Internal heat gains[1]

Internal heat gain is the sensible and latent heat emitted within an internal space from any source that is to be removed by air conditioning or ventilation, and/or results in an increase in the temperature and humidity within the space.

Benchmark values for internal heat gains are based on either surveys of measured internal heat gains from a number of buildings of particular types and usage, or empirical values found appropriate from experience, survey and considered good practice in the industry.

Following sources are concerned in most cases:

- Occupants
- Lighting
- Office equipment and computers

1. Occupants

All active animal bodies including humans lose heat to their surroundings due to their metabolic activity, which is related to the activity to subject is performing (i.e. sedentary, sleeping, dancing etc…). The heat can be released as sensible or latent heat. The sensible heat release is due to the higher temperature the surface of the skin can have in respect to the surrounding environment, while the latent heat is released by means of respiration and sweating.
Table 6.3 provides representative heat emissions from an average adult male in different states of activity. The figures for a mixture of males and females assume typical percentages of men, women and children for the stated building type.

Table 6.3 Typical rates at which heat is given off by human beings in different states of activity.

Degree of activity	Typical building	Total rate of heat emission for adult male / W	Rate of heat emission for mixture of males and females / W			Percentage of sensible heat that is radiant heat for stated air movement / %	
			Total	Sensible	Latent	High	Low
Seated at theatre	Theatre, cinema (matinee)	115	95	65	30	—	—
Seated at theatre, night	Theatre, cinema (night)	115	105	70	35	60	27
Seated, very light work	Offices, hotels, apartments	130	115	70	45	—	—
Moderate office work	Offices, hotels, apartments	140	130	75	55	—	—
Standing, light work; walking	Department store, retail store	160	130	75	55	58	38
Walking; standing	Bank	160	145	75	70	—	—
Sedentary work	Restaurant	145	160	80	80	—	—
Light bench work	Factory	235	220	80	140	—	—
Moderate dancing	Dance hall	265	250	90	160	49	35
Walking; light machine work	Factory	295	295	110	185	—	—
Bowling	Bowling alley	440	425	170	255	—	—
Heavy work	Factory	440	425	170	255	54	19
Heavy machine work; lifting	Factory	470	470	185	285	—	—
Athletics	Gymnasium	585	525	210	315	—	—

Source: ASHRAE Handbook: *Fundamentals* (2001)[6]

[1] Refer to CIBSE Guide A Chapter 6 'Internal heat gains' for more detailed information.

Table 6.2 provides benchmark allowances for internal heat gains in typical buildings

Table 6.2 Benchmark allowances for internal heat gains in typical buildings

Building type	Use	Density of occupation / person·m^{-2}	Sensible heat gain / W·m^{-2}			Latent heat gain / W·m^{-2}	
			People	Lighting*	Equip't†	People	Other
Offices	General	12	6.7	8–12	15	5	—
		16	5	8–12	12	4	—
	City centre	6	13.5	8–12	25	10	—
		10	8	8–12	18	6	—
	Trading/dealing	5	16	12–15	40+	12	—
	Call centre floor	5	16	8–12	60	12	—
	Meeting/conference	3	27	10–20	5	20	—
	IT rack rooms	0	0	8–12	200	0	—
Airports/stations‡	Airport concourse	0.83	75	12	5	4	—
	Check-in	0.83	75	12	5	50	—
	Gate lounge	0.83	75	15	5	50	—
	Customs /immigration	0.83	75	12	5	50	—
	Circulation spaces	10	9	12	5	6	—
Retail	Shopping malls	2–5	16–40	6	0	12–30	—
	Retail stores	5	16	25	5	12	—
	Food court	3	27	10	†	20	§
	Supermarkets	5	16	12	†	12	§
	Department stores:						
	— jewellery	10	8	55	5	6	—
	— fashion	10	8	25	5	6	—
	— lighting	10	8	200	5	6	—
	— china/glass	10	8	32	5	6	—
	— perfumery	10	8	45	5	6	—
	— other	10	8	22	5	6	—
Education	Lecture theatres	1.2	67	12	2	50	—
	Teaching spaces	1.5	53	12	10	40	—
	Seminar rooms	3	27	12	5	20	—
Hospitals	Wards	14	57	9	3	4.3	—
	Treatment rooms	10	8	15	3	6	—
	Operating theatres	5	16	25	60	12	—
Leisure	Hotel reception	4	20	10–20	5	15	—
	Banquet/conference	1.2	67	10–20	3	50	—
	Restaurant/dining	3	27	10–20	5	20	—
	Bars/lounges	3	27	10–20	5	20	—

* The internal heat gain allowance should allow for diversity of use of electric lighting coincident with peak heat gain and maximum temperatures. Lighting should be switched off in perimeter/window areas (up to say 4.5 m) and no allowance account for any dimming or other controls.

† Equipment gains do not allow for large duty local equipment such as heavy-duty photocopiers and vending machines.

‡ The exact density will depend upon airport and airplane capacity, the type of gate configuration (open or closed) and passenger throughput. Absolute passenger numbers if available would be a more appropriate design basis. Appropriate building scale diversities need to be derived based on airport passenger throughput.

§ Latent gains are likely but there are no benchmark allowances and heat gains need to be calculated from the sources, e.g. for meals, 15 W per meal[6] served, of which 75% is sensible and 25% latent heat; see also Appendix 6.A2

Steps to calculate the internal heat gain (W/m^2) due to occupants

- Record the density of occupants (people/m^2) and the activities they are doing for each hour.
- Work out the heat gain based on Table 6.3.

2. Lighting

All the electrical energy used by a lamp is ultimately released as heat. The energy is emitted by means of conduction, convection or radiation. When the light is switched on the luminaire itself absorbs some of the heat emitted by the lamp. Some of this heat may then be transmitted to the building structure, depending on the manner in which the luminaire is mounted. The radiation energy emitted from a lamp will result in a heat gain to the space only after it has been absorbed by the room surfaces. This storage effect results in a time lag before the heat appears as a part of the cooling load.

In determining the internal heat gain due to artificial lighting the following must be known:

- Total electrical input power
- Fraction of heat emitted which enters the space
- Radiant, convective and conductive ratio of the heat emitted by the lighting system

All figures quoted in the following section are typical. Manufacturers' data should be used where possible.

2.1 Total electrical power input

Where the actual installed power is not known reference should be made to Table 6.4, which provides target installed power densities for various task illuminances.

Table 6.4 Lighting energy targets

Application	Lamp type	Task illuminance / lux	Average installed power density / $W \cdot m^{-2}$
Commercial and similar applications (e.g. offices, shops*, schools)	Fluorescent-triphosphor	300	7
		500	11
		750	17
	Compact fluorescent	300	8
		500	14
		750	21
	Metal halide	300	11
		500	18
		750	27
Industrial and manufacturing	Fluorescent-triphosphor	300	6
		500	10
		750	14
		1000	19
	Metal halide	300	7
		500	12
		750	17
		1000	23
	High pressure sodium	300	6
		500	11
		750	16
		1000	21

* Excluding display lighting Source: *Code for Lighting* (2002)[10]

2.2 Fraction of emitted heat entering the space

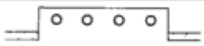
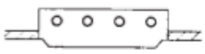
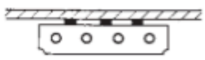
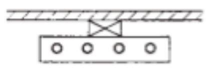
The proportion of heat entering the space depends upon the type and location of the light fittings.

Where the luminaire is suspended from the ceiling or wall-mounted or where uplighters or desk lamps are used, all the heat input will appear as an internal heat gain.

Where recessed or surface-mounted luminaires are installed below a false ceiling, some of the total input power will result in a heat gain to the ceiling void. Obtained the data from the manufacturer. In the absence of manufacturer's data, refer to Table 6.5 which data are based on laboratory measurements.

For air handling luminaires, up to 80% of the total input power can be removed by the air stream, leaving only 20% to enter the space as heat gain.

Table 6.5 Measured energy distribution for fluorescent fittings having four 70 W lamps[7]

Type of fitting			Energy distribution / %	
Mounting	Schematic	Description	Upwards	Downwards
Recessed		Open	38	62
		Louvre	45	55
		Prismatic or opal diffuser	53	47
Surface		Open	12	88
		Enclosed prismatic or opal	22	78
		Enclosed prismatic on metal spine	6	94

2.3 Radiant, convective and conductive components

Little information exists on the proportions of radiant, convective and conducted heat gain from lighting. Table 6.6 provides approximate data for different lamp types.

Table 6.6 Energy dissipation in lamps[10]

Lamp type	Heat output / %		
	Radiant	Conducted/ convected*	Total
Fluorescent	30	70	100
Filament (tungsten)	85	15	100
High pressure mercury/ sodium, metal halide	50	50	100
Low pressure sodium	43	57	100

* The power loss of ballasts should be added to the conducted/convected heat.

3. Office equipment and computers

Personal computers and associated office equipment result in heat gains to the room equal to the total power input.
The internal heat gains can be estimated from basic data but care must be taken to allow for diversity of use, idle operation and the effects of energy saving features of the equipment.

Table 6.7 and 6.8 show the results as typical heat gains from PCs and monitors in the continuous and energy saver modes.

Table 6.7 Typical heat gains from PCs[14]

Nature of value	Value for stated mode / W	
	Continuous	Energy saving
Average	55	20
Conservative	65	25
Highly conservative	75	30

Table 6.8 Typical heat gains from PC monitors[14]

Monitor size	Value for stated mode / W	
	Continuous	Energy saving
Small (13–15 inch)	55	0
Medium (16–18 inch)	70	0
Large (19–20 inch)	80	0

The actual peak internal heat gain for all office equipment in a single common area is less than the sum of the individual continuous gains due to diversity of use. Diversity is the factor that accounts for a percentage of equipment being idle or turned off. It varies between 37 and 78%.

Source of information for typical internal gains values, and their schedules during the day, for reference buildings (domestic and non-domestic) and constructions are given, for the UK context, by the BRE (Building Research Established) in the National Calculation Methodology (http://www.ncm.bre.co.uk). In particular all schedules, constructions and materials can be found at http://www.ncm.bre.co.uk/download.jsp (Optional Downloads >> Database).