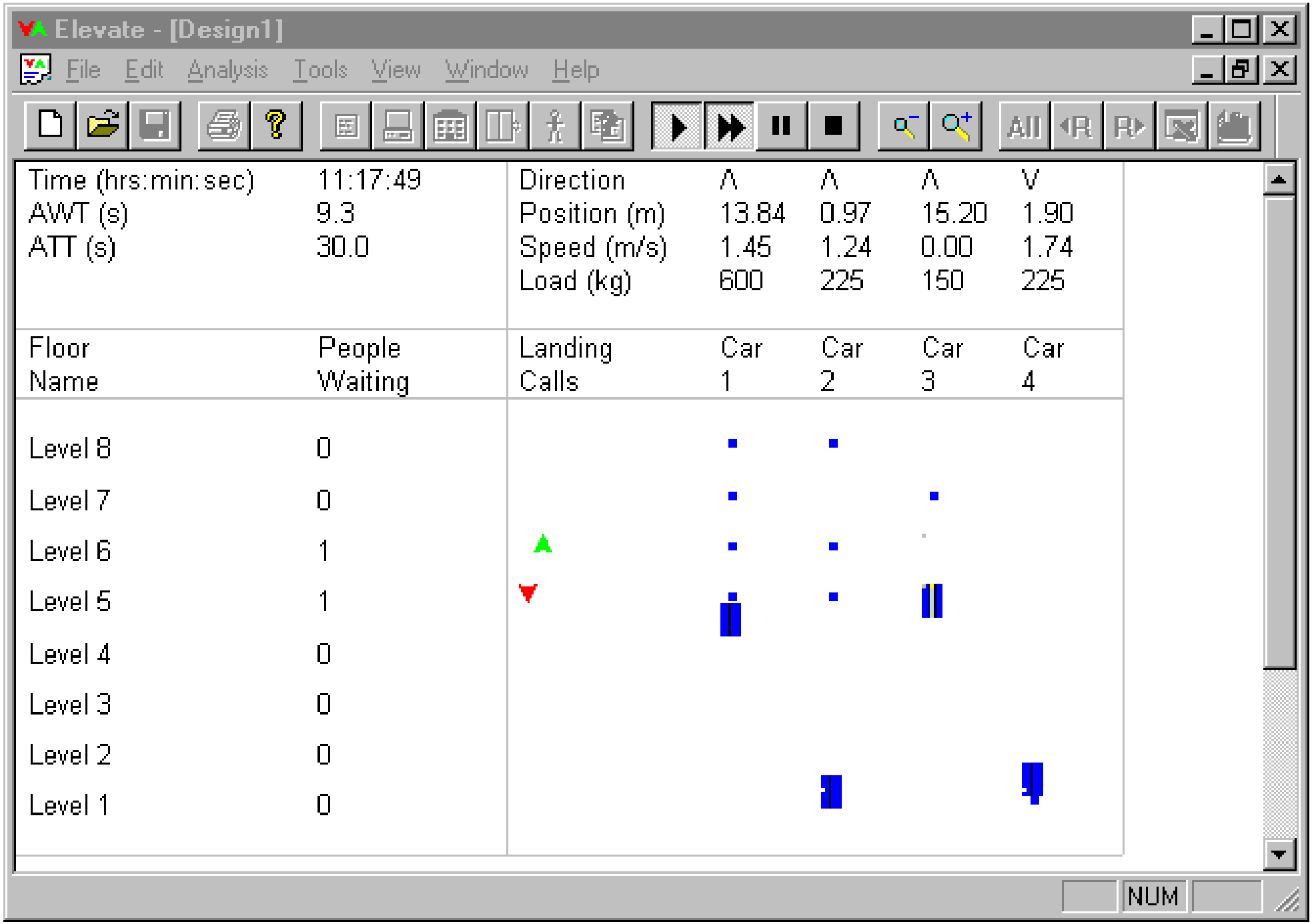
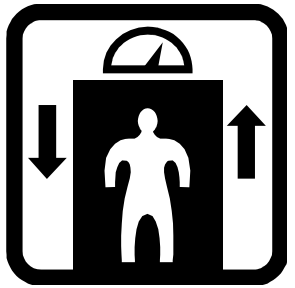
ELEVATE software



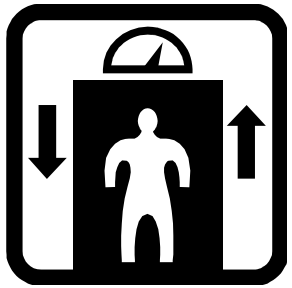
[Source: www.elevate.peters-research.com]

Advanced Traffic Planning



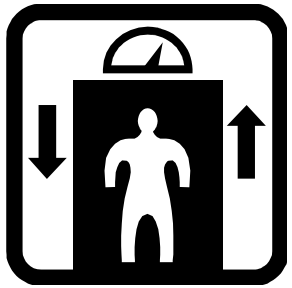
- Basic issues
  - The "art" of lift traffic planning
    - Efficient traffic planning is based on the characteristics and population distribution of a building
  - Good traffic planning results in:
    - Correct number and type of transportation devices
    - Right size and speed for transportation devices
    - Control systems and other features that optimize and synchronize traffic flow
    - Optimum layout including positioning in the building and in relation to one another
    - Easy access to buildings and a smooth flow of people and goods

Advanced Traffic Planning



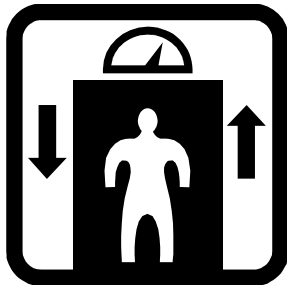
- Key considerations
  - Lifts and escalators should provide
    - Sufficient handling capacity for the building's traffic
    - Short waiting and journey times throughout the day
    - Optimum use of core building space
  - The main parameters are
    - Handling Capacity (HC) – the number of people the elevators can carry to upper floors within five minutes during the morning "up-peak“
    - Interval (I) – the average departure time for elevators from the main entrance during morning up peak

Advanced Traffic Planning

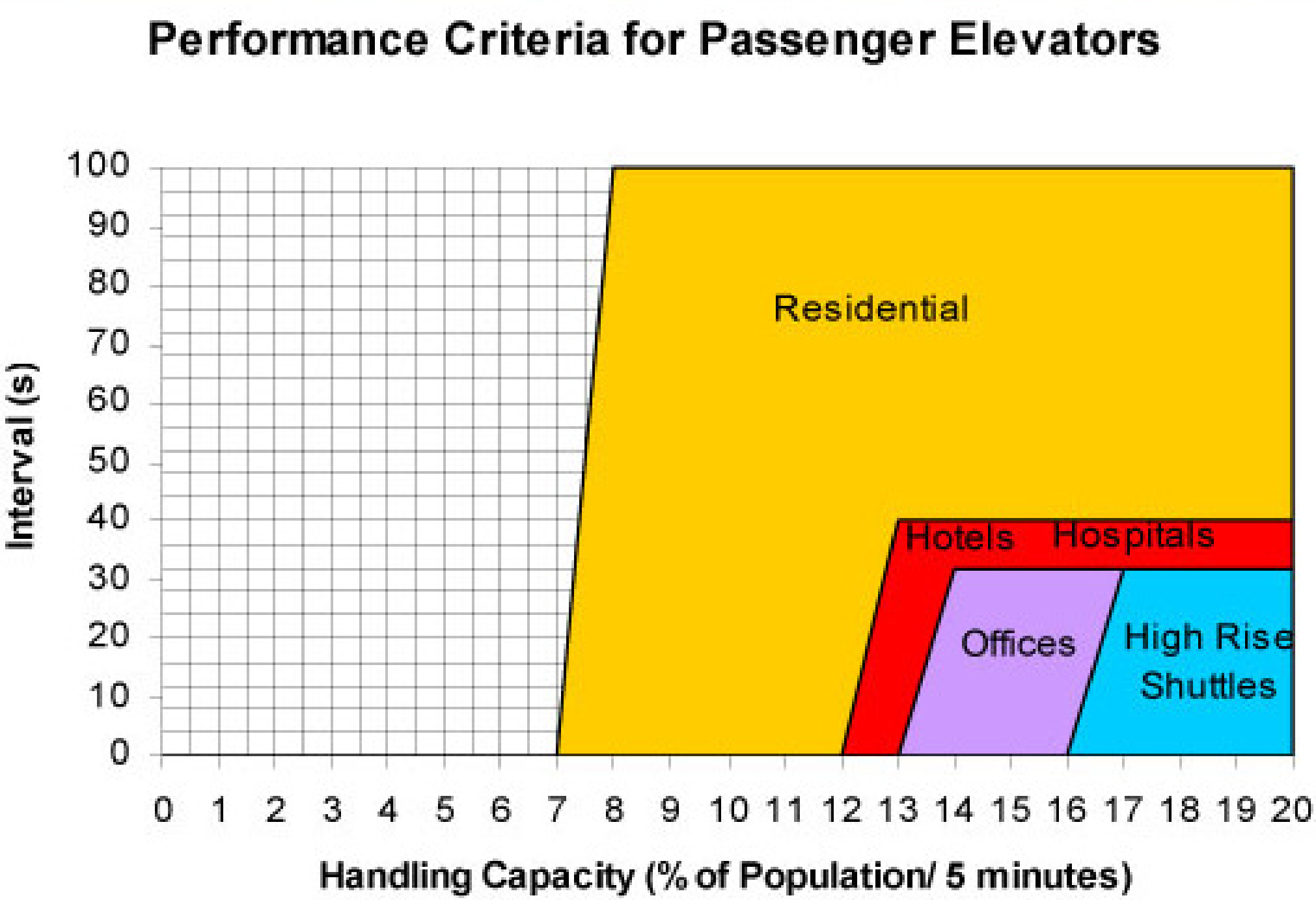


- Building categorization
  - The need for traffic planning varies according to the type and usage of the building
  - Typical categories:
    - Residential
    - Public service (e.g. subways, shopping centers, airports)
    - Hospital and multi-purpose buildings
    - Commercial mid-, high- and mega high rise -buildings (e.g. offices, hotels, cruise liners)

Advanced Traffic Planning

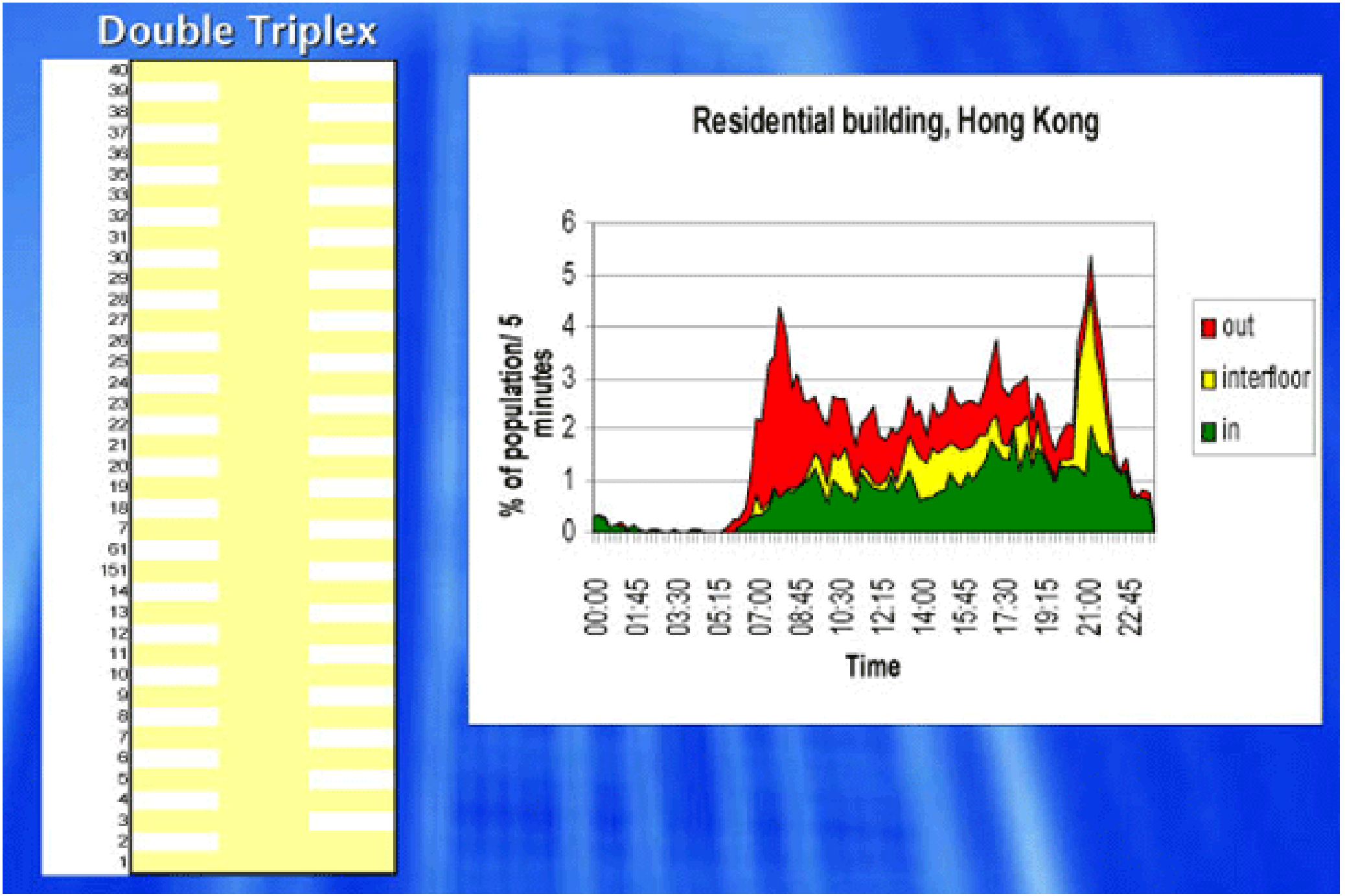


- Residential buildings
  - Traffic intensity is rather low
  - Waiting times even twice as long as those in commercial buildings may be acceptable
  - Can normally be selected by using local, international or comparable standards
- Public service (airports/subways, shopping centres)
  - Travelling height is typically no more than a few floors
  - Escalators can handle many times the traffic of lifts
  - Autowalks speed the people flow across long walking distances
  - Lifts are usually provided for handicapped access and the transport of goods or equipment


Performance Criteria for Passenger Elevators
Interval (s)
100
90
80
70
60
50
40
30
20
10
0
Residential
Hotels
Hospitals
Offices
High Rise
Shuttles
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Handling Capacity (% of Population/ 5 minutes)

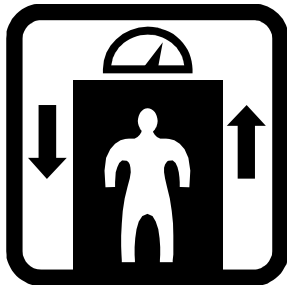
[Source: Kone]

Residential buildings – passenger traffic flow



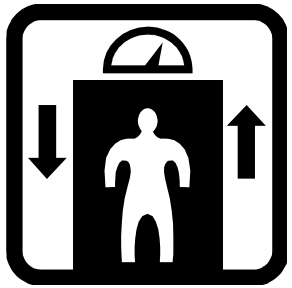
[Source: Kone]

Advanced Traffic Planning



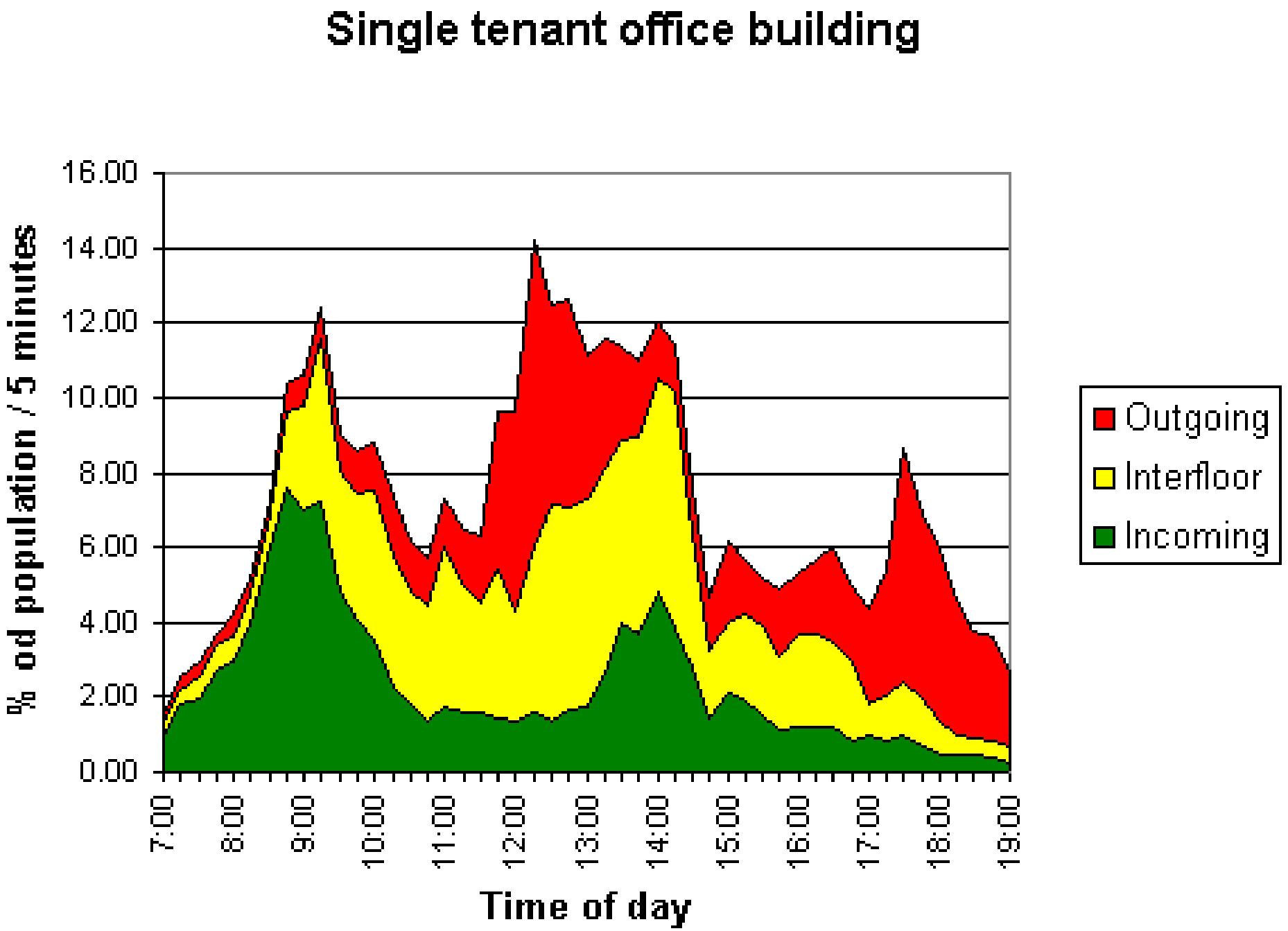
- Hospitals
  - Need detailed planning to cover emergency, service, bed, patient, visitor and staff transportation
  - Architecture and special needs e.g. the location of the operating theatre affect transportation arrangements
- Multi-purpose buildings
  - Separate elevators for different purposes
  - If the same lifts are to serve office and residential areas, they should be selected according to the highest estimated peak traffic demands

Advanced Traffic Planning



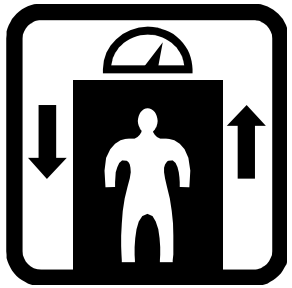
- Mid-rise commercial buildings
  - Hotels: the selection largely depends on the number of rooms and beds. Additional lifts are required for service purposes
  - Office buildings: three peak traffic hours generally occur: morning up peak, lunchtime mixed traffic and evening down peak
    - Up peak is normally used in lift planning
    - Lunch hour traffic is often heavier than the morning up peak

Commercial buildings – passenger traffic flow



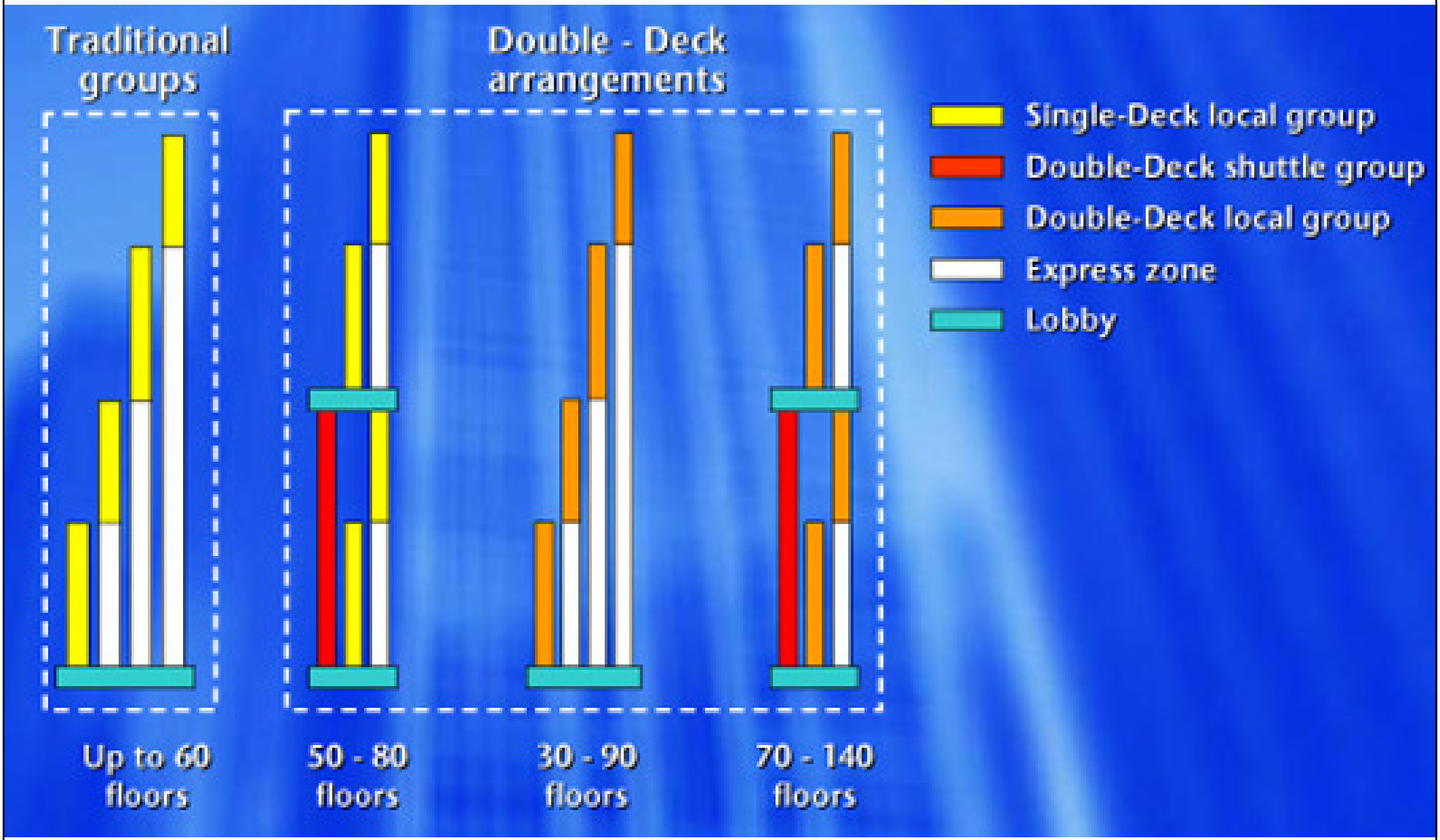
[Source: Kone]

Advanced Traffic Planning



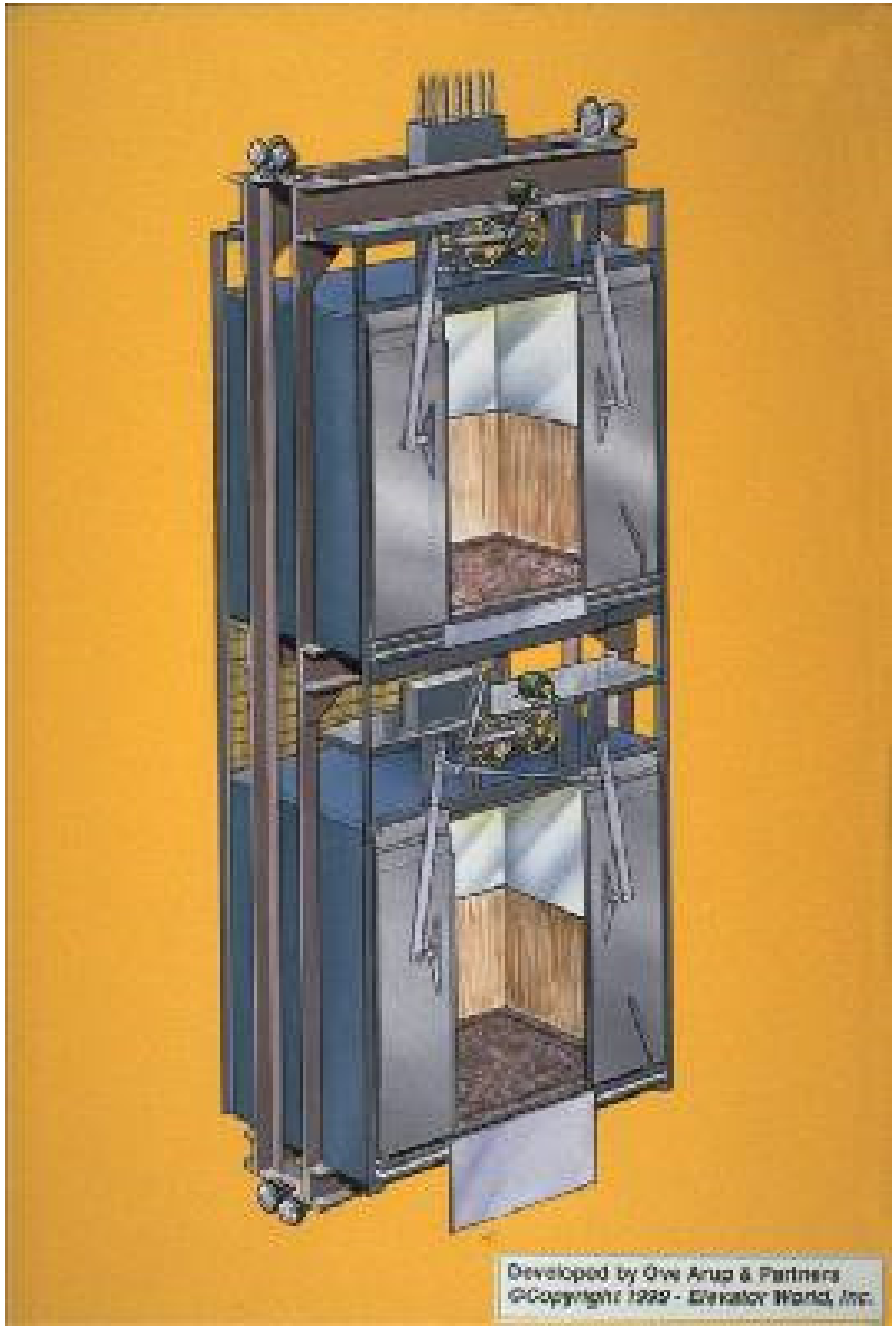
- High-rise commercial buildings
  - One lift group alone cannot meet all needs. They are often divided into zones, served by separate lifts groups
  - In mega-high-rise buildings (> 50-60 floors), either double-deck lifts are used or lift groups are stacked on top of one another in sky lobby arrangements
    - Shuttle groups serve traffic between the main entrance floor and the sky lobby
    - Local elevator groups start from both the main floor and from the sky lobby
    - Shuttle group criteria: HC > 16 % / 5 min.; Interval < 32 sec

Typical lift arrangements in Mega high rise buildings



[Source: Kone]

Typical double-deck lifts

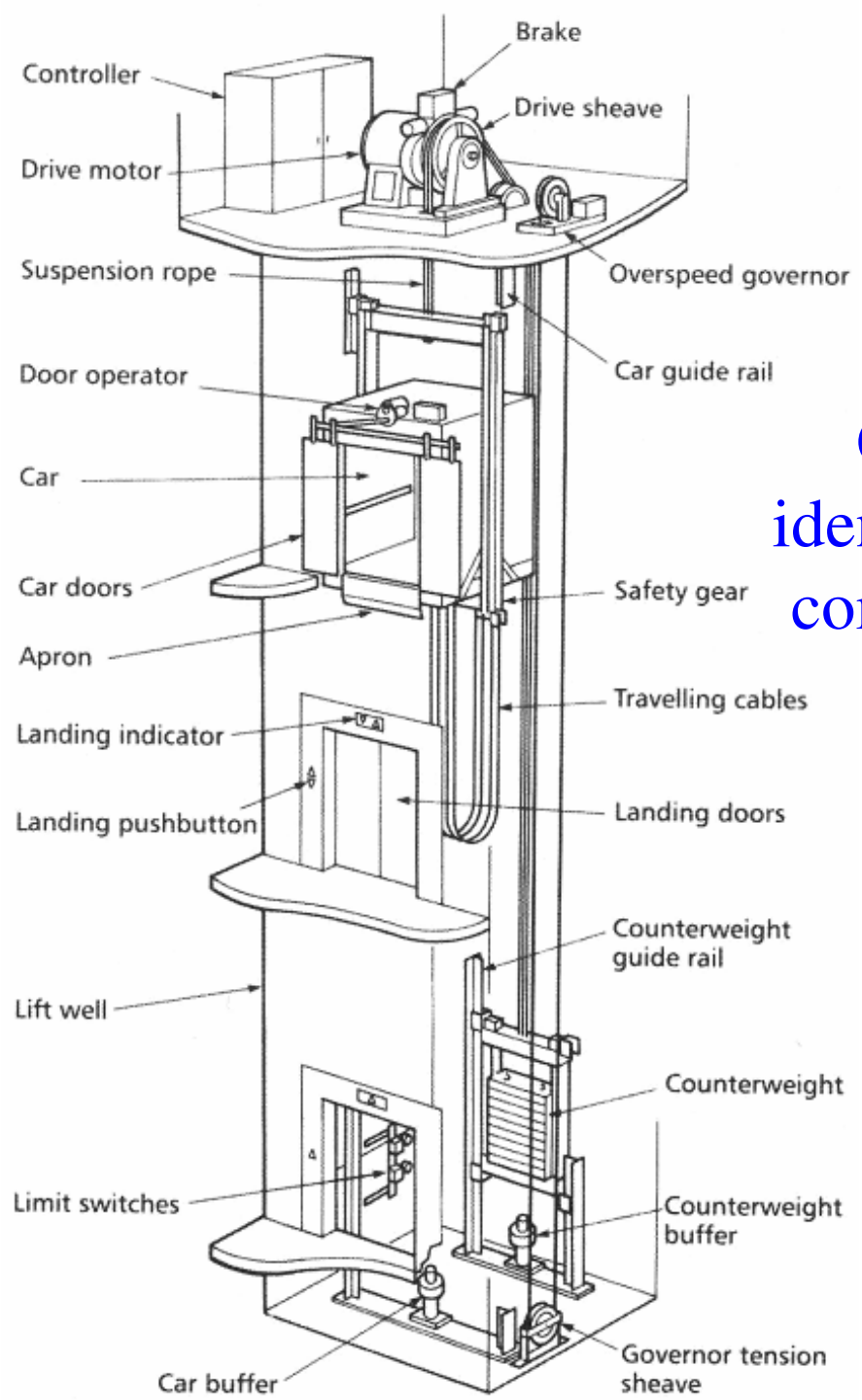


[Source: http://www.elevator-world.com]

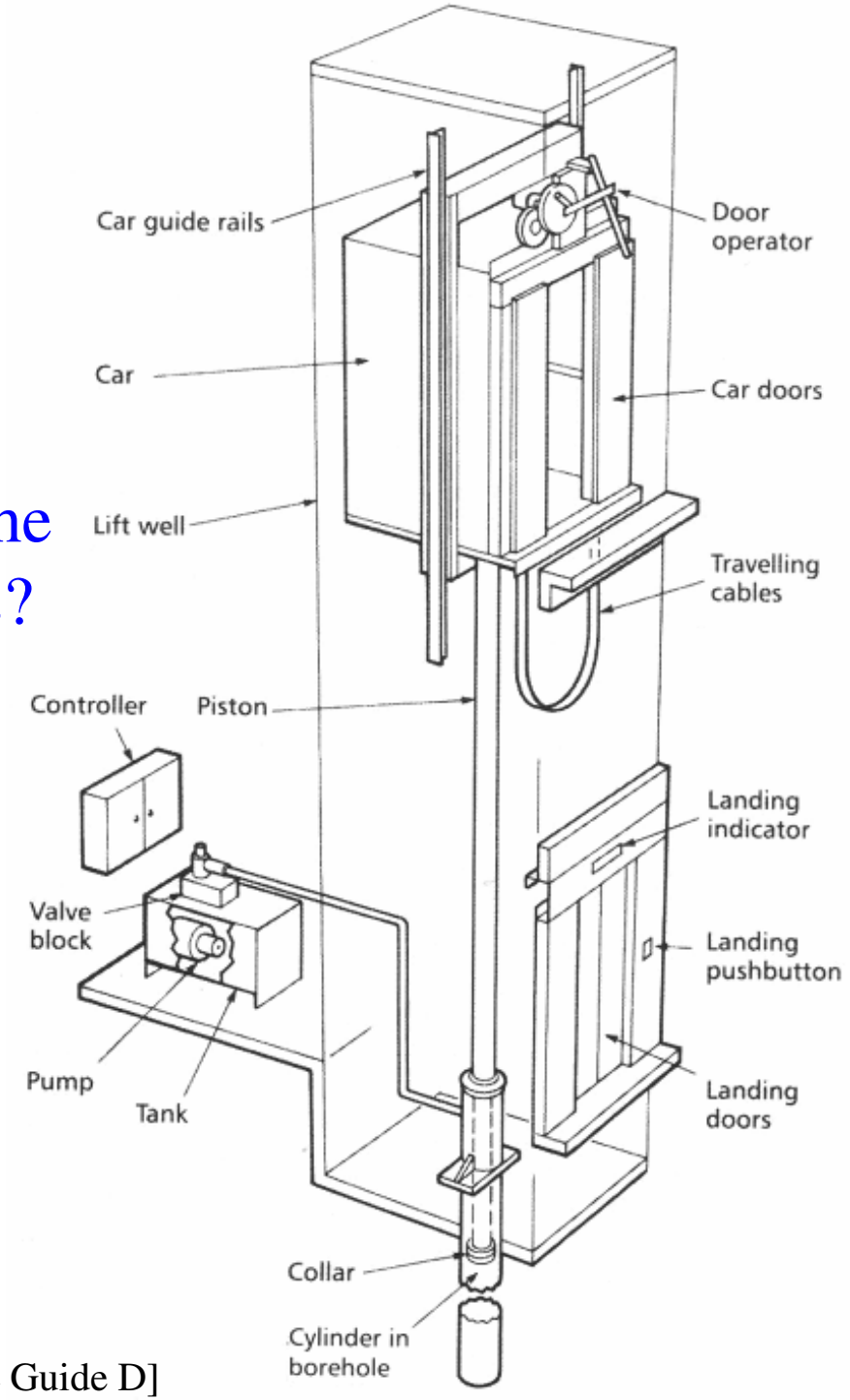
Lift Components

- Major lift components:
  - Prime mover (electric machine or hydraulic pump)
  - Lift car (car frame, the car itself)
  - Counterweight (if used)
  - Guide rails
  - Entrances/Doors
  - Safety gear & overspeed governor
  - Buffers (energy accumulation, energy dissipation)
  - Roping systems (compensating ropes, traction systems)
  - Car & landing fixtures (buttons, indicators & switches)

Components of electric traction passenger lift and hydraulic lift



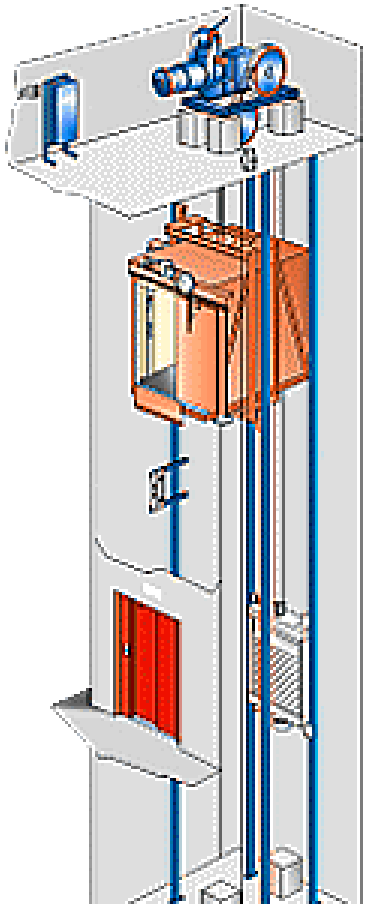
Can you identify all the components?



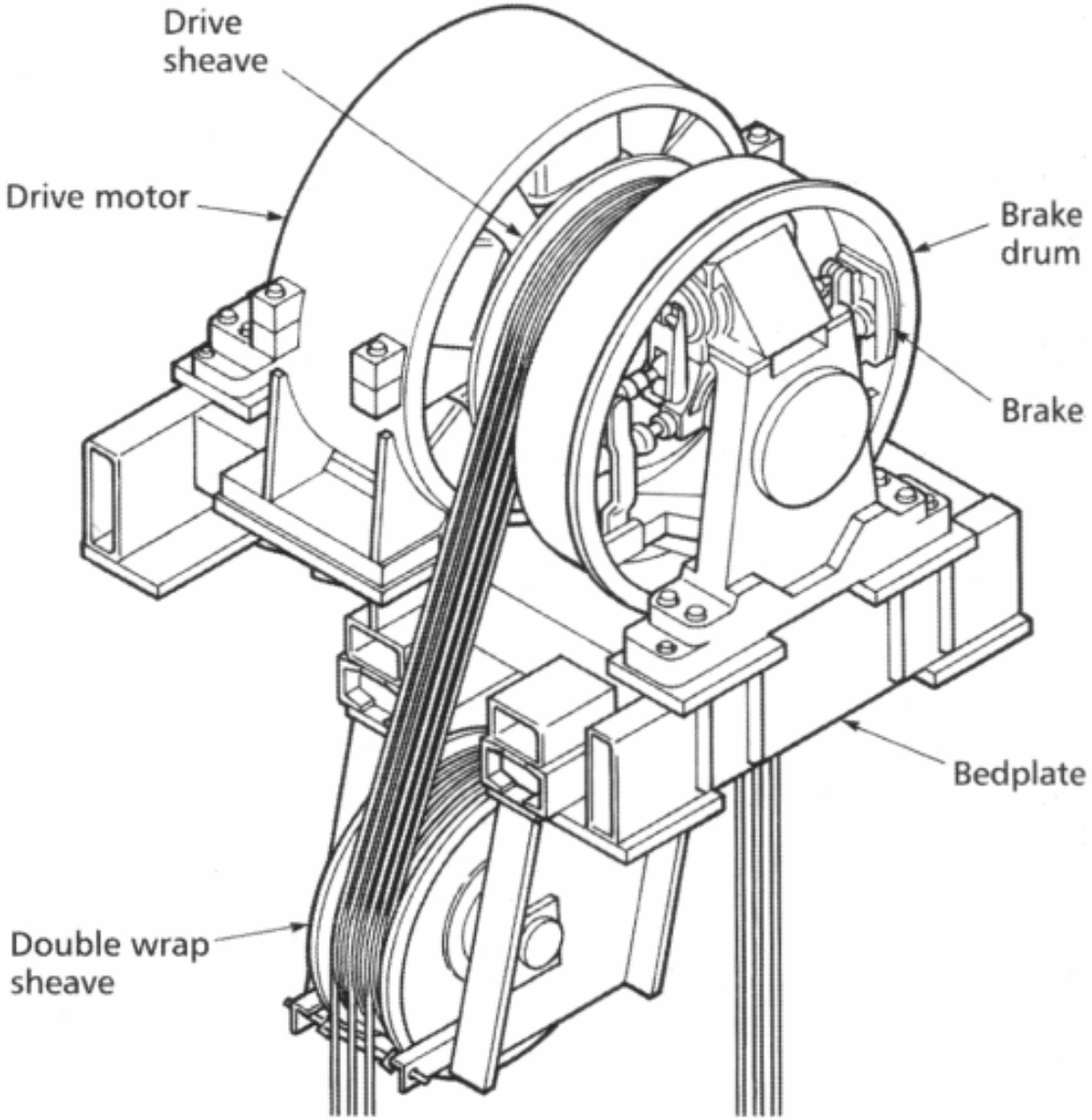
[Source: CIBSE Guide D]

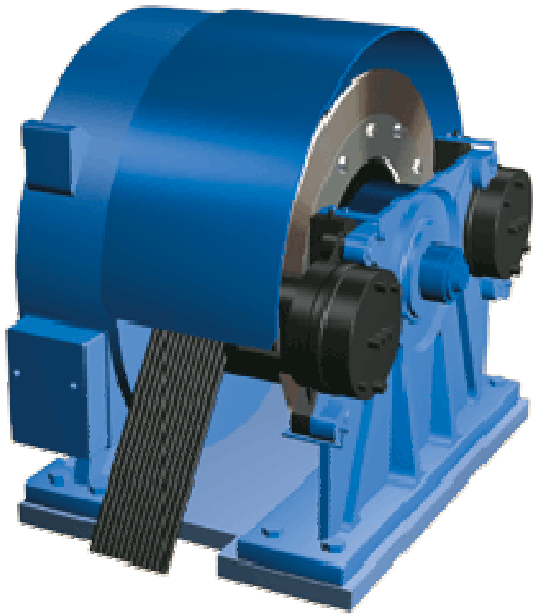
Lift Components

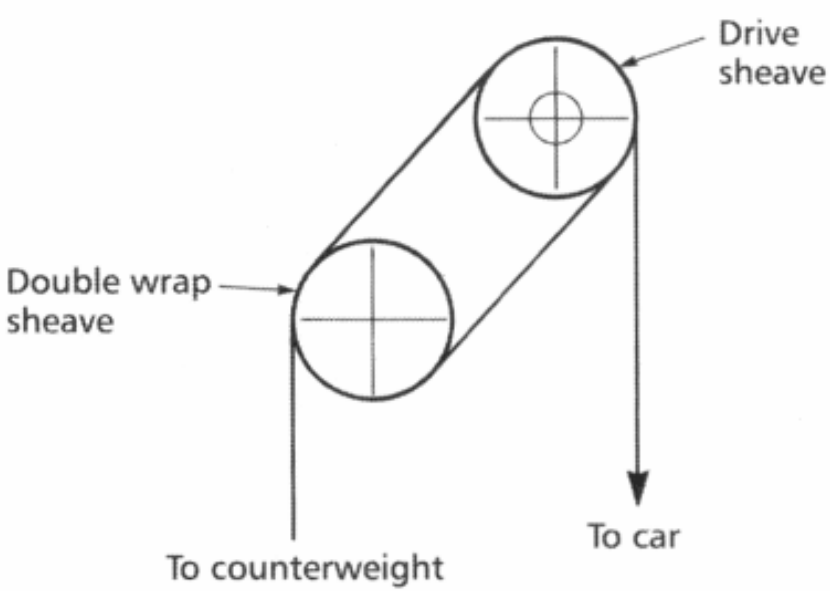
- Electric traction lift
  - Motor (AC or DC; gear or gearless)
  - Roping
  - Emergency brake
  - Lift doors
  - Constructional dimensions
  - Machine room position
  - Controller cabinet
  - Pit
  - Shaft



Video: What Is An Elevator? (10:21), http://youtu.be/P82fQMq9bXs

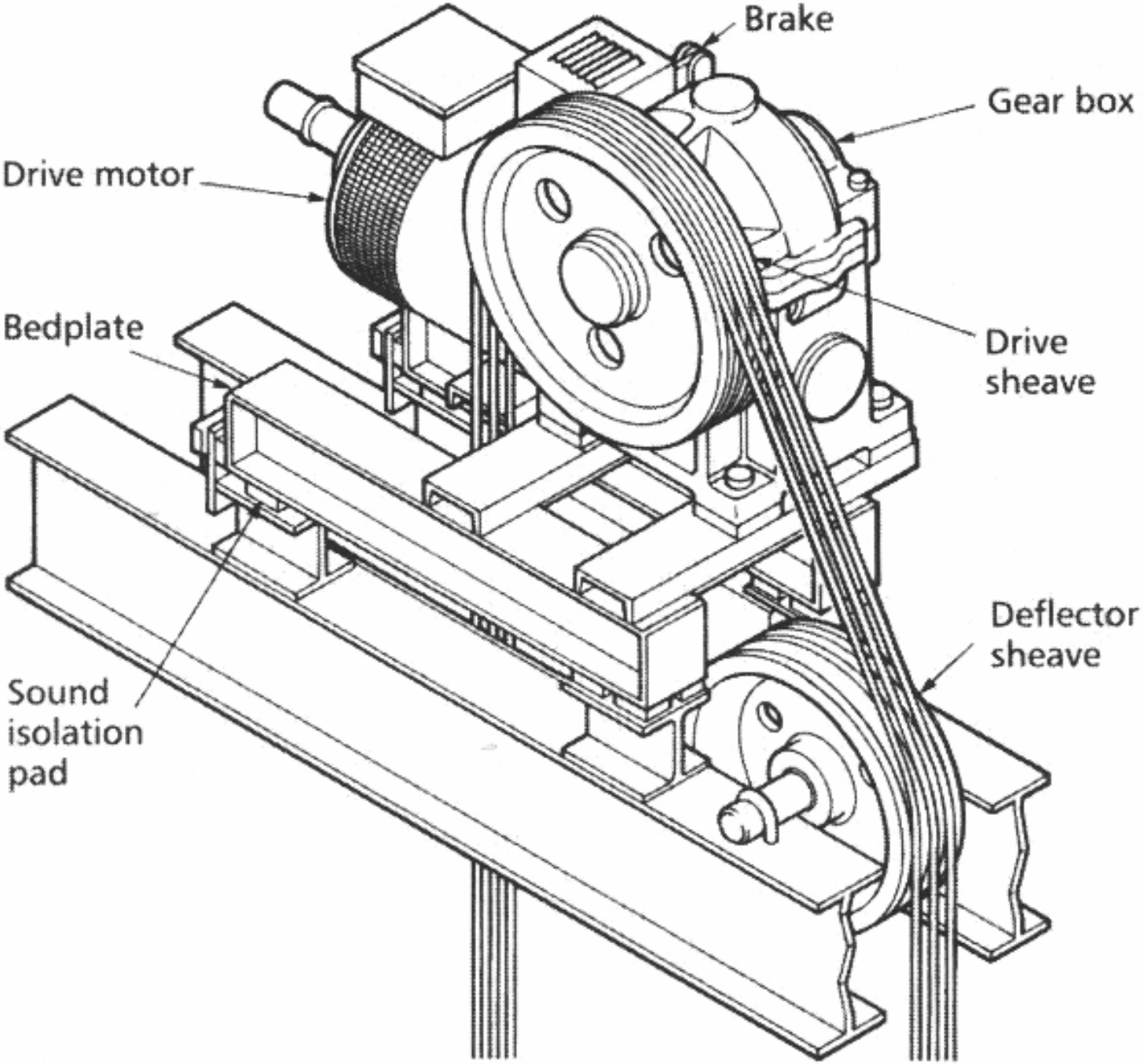






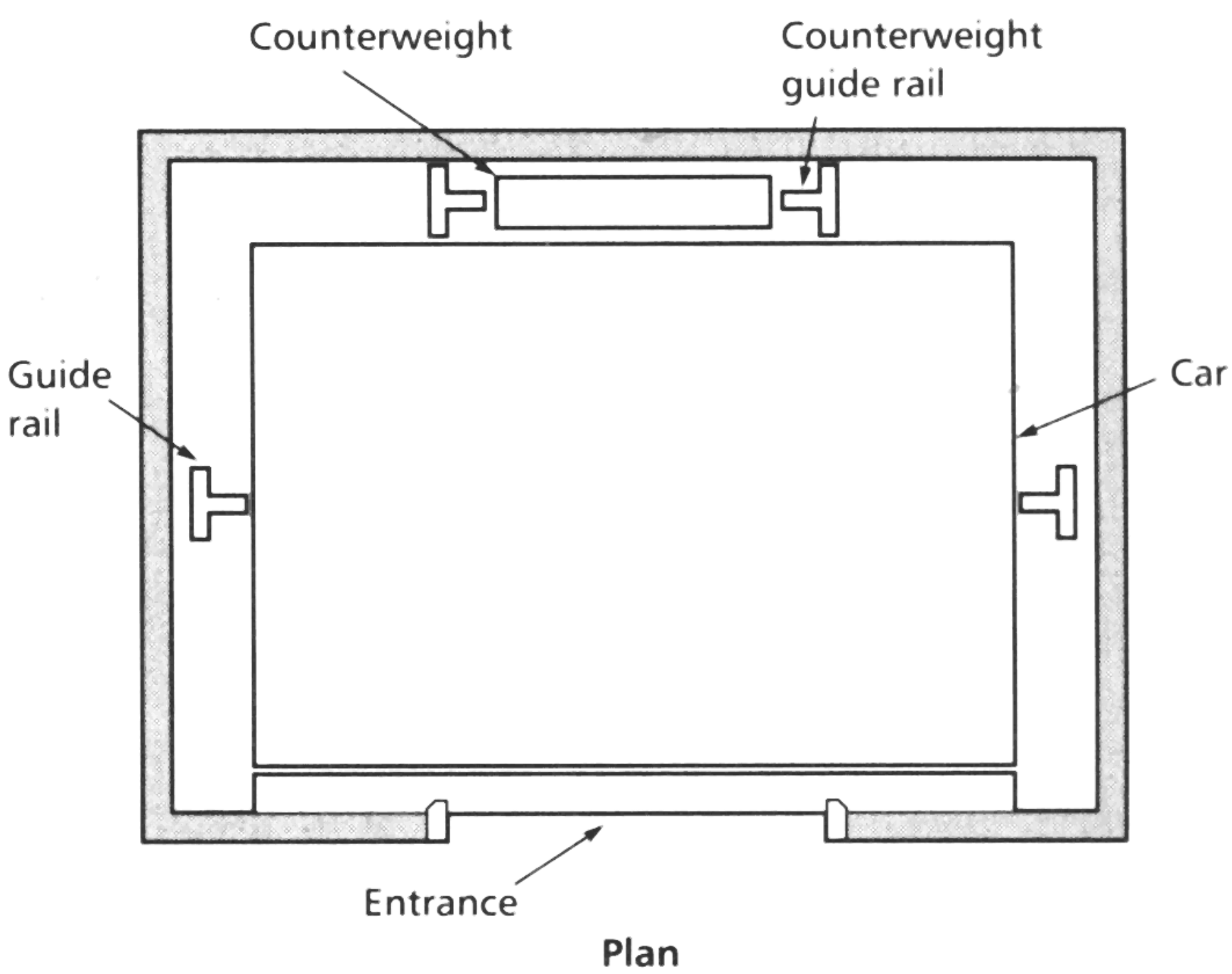
Typical gearless machine

[Source: CIBSE Guide D]



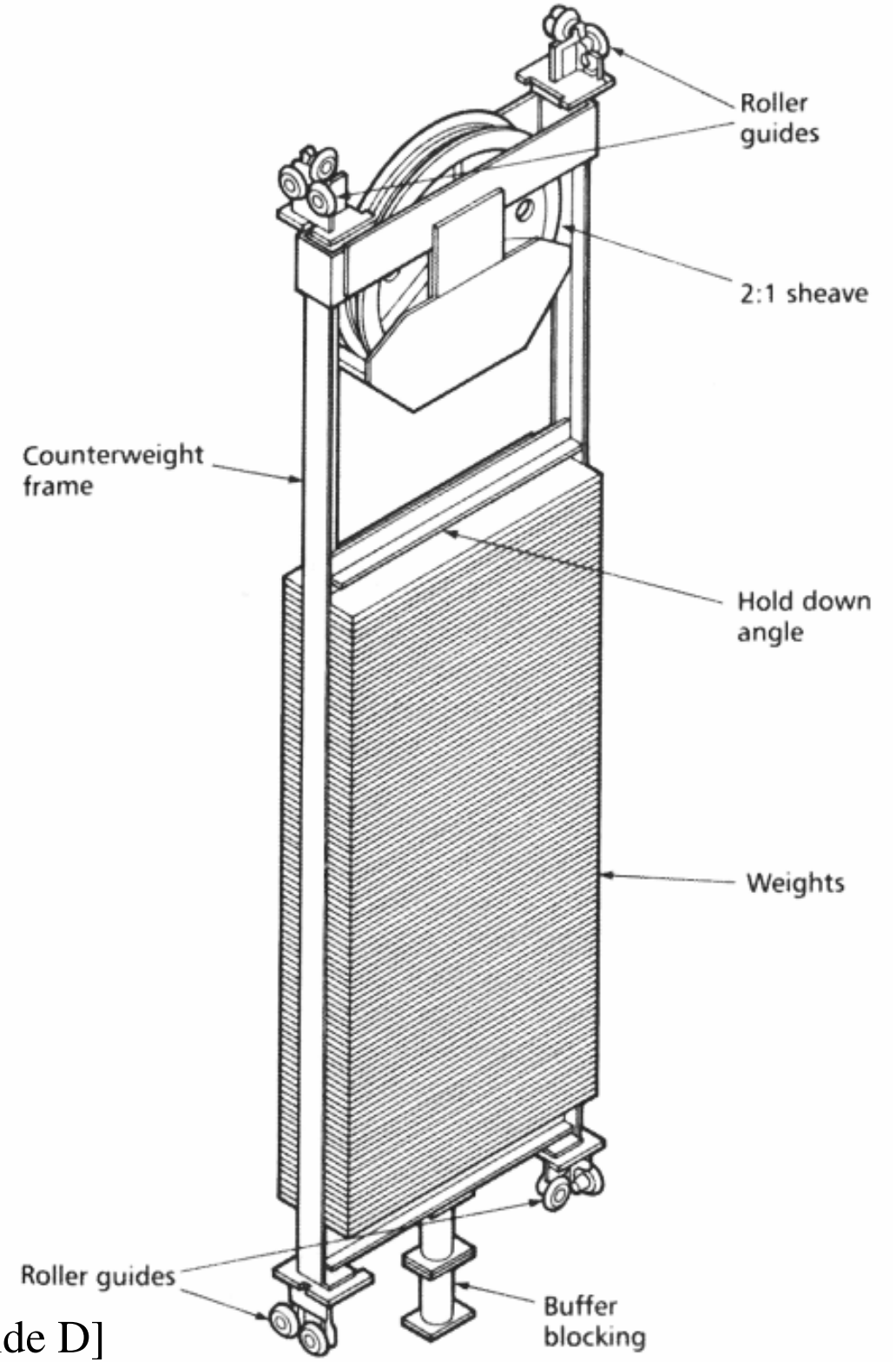
Typical geared machine

[Source: CIBSE Guide D]



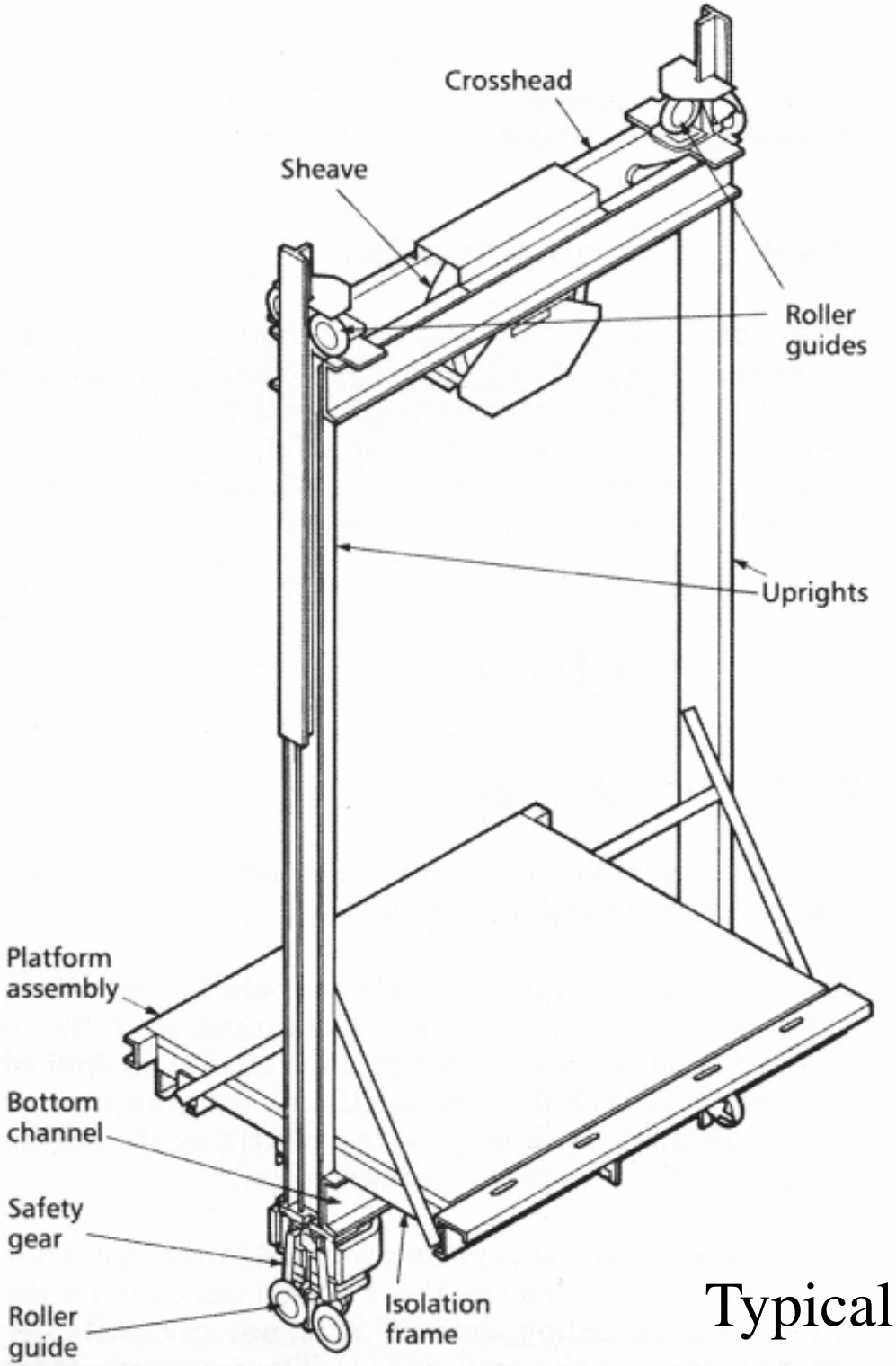
Position of guide rails

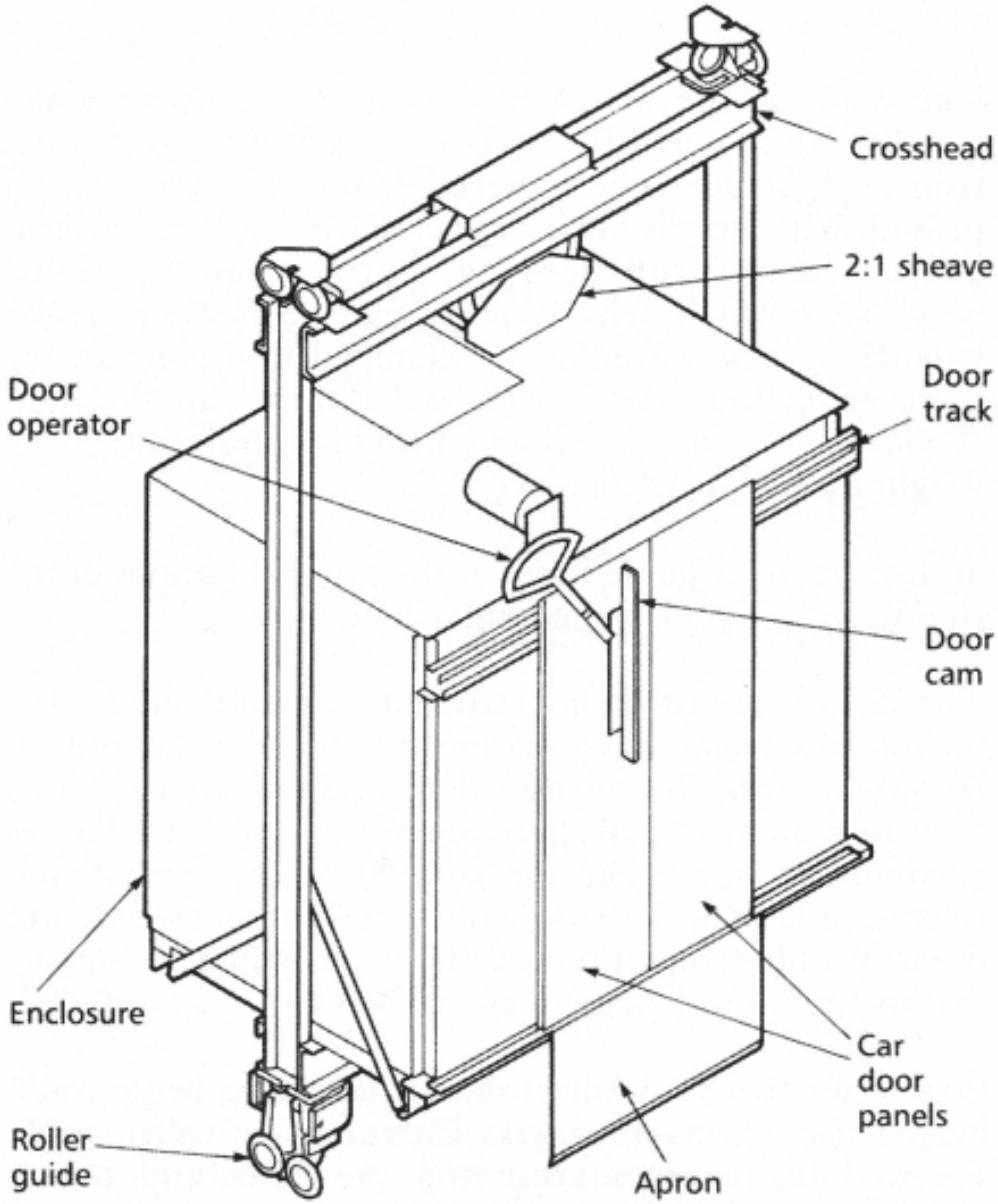
[Source: CIBSE Guide D]



Typical counterweight

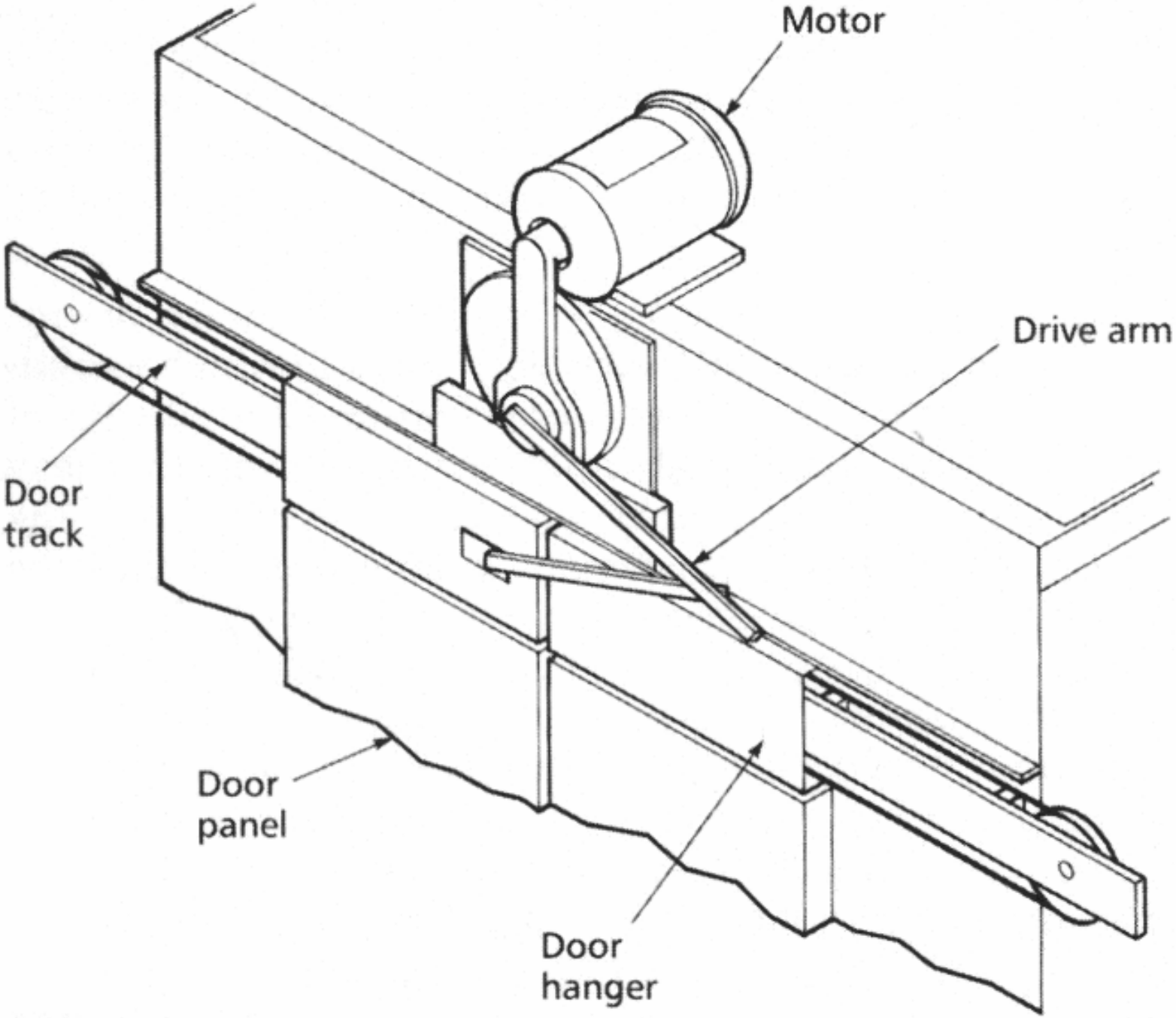
[Source: CIBSE Guide D]





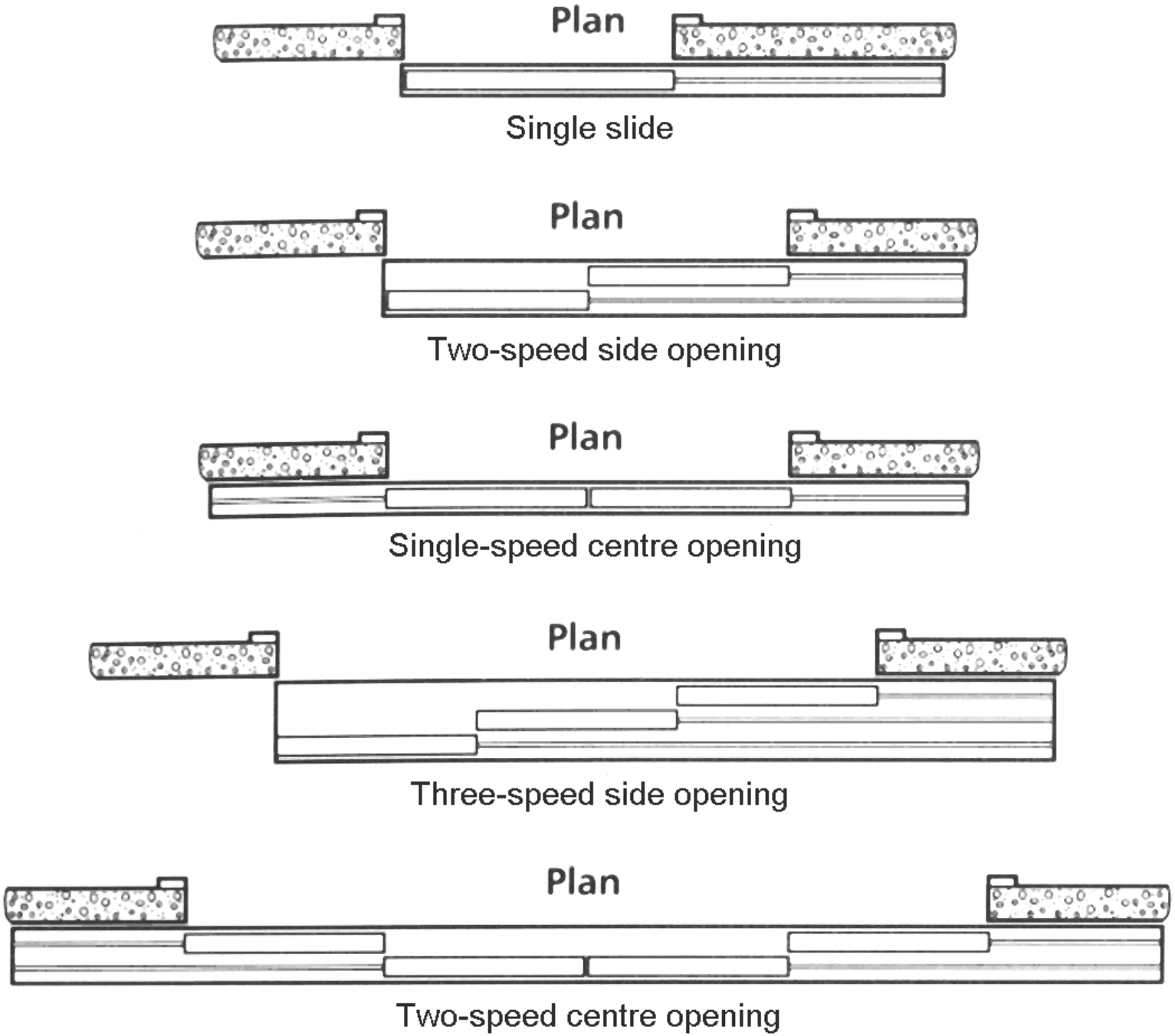
Typical car frame and lift car construction

[Source: CIBSE Guide D]



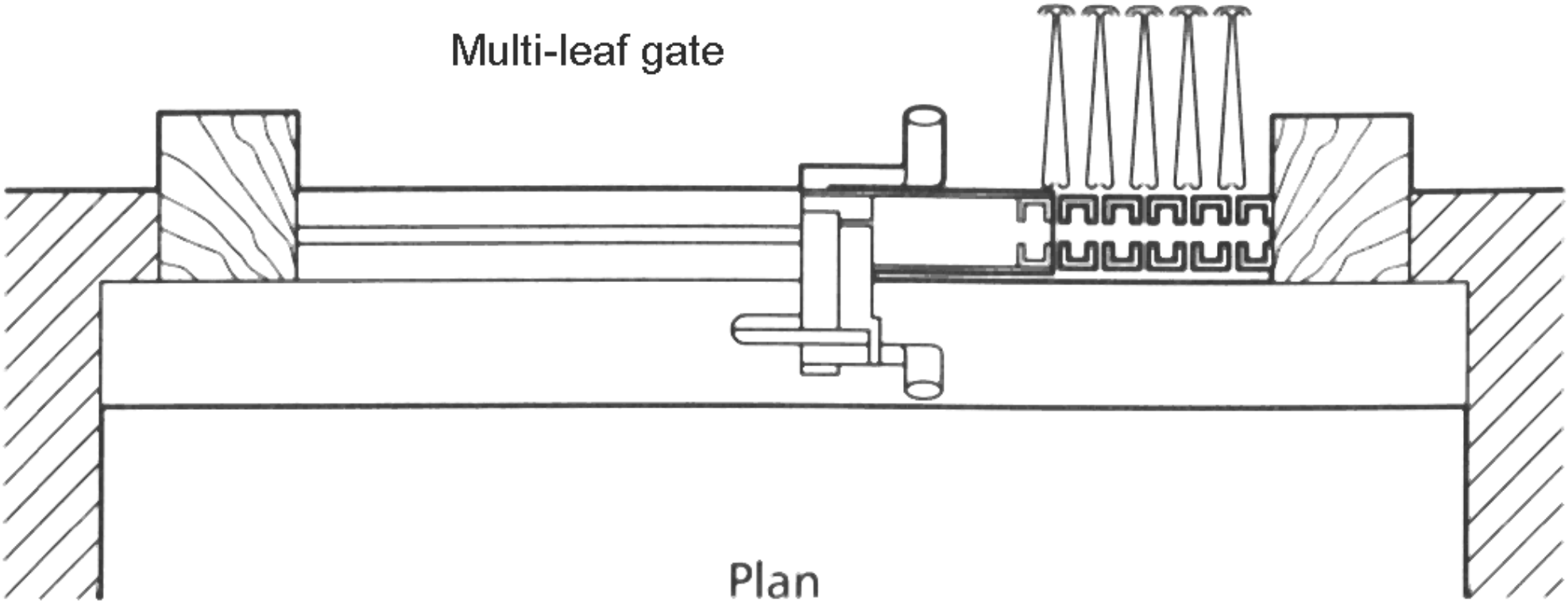
Typical door operator

[Source: CIBSE Guide D]

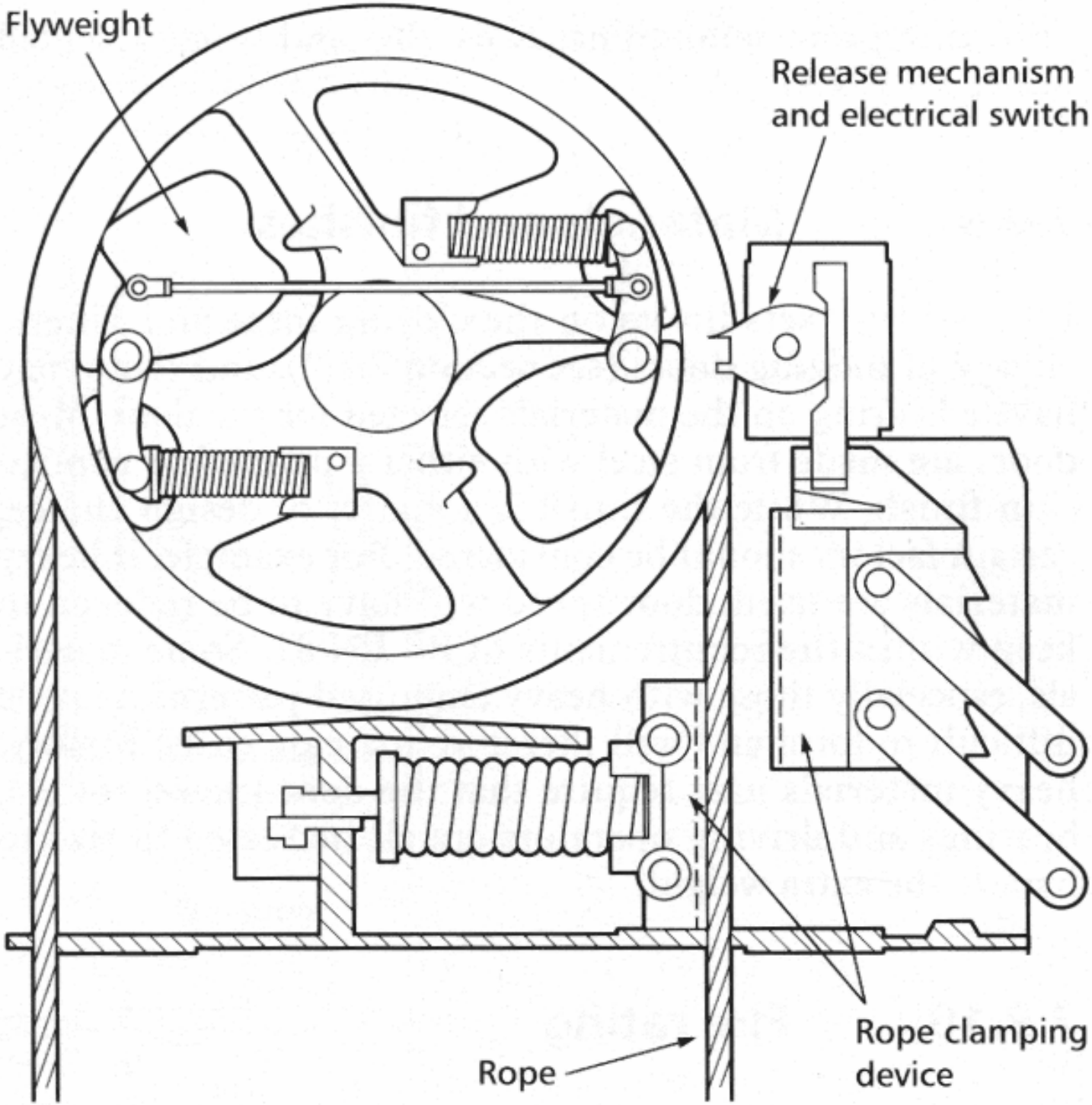


Horizontal power-operated sliding doors

[Source: CIBSE Guide D]

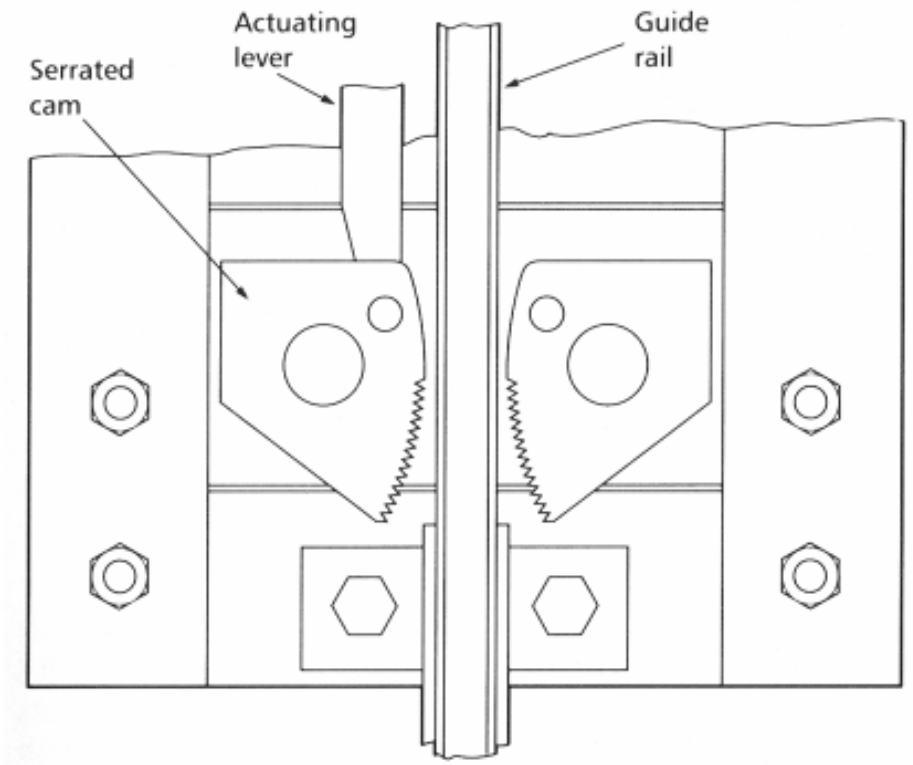


[Source: CIBSE Guide D]

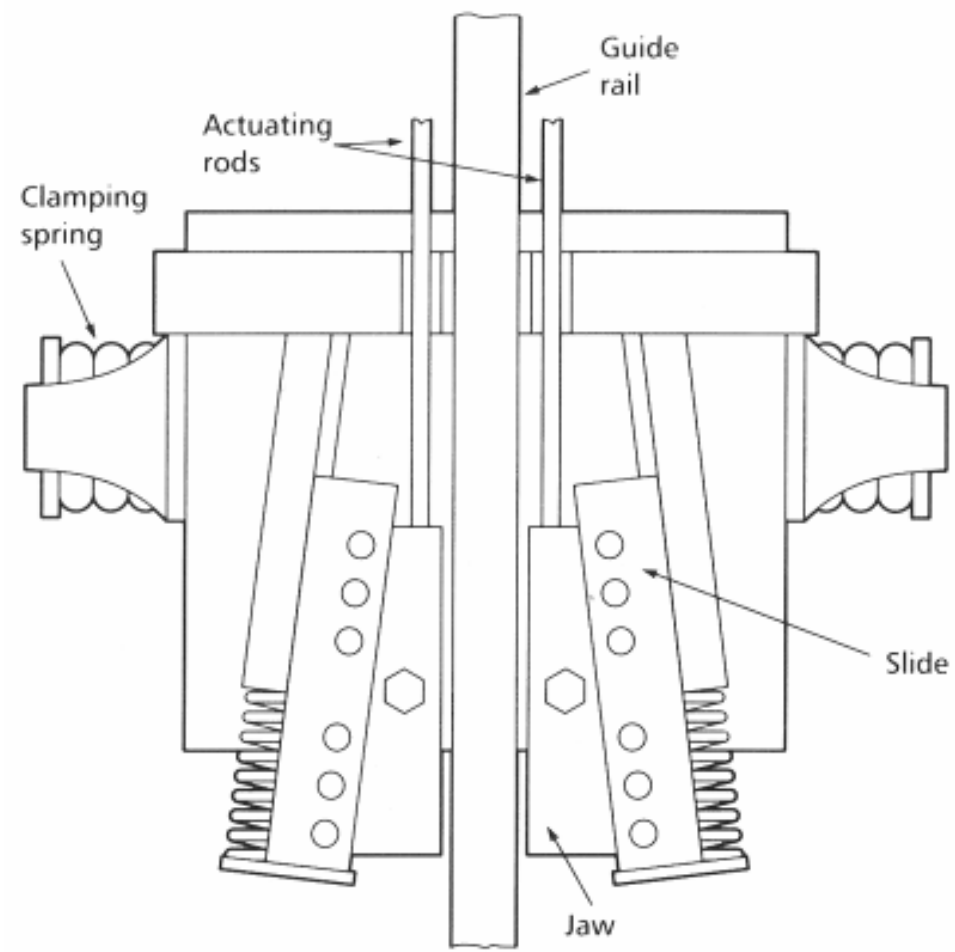


Centrifugal governor

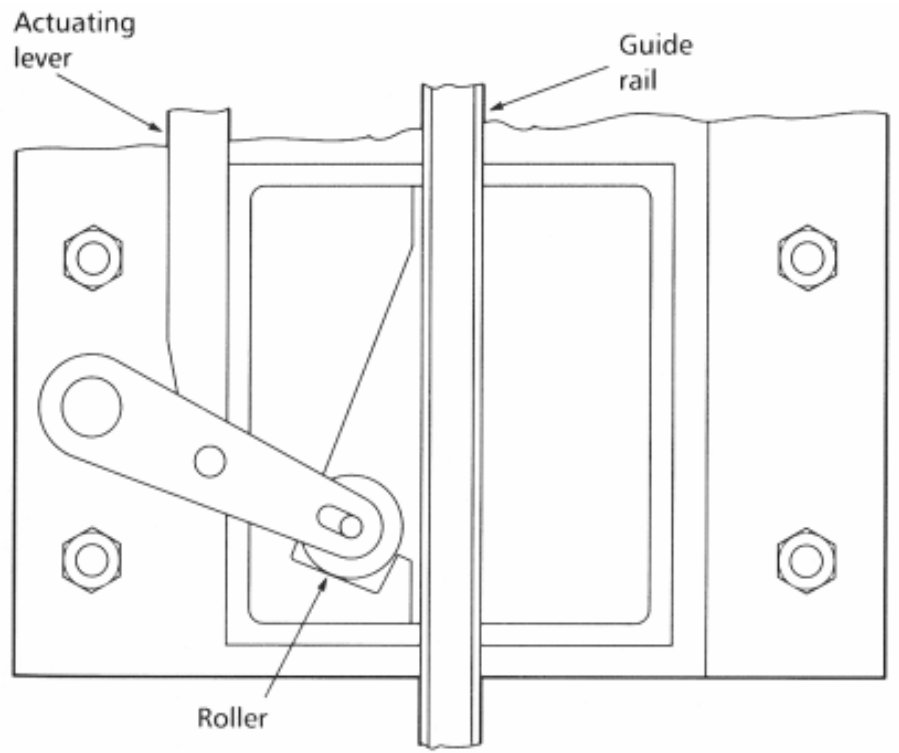
[Source: CIBSE Guide D]



Instantaneous safety gear: serrated cam

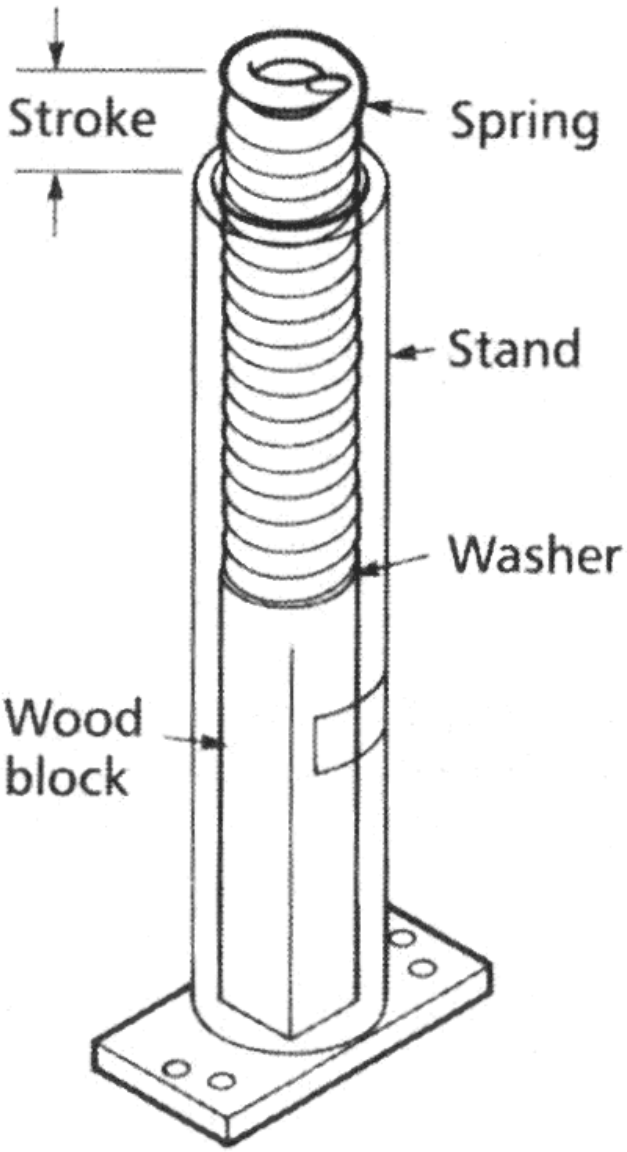


Progressive safety gear

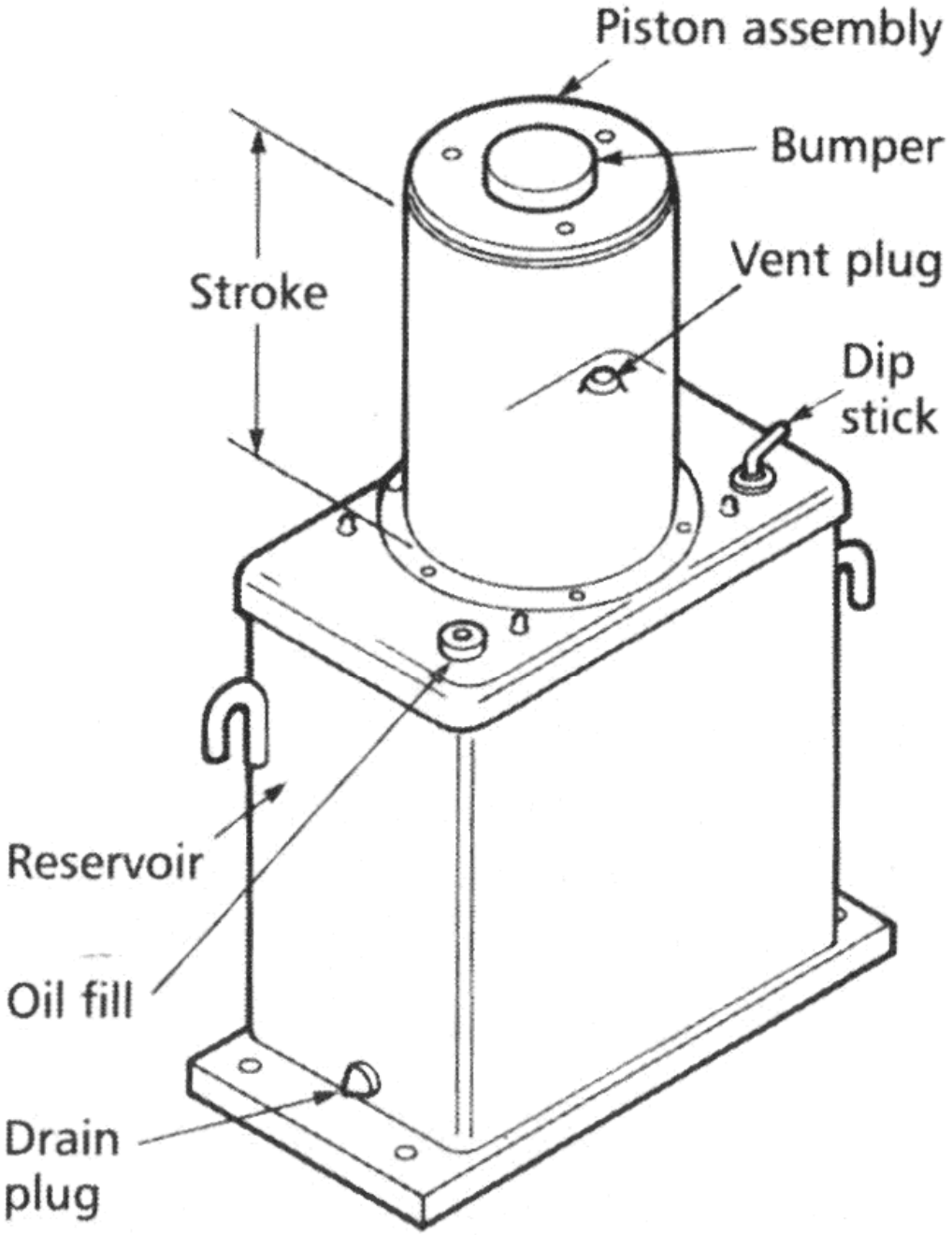


Instantaneous safety gear: roller type

[Source: CIBSE Guide D]



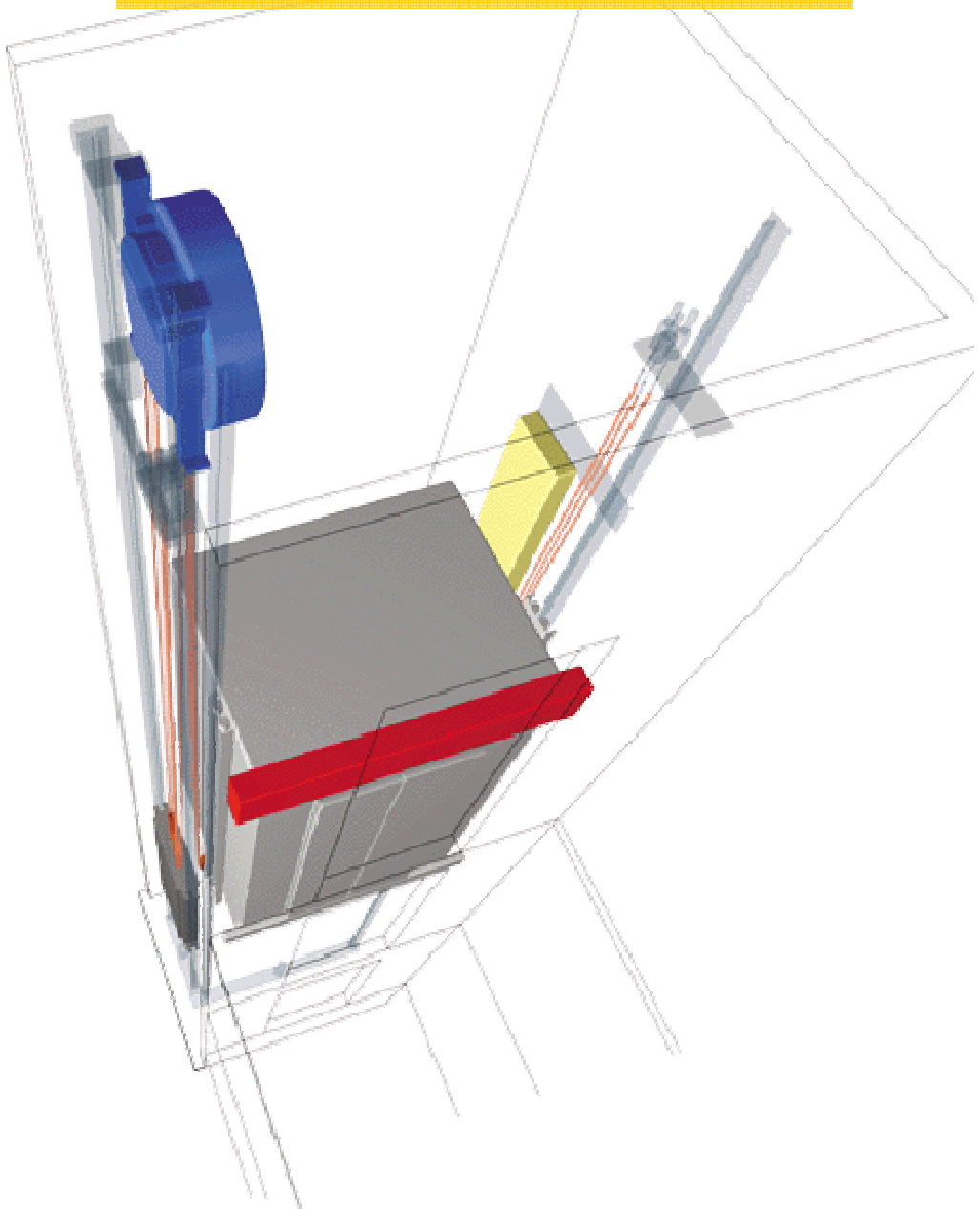
Energy accumulation type buffer

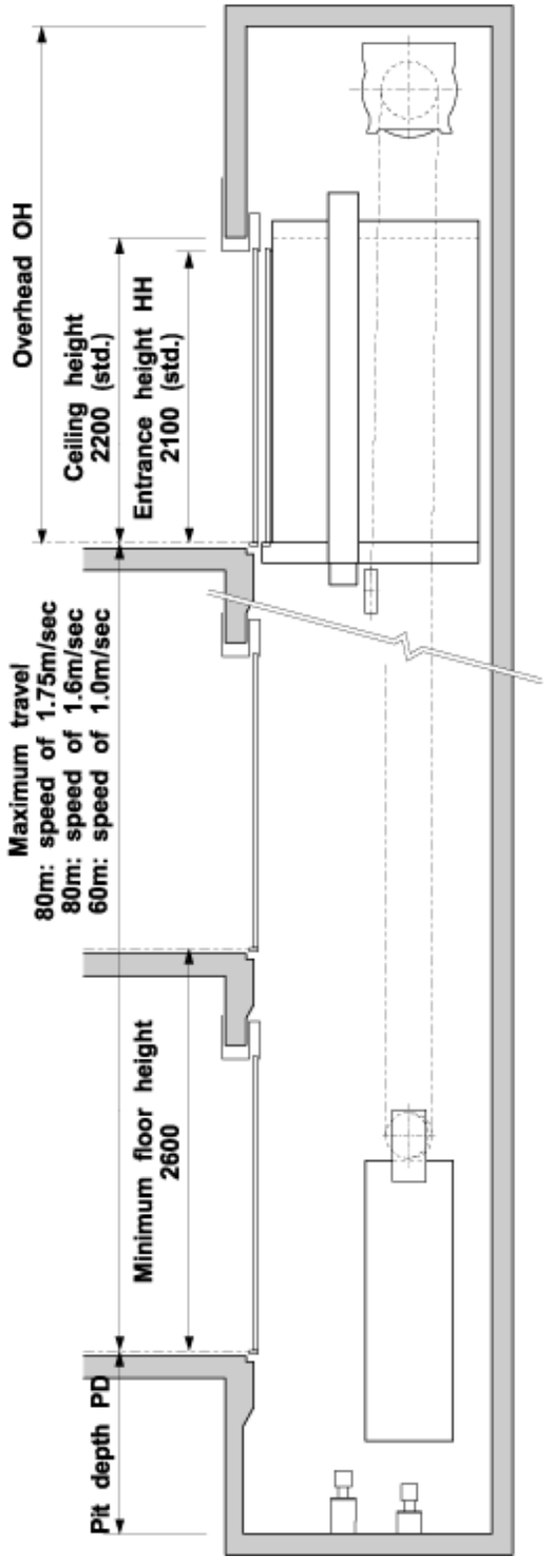


Energy dissipation type buffer

[Source: CIBSE Guide D]

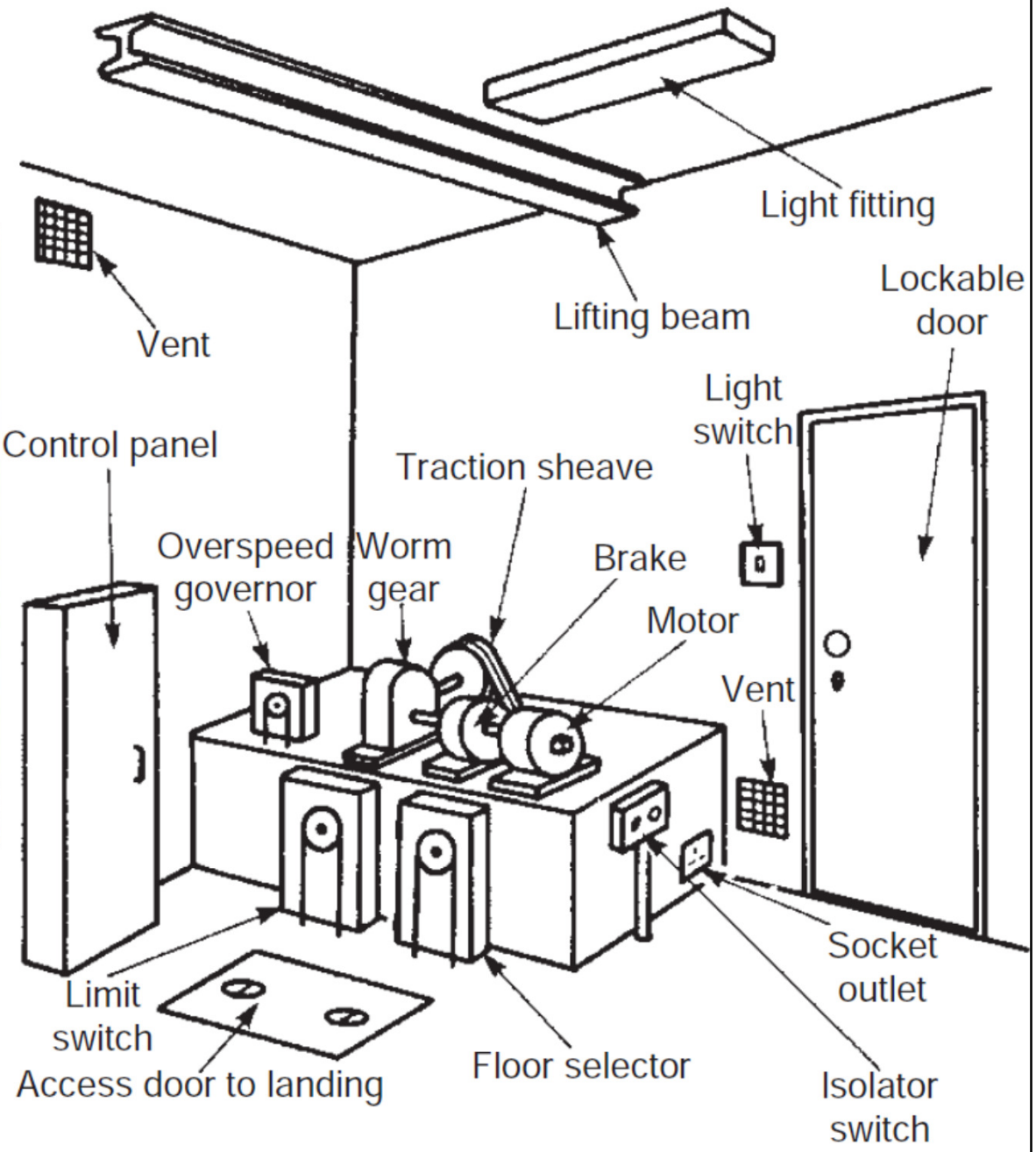
What are the advantages?





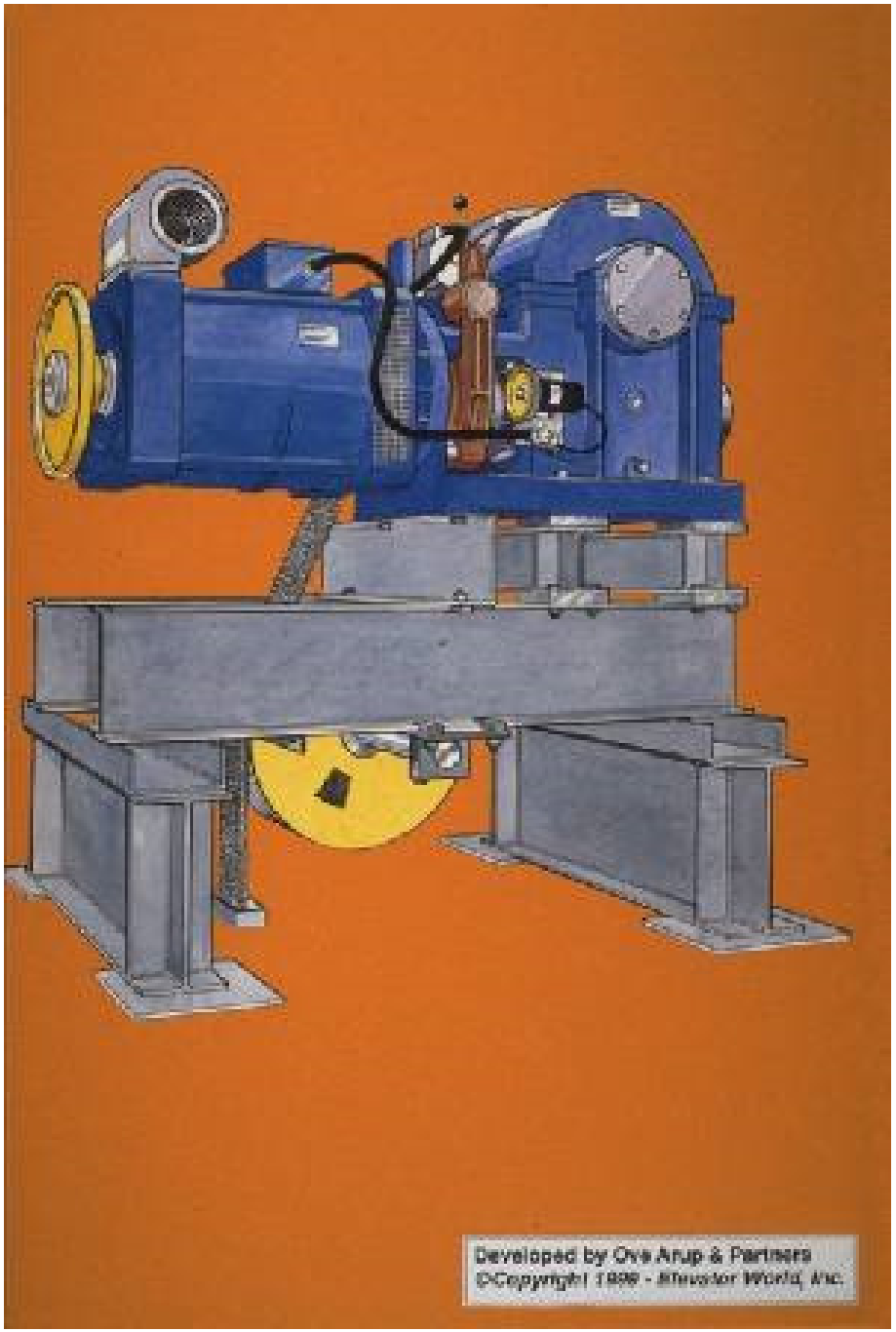
Machine-room-less lift system

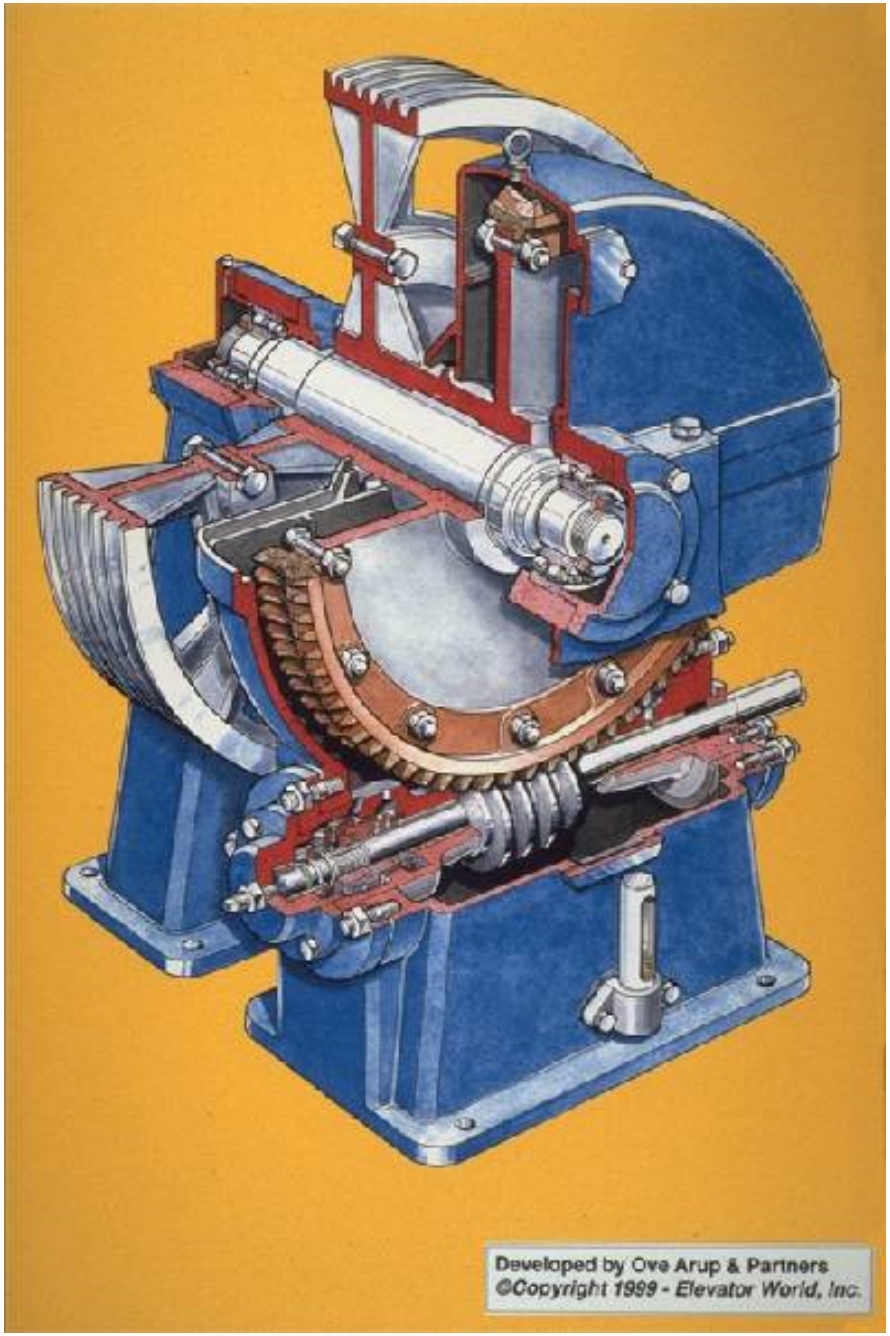
Typical lift machine room



[Source: http://www.elevator-world.com and *Building Services Handbook*]

Geared machine and baseplate assembly

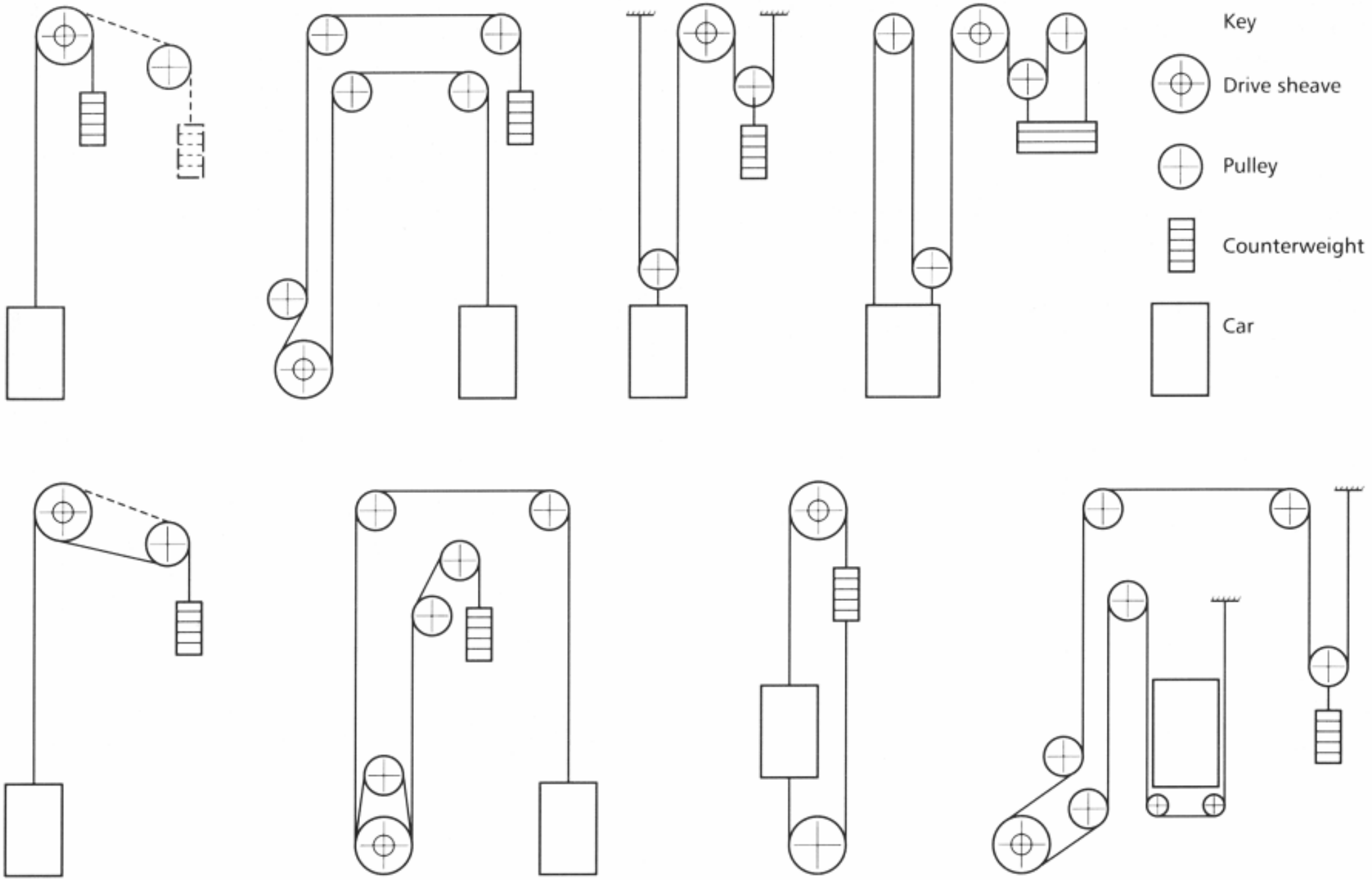




[Source: http://www.elevator-world.com]

Lift Components

- Electric traction lift
  - Roping systems
    - Single wrap
      - 1:1 roped
      - 1:1 roped with diverter pulley
      - 1:1 roped with machine room below roof level
      - 2:1 roped
      - 3:1 roped
    - Double wrap
      - 1:1 roped (for high speed & medium to heavy duty loads)
      - 1:1 roped with compensating rope
    - Drum drive



Roping systems

[Source: CIBSE Guide D]

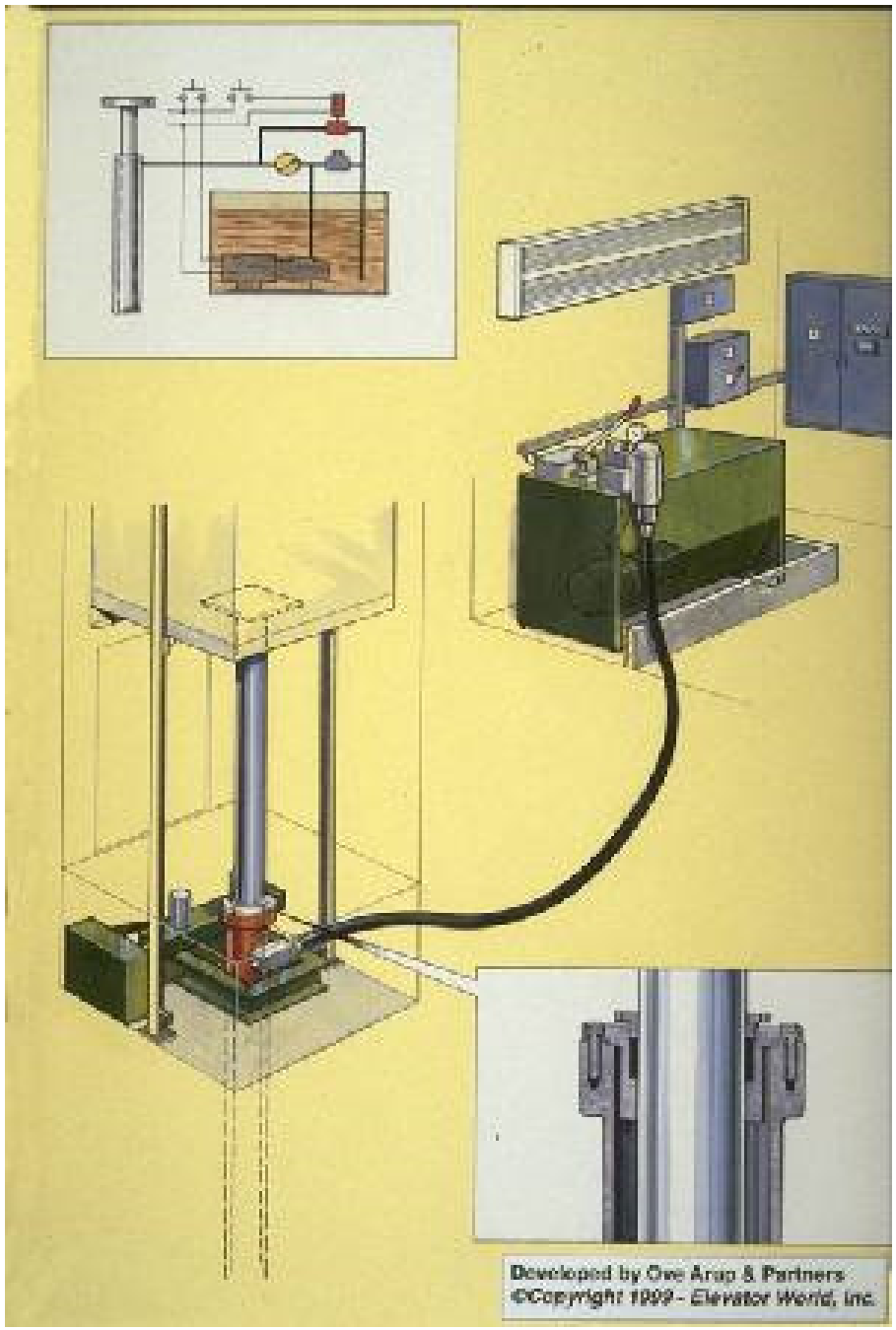
Lift Components

- Electric traction lift: motor drives
  - Gear
    - Single-speed or two-speed AC motor
    - Variable voltage AC motor
    - VVVF (variable voltage, variable frequency) AC motor
    - Variable voltage DC motor
  - Gearless
    - Variable voltage DC motor
    - VVVF (variable voltage, variable frequency) AC motor
  - Linear induction drive

Lift Components

- Hydraulic lift
  - Maximum travel of 21 m; speed up to 0.75 m/s
  - Advantages:
    - Capacity for very heavy loads
    - Accuracy in floor leveling
    - Smooth ride characteristics
    - Low-level plant room
    - No structural loads from winding gear
    - Pump room can be located up to 10 m from the shaft

Typical hydraulic lift arrangement



[Source: http://www.elevator-world.com]

Lift Components

- Hydraulic lift
  - Jack arrangements
    - Direct-acting
    - Single side-acting: direct or indirect
    - Twin side-acting: direct or indirect
  - Power units
    - Tank or oil reservoir
    - Pump
    - Pump motor (e.g. single-speed AC induction type)
    - Flow control valve block

Lift Components

- Firefighting or fireman's lift
  - Specific provisions include
    - Break-glass key switch (at G/F to control the lift)
    - Min. duty load, say 630 kg (for firefighting equipment)
    - Min. internal dimensions (m), 1.1(W) x 1.4(D) x 2.0(H)
    - An emergency hatch in the car roof
    - Manufactured from non-combustible material
    - A two-way intercom
    - 1 hour fire-resisting doors of 0.8 m (W) x 2 m (H)
    - A max. of 60 sec to run full building height
    - Dual power supplies (normal + emergency)

Can you explain why we need each of them?

Lift Components

- Lift shaft should have the following features:
  - Water-tightness
  - Means of drainage
  - Plumb, vertical sides
  - Smooth painted finish
  - Ventilation void for emission of smoke
  - Permanent inspection lights
  - Have no other services (except this for the lift)