These values are similar to those given in BS 5655-6 (BSI, 2011).

A target value for the average interval may be provided by either the building owner or the developer.

Caution: when using the interval as a quality indicator, passenger waiting time depends on car occupancy, i.e. the number of passengers in the lift. In general, an average passenger waiting time is less than the calculated interval, when the average car occupancy is less than 80% of probable capacity. When average passenger capacity factor exceeds 80% (for a sufficiently long time), the average passenger waiting time increases substantially and it rapidly becomes unacceptable. The lift system becomes saturated and the lobby queues increase uncontrollably, because the lifts cannot cope with the passenger demand. See section 3.10.

Simulation can be used to obtain more definitive values for average passenger waiting (see chapter 4).

Design tip: a useful rule of thumb for the general level of service provided by a single lift serving several floors is:

- excellent service: one lift per 3 floors
- average service: one lift per 4 floors
- below average service: one lift per 5 floors.

The performance time (T) has the most effect on the round trip time, equation 3.1. Reducing the value of T by one second can increase the handling capacity of a lift installation by about 5%. Quality of service may be judged by the value selected for T. For a 3.6 m interfloor height, Table 3.8 gives the values of T that can indicate the probable performance of an installed lift system.

The above two rules of thumb may need to be ignored in order to achieve, for example, either a specified interval, or a specified handling capacity.

Table 3.8 The performance time (T) as a quality of service indicator

Value of T (s)	Comment
8.0–9.0	Excellent system
9.0–10.0	Good system
10.0–11.0	Average system
11.0–12.0	Poor system
>12.0	Consider system replacement

3.9 Worked example of design calculations

Example 3.2

A 10-floor (above the main terminal) office building with a net usable area of 8125 m^2 for a single speculative tenant with open plan accommodation is to be built. The interfloor distance is 3.6 m. Design a suitable lift installation.

Note: this example is typical of an initial enquiry. Little is known, except the number of floors, interfloor distance, net usable floor area, type of accommodation.

Net internal area (NIA) = 8125 m^2

Using section 3.8.2 assume 80% utilisation:

Net usable area (NUA) = 8125 × 0.8 = 6500 m^2

Using section 3.8.3 assume 8 m^2 per person, hence:

Maximum population = 6500/8 = 813 persons

Assume 10% absenteeism (section 3.8.3):

Actual population = 813 × 0.9 = 731 persons

Using section 3.8.4 assume 12% arrival rate (multiply by 0.12):

Arrival rate = 731 × 0.12 = 88 person/5-minutes

Using section 3.8.5 assume interval is 30 s (average system).

Thus the lift system requirements are to provide a handling capacity of 88 persons/5-minutes (12%) with a 30-second interval.

In simple terms, there will be 10 trips in five minutes at an interval of 30 s. To transport 88 persons in 10 trips requires an average car occupancy of 8.8 persons. Table 3.1 shows a lift with a rated load of 1000 kg can accommodate 9.1 persons (by area).

Equation 3.1 needs to be solved:

$$\text{RTT} = 2\,H\,t_v + (S + 1)\,(T - t_v) + 2\,P\,t_p$$

Values for H and S can be obtained from Appendix 3.A1. Hence, for N = 10 and P = 8.8:

$$H = 9.4 \text{ and } S = 6.0$$

The total travel is 36 m and a value for v is obtained from Table 3.2 as 1.6 m/s. This gives:

$$t_v = 3.6/1.6 = 2.25 \text{ s}$$

A value for T is obtained from equation 3.10:

$$T = t_f(1) + t_{sd} + t_c + t_o - t_{ad}$$

Table 3.4 indicates a suitable value for $t_f(1)$ as 5.2 s and Table 3.5 indicates suitable door operating times for a 1100 mm centre opening doors as t_c = 3.0 s and t_o = 2.5 s.

From section 3.7.6 assume the start delay is 0.5 s and the advance opening is 0.5 s. Thus:

$$T = 5.2 + 0.5 + 3.0 + 2.5 - 0.5 = 10.7 \text{ s}$$

From Table 3.6 assume t_p = 1.0 s.

The data determined for the lift system are:

— Number of floors (N): 10

— Rated speed (v): 1.6 m/s

- Rated load (RL): 1000 kg
- Interfloor distance (d_f): 3.6 m
- Single floor flight time: 5.2 s
- Door close time: 3.0 s
- Door open time: 2.5 s
- Advance door opening: 0.5 s
- Start delay: 0.5 s

The data for equation 3.1 are:

- $H = 9.4$
- $S = 6.0$
- $P = 8.8$
- $t_v = 2.25$ s
- $T = 10.7$ s
- $t_p = 1.0$ s

The calculations are as follows:

$$\text{RTT} = 2 \times 9.4 \times 2.25 + (7.0 \times 8.6) + 2 \times 8.8 \times 1.0$$

$$= 42.3 + 60.2 + 17.6$$

$$= 120.1 \text{ s}$$

To achieve an average system (Table 3.7), i.e. a 30-second interval, then four lifts would need to be installed.

UPPINT = 30.0 s

%POP = 12%

UPPHC = 88 persons/5-minutes

These values meet the design criteria.

3.10 Frequently asked questions in the evaluation of RTT

A number of assumptions are made in order to derive the round trip time equation (equation 3.1). These can place limits on the validity of the method. It is important for a designer to be aware of these limitations, especially when using computerised design methods, in order to ensure a realistic design.

(*a*) *Do passengers arrive uniformly in time?*

The derivation of the round trip time equation assumes that passengers arrived at a lift system for transportation, according to a rectangular probability distribution function (PDF). However, it is more likely that the arrival processes can be according to a Poisson PDF.

It has been shown (Barney, 2003) that values for S and H derived using the Poisson PDF are always smaller than with a rectangular PDF. Thus the use of formulae based on the rectangular PDF produces slightly more conservative designs when compared to designs using formulae derived from other PDFs.

(*b*) *Can the rated load be used to determine the number of passengers a lift car can accommodate?*

The nominal capacity in persons based on BS EN 81-20 (BSI, 2014a) is the rated load divided by 75. This is not the probable capacity (PC). As discussed in section 3.7.3, the nominal passenger carrying capacity of lifts presented in safety standards should not be used for traffic planning. To determine the maximum practical loading of the car, consider area only.

(*c*) *Why should lifts load to 80% of probable capacity?*

In the round trip time calculation the lifts are assumed to fill to 80% of the probable capacity (PC), see Table 3.1. This has been shown (Barney, 2003) to be a reasonable statistical assumption and allows some lifts to fill to capacity and others to lower values, giving an average of 80%. The number of passengers as a percentage of the probable capacity is called the percentage capacity factor (%CF) and is given by equation 3.13.

$$\%\text{CF} = \frac{P}{\text{AC}} \times 100 \qquad (3.13)$$

Note: lifts cannot load to a greater value than 100% of probable capacity.

(*d*) *What happens if all floors are not equally populated?*

Generally the floors of a building are not equally populated. It is possible (Barney, 2003) to derive quite complex formulae for S and H. If calculations are carried out for a building where most of the population occupies the higher floors then it is found that the value for H rises and the value for S falls. Conversely, if most of a building's population occupies the lower floors of a building the value for H falls significantly and the value for S also falls. The effect in both cases, compared to a building with each floor being equally populated, is that the value for the round trip time reduces. Therefore the effect of an unequal population is generally favourable to the conservative sizing of a lift system.

(*e*) *What happens if the rated speed is not reached in a single floor jump and if the interfloor heights are not equal?*

These two assumptions are related. For lifts with speeds greater than 1.6 m/s the first assumption is usually not valid. Most buildings have irregular interfloor distances (e.g. main entrance floors, service floors, conference floors), making the second assumption incorrect. It has been found (Barney, 2003) that if the flight time to travel the average interfloor distance is determined and this time is used as $t_f(1)$ in the round trip time calculation, then an error in the calculation of only a few percent occurs. Peters (1997) has provided formulae for the 'corrections' recommended in the 1993 edition of this Guide.