

## Air conditioning heat load calculation

PULLOUT

### Building survey and load estimate

The primary function of air conditioning is to maintain conditions that are (1) conducive to human comfort and/or efficiency, or (2) required by a product, or process within a space.

To perform this function, equipment of the proper capacity must be installed and controlled throughout the year. The equipment capacity is determined by the actual instantaneous peak load requirements: type of control is determined by the conditions to be maintained during peak and partial load. Generally it is impossible to measure either the actual peak or the partial load in any given space: these loads must be estimated.

Before the load can be estimated, it is important that a comprehensive survey be made to ensure accurate evaluation of the load components. If the building facilities and the actual instantaneous load within a given mass of the building are carefully studied, an economical equipment selection and system design can result, and smooth, trouble-free performance is then possible.

The heat gain or loss is the amount of heat instantaneously coming into or out of the space. The actual load is defined as that amount of heat that is instantaneously added or removed by the equipment. The instantaneous heat gain and the actual load on the equipment will rarely be equal, because of the thermal inertia or storage effect of the building structures surrounding a conditioned space.

### Building Survey

#### Space characteristics and heat load sources

An accurate survey of the load components of the space to be air conditioned is a basic requirement for a realistic estimate of cooling and heating loads. The completeness and accuracy of this survey is the very foundation of the estimate, and its importance cannot be overemphasised. Mechanical and architectural drawings, completed field sketches and, in some cases, photographs of important aspects are part of a good survey. The following physical aspects must be considered:

1. **Orientation of building** – Location of the space to be air conditioned with respect to:
  - (a) Compass points – sun and wind effects.
  - (b) Nearby permanent structures – shading effects.



2. **Use of space(s)** – Office, hospital, department store, laboratory, machine shop, factory, assembly plant, etc.
3. **Physical dimensions of space(s)** – Length, width, and height.
4. **Ceiling height** – Floor to floor height, floor to ceiling, clearance between suspended ceiling and beams.
5. **Columns and beams** – Size, depth, also knee braces.
6. **Construction materials** – Materials and thickness of walls, roof, ceiling, floors and

partitions, and their relative position in the structure.

7. **Surrounding conditions** – Exterior colour of walls and roof, shaded by adjacent buildings or sunlit. Attic spaces – unvented or vented, gravity or forced ventilation. Surrounding spaces conditioned or unconditioned – temperature of non-conditioned adjacent spaces, such as furnace or boiler room, and kitchens. Floor on ground, crawl space, basement.
8. **Windows** – Size and location, wood or metal sash, single or double glazing, gasketed or not. Type of glass and type of shading device. Dimensions of reveals and overhangs.
9. **Doors** – Location, type, size, and frequency of use.
10. **Stairways, lifts and escalators** – Location, temperature of space if open to unconditioned area. Power of machinery, ventilated or not.
11. **People** – Number, duration of occupancy, nature of activity, any special concentration. At times, it is required to estimate the number of people on the basis of square metre per person, or on average traffic.
12. **Lighting** – Wattage at peak. Type – incandescent, fluorescent, recessed, exposed. If the lights are recessed, the type of air flow over the lights, exhaust, return or supply, should be anticipated. At times, it is required to estimate the wattage on a basis of watts per square metre due to lack of exact information.
13. **Motors** – Location, rated output, and usage. The latter is of great significance and should be carefully evaluated.

The power input to electric motors is not necessarily equal to the rated output divided by the motor efficiency. These motors may be operating under a continuous overload, or may be operating at less than rated capacity. It is always advisable to measure the power input wherever possible. This is especially important in estimates for industrial installations where the motor machine load is normally a major portion of the cooling load.

14. **Appliances, business machines, electronic equipment** – Location, rated wattage, steam or gas consumption, hooded or unhooded, exhaust air quantity installed or required, and usage.

Greater accuracy may be obtained by measuring the power or gas input during times of peak loading. The regular service meters may often be used for this purpose, provided power or gas consumption not contributing to the room heat can be segregated.

Avoid pyramiding the heat gains from various appliances and business machines.

For example, a toaster may not be used during the evening, or the hot-press may not be used during morning, or not all business machines in a given space may be used at the same time.

Electronic equipment often requires individual air conditioning. The manufacturer's recommendation for temperature and humidity variation must be followed, and these requirements are often quite stringent.

15. **Ventilation** – Criteria for ventilation requirements, i.e. dilution of odours or of toxic or explosive mixtures, offsetting air infiltration, limitation of equipment, and economic factor.
16. **Thermal storage** – Includes system operating schedule (12, 16 or 24 hours per day) specifically during peak outdoor conditions permissible temperature swing during a design day, rugs on floor, nature of surface materials enclosing space.
17. **Continuous or intermittent operation** – Whether system be required to operate every business day during cooling season, or only occasionally, such as churches and ballrooms. If intermittent operation, determine duration of time available for pre-cooling or pull-down.

## Location of equipment and services

The building survey should also include information which enables the engineer to select equipment location, and plan the air and water distribution systems. The following is a guide to obtaining this information:

1. **Available spaces** – Location of all stairwells, lift shafts, abandoned smokestacks, pipe shafts, dumbwaiter shafts, etc., and spaces for air handling apparatus, refrigeration machines, cooling towers, pumps, and services (see also Item 5).
2. **Possible obstructions** – Locations of all electrical conduits, pipe lines, and other obstructions or interferences that may be in the way of the duct system.
3. **Location of all fire walls and partitions** – Requiring fire dampers.
4. **Location of outdoor air intakes** – In reference to street, other buildings, wind direction, dirt, and short-circuiting of unwanted contaminants.
5. **Power service** – Location, capacity, current limitations, voltage, phases and cycle; how additional power (if required) may be brought in and where.
6. **Water service** – Location, size of lines, capacity, pressure, maximum temperature.

7. **Steam or high pressure hot water service** – Location, size, capacity, temperature, pressure, type of return system.
8. **Refrigeration, brine or chilled water (if furnished by client)** – Type of system, capacity, temperature, pressure.
9. **Architectural characteristics of space** – For selection of shading devices (blinds, drapes) and of air outlets that will blend into the space design.
10. **Existing air conveying equipment and ducts** – for possible reuse.
11. **Drains** – Location and capacity, sewage disposal.
12. **Control facilities** – Compressed air source and pressure, electrical.
13. **Foundation and support** – Requirements and facilities, strength of building.
14. **Sound and vibration control requirements** – Relation of refrigeration and air handling apparatus location to critical areas.
15. **Accessibility for moving equipment to the final location and for regular maintenance** – Lifts, stairways, doors, accessibility from street.

## Air conditioning load estimate

The air conditioning load is estimated to provide the basis for selecting the conditioning equipment. It must take into account the heat coming into the space from outdoors on a design day, as well as the heat being generated within the space. A design day is defined as a day of outside and inside design conditions, when there is little or no haze in the air to reduce the solar heat and when all of the internal loads are normal.

The time of peak load can usually be established by inspection, although, in some cases, estimates must be made for several different times of the day.

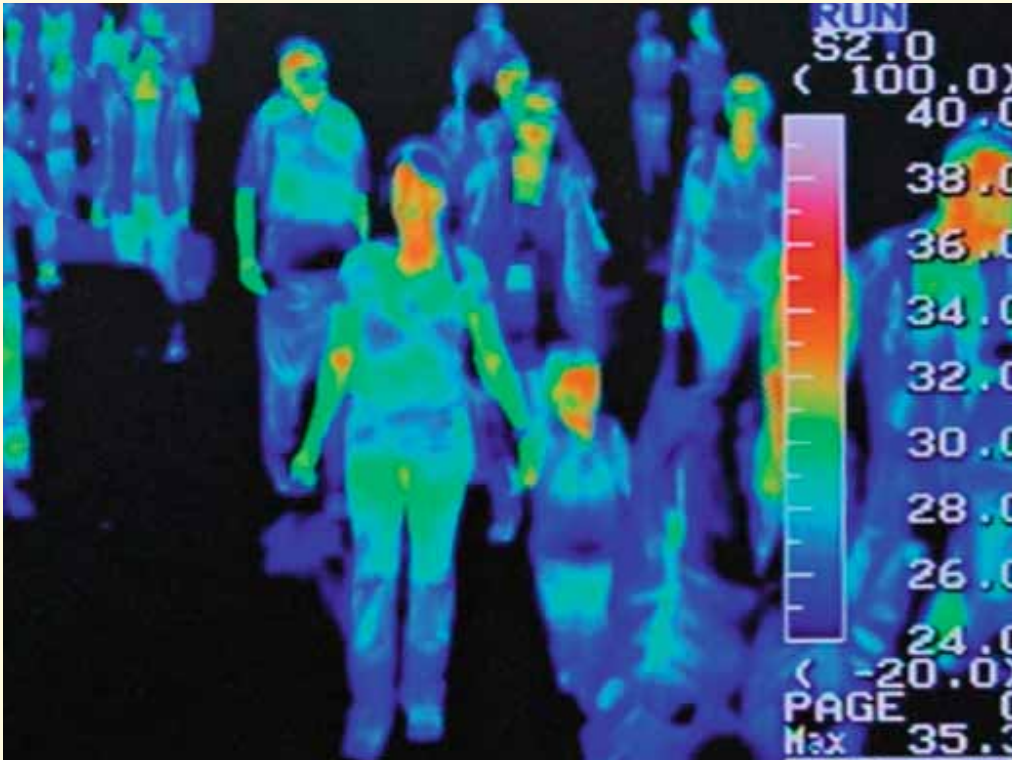
Actually, the situation of having all of the loads peaking at the same time will very rarely occur. To be realistic, various diversity factors must be applied to some of the load components.

### Outdoor loads

The loads from outdoors consist of:

1. **The sun rays entering windows** – Tables provide data from which the solar heat gain through glass and shading devices is estimated. In addition to this reduction, all or part of the window may be shaded by reveals, overhangs, and by adjacent buildings. A large portion of solar heat gain is radiant and will be partially stored.





The human body generates heat

# PULLOUT

2. **The sun rays striking the walls and roof** – These, in conjunction with the high outdoor air temperature, cause heat to flow into the space.
3. **The air temperature outside the conditioned space** – A higher temperature causes heat to flow through the windows, partitions, and floors.
4. **The air vapour pressure** – A higher vapour pressure surrounding conditioned space causes water vapour to flow through the building materials. This load is significant only in low dewpoint applications. In comfort applications, this load is neglected.
5. **The wind blowing against a side of the building** – Wind causes the outdoor air that in summer is higher in temperature and moisture content to infiltrate through the cracks around the doors and windows, resulting in localised sensible and latent heat gains. All or part of this infiltration may be offset by air being introduced through the apparatus for ventilation purposes. In winter, infiltration causes localised heat losses; stack effect must be taken into consideration in tall buildings with unrestricted access from floors to stair wells.
6. **Outdoor air is usually required for ventilation purposes** – Outdoor air is usually necessary to flush out the space and keep the odour level down. This ventilation air imposes a cooling and dehumidifying load on the apparatus because the heat and/or moisture must be removed. Most air conditioning equipment permits some outdoor air to bypass the cooling surface. This bypassed outdoor air becomes a load

within the conditioned space, similar to infiltration; instead of coming through a crack around the window, it enters the room through the supply air duct. The amount of bypassed outdoor air depends on the type of equipment used.

## Internal loads

The internal load, or heat generated within the space, depends on the character of the application. Proper diversity and usage factor should be applied to all internal loads. As with solar heat gain, some internal gains consist of radiant heat which is partially stored, this reducing the load to be impressed on the air conditioning equipment.

Generally, internal heat gains consist of some or all of the following items:

1. **People** – The human body through metabolism generates heat within itself and releases it by radiation, convection and evaporation in the respiratory tract. The amount of heat generated and released

depends on surrounding temperature and on the activity level of the person.

2. **Lights** – Luminaires convert electrical power into light and heat. Some of the heat is radiant and is partially stored.
3. **Appliances** – Pantries and tearooms, hospitals and laboratories have electrical, gas or steam appliances which release heat into the space.
4. **Computers** – Refer to manufacturer's data to evaluate the heat gain from IT equipment. Normally, not all of the machines would be in use simultaneously, and, therefore, a usage or diversity factor should be applied to the full load heat gain. The equipment may also be hooded, or partially cooled internally, to reduce the load on the air conditioning system.
5. **Electric motors** – Electric motors are a significant load in industrial applications and should be thoroughly analysed with respect to operating time and capacity before estimating the load. It is frequently possible to actually measure this load in existing applications, and this should be done where possible.
6. **Hot pipes and tanks** – Steam or hot water pipes running through the air conditioned space, or hot water tanks in the space, add heat. In many industrial applications, tanks are open to the air, causing water to evaporate into the space.
7. **Miscellaneous sources** – There may be other sources of heat and moisture gain within a space, such as escaping steam (industrial cleaning devices, pressing machines, etc.), absorption of water by hygroscopic materials (paper, textiles, etc.).

In addition to the heat gains from the indoor and outdoor sources, the air conditioning equipment and duct system gain or lose heat. The fans and pumps required to distribute air or water through the system add heat; heat is also added to supply and return air ducts running through warmer or hot spaces; cold air may leak out of the supply duct and hot air may leak into the return duct. ▲

More information about air conditioning load estimation, including calculation charts and tables can be found in AIRAH's DA09 application manual *Air conditioning load estimation*.

This can be purchased at the AIRAH online store

[www.airah.org.au](http://www.airah.org.au)