# COMMISSIONING INDUSTRIAL AND COMMERCIAL HEATING AND VENTILATION SYSTEMS.

## What is Commissioning?

The primary goal of Commissioning is to ensure a building's HVAC systems are operating the way according to specifications, placing the equipment into active service and verifying its proper action. Commissioning takes place at the conclusion of project construction but prior to validation. On building projects, this refers primarily to building services.

## What are the three main types of Commissioning?

1. Initial Commissioning: This occurs during the production of a new building or on a new HVAC system within an existing building.
2. Retro-Commissioning: is the first-time commissioning has been implemented in an existing building on existing HVAC equipment.
3. Re-Commissioning: This is when you commission HVAC systems that were already commissioned during the initial commissioning process, and the owner wants to verify, improve and document the performance of the existing HVAC systems.

Once the proper type of commissioning has been determined for a particular building, the actual process of HVAC commissioning can begin.

Testing, adjusting, and balancing (TAB) is the process of checking and adjusting all environmental systems in a building to produce the design objectives. This process includes:

(1) balancing air and water distribution systems,

(2) adjusting the total system to provide design quantities,

(3) electrical measurement,

(4) establishing quantitative performance of all equipment,

(5) verifying automatic control system operation and sequences of operation, and

(6) sound and vibration measurement.

These procedures are accomplished by checking installations for conformity to design, measuring and establishing the fluid quantities of the system as required to meet design specifications, and recording and reporting the results.

Air leakage in a conduit (duct) system can significantly reduce performance, so conduits (ducts) must be designed, constructed, and installed to minimize and control leakage. During construction, all duct systems should be sealed and tested for air leakage.

## Design Considerations

TAB begins as design functions, with most of the devices required for adjustments being integral parts of the design and installation. To ensure that proper balance can be achieved, the engineer should show and specify a sufficient number of dampers, valves, flow measuring locations, and flow-balancing devices; these must be properly located in required straight lengths of pipe or duct for accurate measurement. Testing depends on system characteristics and layout. Interaction between individual terminals varies with pressures, flow requirements, and control devices.

The design engineer should specify balancing tolerances. Minimum flow tolerances are ±10% for individual terminals and branches in noncritical applications and ±5% for main air ducts. For critical water systems where differential pressures must be maintained, tolerances of ±5% are suggested. For critical air systems, recommendations are the following:

| | |
|---|---|
| Positive zones: | |
| Supply air | 0 to +10% |
| Exhaust and return air | 0 to –10% |
| | |
| Negative zones: | |
| Supply air | 0 to –10% |
| Exhaust and return air | 0 to +10% |

## Balancing Devices.

Balancing devices should be used to provide maximum flow-limiting ability without causing excessive noise. Flow reduction should be uniform over the entire duct or pipe. Single-blade dampers or butterfly balancing valves are not good balancing valves because of the uneven flow pattern at high pressure drops.

Pressure drop across equipment is not an accurate flow measurement but can be used to determine whether the manufacturer design pressure is within specified limits. Liberal use of pressure taps at critical points is recommended.

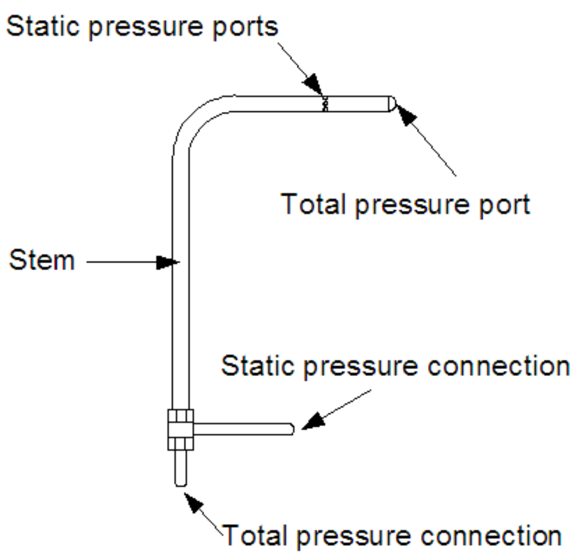
PADDECO

## Air Volumetric Measurement Methods

The pitot-tube traverse is the generally accepted method of measuring airflow in ducts; ways to measure airflow at individual terminals are described by manufacturers. The primary objective is to establish repeatable measurement procedures that correlate with the pitot-tube traverse.

## Air Devices

All flow-measuring instruments should be field verified by comparing to pitot-tube traverses to establish correction and/or density factors.




Generally, correction factors given by air diffuser manufacturers should be checked for accuracy by field measurement and by comparing actual flow measured by pitot-tube traverse to actual measured velocity. Air diffuser manufacturers usually base their volumetric test measurements on a deflecting vane anemometer. The velocity is multiplied by an empirical effective area to obtain the air diffuser's delivery. Accurate results are obtained by measuring at the vena contracta with the probe of the deflecting vane anemometer. Methods advocated for measuring airflow of troffer-type terminals are similar to those for air diffusers.

A capture hood is frequently used to measure device airflows, primarily of diffusers and slots. Loss coefficients should be established for hood measurements with varying flow and deflection settings. If the air does not fill the measurement grid, the readings will require a correction factor.


Rotating vane anemometers are commonly used to measure airflow from sidewall grilles. Effective areas (correction factors) should be established with the face dampers fully open and deflection set uniformly on all grilles. Correction factors are required when measuring airflow in open ducts [i.e., damper openings and fume hoods (Sauer and Howell 1990)].

## Duct Flow

The preferred method of measuring duct volumetric flow is the pitot-tube traverse average. The maximum straight run should be obtained before and after the traverse station. When using factory-fabricated volume-measuring stations, the measurements should be checked against a pitot-tube traverse.

Power input to a fan's driver should be used as only a guide to indicate its delivery; it may also be used to verify performance determined by a reliable method (e.g., pitot-tube traverse of system's main) that considers possible system effects. For some fans, the flow rate is not proportional to the power needed to drive them. In some cases, as with forward-curved-blade fans, the same power is required for two or more flow rates. The backward-curved-blade centrifugal fan is the only type with a flow rate that varies directly with power input.

If an installation has an inadequate straight length of ductwork or no ductwork to allow a pitot-tube traverse, the procedure from Sauer and Howell (1990) can be followed: a vane anemometer reads air velocities at multiple points across the face of a coil to determine a loss coefficient.

## Pressure Measurement

Air pressures measured include barometric, static, velocity, total, and differential.
When measured in the field, pressure readings, air quantity, and power input often do not correlate with manufacturers' certified performance curves unless proper correction is made. Pressure drops through equipment such as coils, dampers, or filters should not be used to measure airflow. Pressure is an acceptable means of establishing flow volumes only where it is required by, and performed in accordance with, the manufacturer certifying the equipment.

## Stratification

Normal design minimizes conditions causing air turbulence, to produce the least friction, resistance, and consequent pressure loss. Under some conditions, however, air turbulence is desirable and necessary. For example, two airstreams of different temperatures can stratify in smooth, uninterrupted flow conditions. In this situation, design should promote mixing. Return and outdoor airstreams at the inlet side of the air-handling unit tend to stratify where enlargement of the inlet plenum or casing size decreases air velocity. Without a deliberate effort to mix the two airstreams (e.g., in cold climates, placing the outdoor air entry at the top of the plenum and return air at the bottom of the plenum to allow natural mixing), stratification can be carried throughout the system (e.g., filter, coils, eliminators, fans, ducts). Stratification can freeze coils and rupture tubes, and can affect temperature control in plenums, spaces, or both.

Stratification can also be reduced by adding vanes to break up and mix the airstreams. No solution to stratification problems is guaranteed; each condition must be evaluated by field measurements and experimentation.

## BALANCING PROCEDURES FOR AIR DISTRIBUTION

No one established procedure is applicable to all systems. The bibliography lists sources of additional information.

## Instruments for Testing and Balancing

The minimum instruments necessary for air balance are:

- Manometer calibrated in 0.005 in. of water divisions.
- Combination inclined/vertical manometer (0 to 10 in. of water).
- Pitot tubes in various lengths, as required.

- Tachometer (direct-contact, self-timing) or strobe light.
- Clamp-on ammeter with voltage scales [root-mean-square (RMS) type].
- Rotating vane anemometer.
- Deflecting vane anemometer.
- Thermal anemometer.
- Capture hood.
- Digital thermometers (0.1°F increments as a minimum) and glass stem thermometers (0.1°F graduations minimum).
- Sound level meter with octave band filter set, calibrator, and microphone.
- Vibration analyzer capable of measuring displacement velocity and acceleration.
- Water flowmeters (0 to 50 in. of water and 0 to 400 in. of water ranges).
- Compound gage.
- Test gages (100 psi and 300 psi).
- Sling psychrometer.
- Etched-stem thermometer (30 to 120°F in 0.1°F increments).
- Hygrometers
- Relative humidity and dew-point instruments.

Instruments must be calibrated periodically to verify their accuracy and repeatability before use in the field.

**Preliminary Procedure for Air Balancing**

1. Before balancing, all pressure tests (duct leakage) of duct and piping systems must be complete and acceptable.
2. Obtain as-built design drawings and specifications, and become thoroughly acquainted with the design intent.
3. Obtain copies of approved shop drawings of all air-handling equipment, outlets (supply, return, and exhaust), and temperature control diagrams, including performance curves. Compare design requirements with shop drawing capacities.
4. Compare design to installed equipment and field installation.
5. Walk the system from air-handling equipment to terminal units to determine variations of installation from design.
6. Check dampers (both volume and fire) for correct and locked position and temperature control for completeness of installation before starting fans.
7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommend test procedure. A summation of required outlet volumes allows cross-checking with required fan volumes.
8. Determine the best locations in the main and branch ductwork for the most accurate duct traverses.
9. Place all outlet dampers in full open position.
10. Prepare schematic diagrams of system as-built ductwork and piping layouts to facilitate reporting.

11. Check filters for cleanliness and proper installation (no air bypass). If specifications require, establish procedure to simulate dirty filters.
12. For variable-volume systems, develop a plan to simulate diversity (if required).

**Equipment and System Check**

1. All fans (supply, return, and exhaust) must be operating before checking the following items:
   - Motor amperage and voltage to guard against overload
   - Fan Rotation
   - Operability of static pressure limit switch
   - Automatic dampers for proper position
   - Air and water controls operating to deliver required temperatures.
   - Air leaks in the casing and around the coils and filter frames must be stopped. Note points where piping enters the casing to ensure that escutcheons are right. Do not rely on pipe insulation to seal these openings (insulation may shrink). In prefabricated units, check that all panel-fastening holes are filled.

2. Traverse the main supply ductwork whenever possible. All main branches should also be traversed where duct arrangements allow. Traverse points and method of traverse should be selected as follows:

   - Traverse each main or branch after the longest possible straight run for the duct involved.
   - Traverse using a pitot tube and manometer where velocities are over 600 fpm. Below this velocity, use either a micro manometer and pitot tube or an electronic multimeter and a pitot tube.
   - Note temperature and barometric pressure and correct for standard air quantity if needed.
   - After establishing the total air being delivered, adjust fan speed to obtain design airflow, if necessary. Check power and speed to confirm motor power and/or critical fan speed are not exceeded.
   - Proportionally adjust branch dampers until each has the proper air volume.
   - With all dampers and registers in the system proportioned and with supply and return fans operating at or near design airflow, set the minimum outdoor and return air ratio. If duct traverse locations are not available, this can be done by measuring the mixture temperature in the return air, outdoor air louver, and filter section. The mixture temperature may be approximated from Equation (1)

The greater the temperature difference between outdoor and return air, the easier it is to get accurate damper settings. Take the temperature at many points in a uniform traverse to be sure there is no stratification.

After the minimum outdoor air damper has been set for the proper percentage of outdoor air, run another traverse of mixture temperatures and install baffling if variation from the average is more than 5%. Remember that stratified mixed-air temperatures vary greatly with outdoor temperature in cold weather, whereas return air temperature has only a minor effect.

3. Balance terminal outlets in each control zone in proportion to each other, as follows:

- Once the preliminary fan quantity is set, proportion the terminal outlet balance from the outlets into the branches to the fan. Concentrate on proportioning the flow rather than the absolute quantity. As fan settings and branch dampers change, the outlet terminal quantities remain proportional. Branch dampers should be used for major adjusting and terminal dampers for trim or minor adjustment only. It may be necessary to install additional sub-branch dampers to decrease the use of terminal dampers that create objectionable noise.
- Normally, several passes through the entire system are necessary to obtain proper outlet values.
- The total tested outlet air quantity compared to duct traverse air quantities may indicate duct leakage.
- With total design air established in the branches and at the outlets, (1) take new fan motor amperage readings, (2) find static pressure across the fan, (3) read and record static pressure across each component (intake, filters, coils, mixing dampers), and (4) take a final duct traverse.

**Multizone Systems**

Balancing should be accomplished as follows:

1. When adjusting multizone constant-volume systems, establish the ratio of the design volume through the cooling coil to total fan volume to achieve the desired diversity factor. Keep the proportion of cold to total air constant during the balance. However, check each zone on full cooling. If the design calls for full flow through the cooling coil, the entire system should be set to full flow through the cooling side while making tests. Perform the same procedure for the hot-air side.
2. Check leaving air temperature at each zone to verify that hot and cold damper inlet leakage is not greater than the established maximum allowable leakage.
3. Check apparatus and main trunks, as outlined in the section on Equipment and System Check.
4. Proportionately balance diffusers or grilles.
5. Change control settings to full heating, and ensure that controls function properly. Verify airflow at each diffuser. Check for stratification.
6. If the engineer included a diversity factor in selecting the main apparatus, it will not be

possible to get full flow to all zones simultaneously, as outlined in item 3 under Equipment and System Check. Zones equaling the diversity should be set to heating.

## Variable-Volume Systems

Many types of variable-air-volume (VAV) systems have been developed to conserve energy. They can be categorized as pressure-dependent or pressure-independent.

**Pressure-dependent** systems incorporate air terminal boxes with a thermostat signal controlling a damper actuator. Air volume to the space varies to maintain space temperature; air temperature supplied to terminal boxes remains constant.
The balance of this system constantly varies with loading changes; therefore, any balancing procedure will not produce repeatable data unless changes in system load are simulated by using the same configuration of thermostat settings each time the system is tested (i.e., the same terminal boxes are fixed in the minimum and maximum positions for the test). Each terminal box requires a balancing damper upstream of its inlet.

In a pressure-dependent system with pneumatic controls, setting minimum airflows to the space (other than at no flow) is not suggested unless the terminal box has a normally closed damper and the manufacturer of the damper actuator provides adjustable mechanical stops.

**Pressure-independent** systems incorporate air terminal boxes with a thermostat signal used as a master control to open or close the damper actuator, and a velocity controller used as a sub-master control to maintain the maximum and minimum amounts of air to be supplied to the space. Air volume to the space varies to maintain the space temperature; air temperature supplied to the terminal remains constant. Take care to verify the operating range of the damper actuator as it responds to the velocity controller to prevent dead bands or overlap of control in response to other system components (e.g., double-duct VAV, fan-powered boxes, retrofit systems).
Care should also be taken to verify the action of the thermostat with regard to the damper position, as the velocity controller can change the control signal ratio or reverse the control signal.

The pressure-independent system requires verifying that the velocity controller is operating properly; it can be adversely affected by inlet duct configurations if a multipoint sensor is not used (Griggs et al. 1990).

The primary difference between the two systems is that the pressure-dependent system supplies a different amount of air to the space as pressure upstream of the terminal box changes. If the thermostats are not calibrated properly to meet the space load, zones may overcool or overheat. When zones overcool and receive greater amounts of supply air than required, they decrease the amount of air that can be supplied to overheated zones. The pressure- independent system is not affected by improper thermostat calibration in the same way as a pressure-dependent system, because minimum and maximum airflow limits may be set for each zone.

## Static Control

Static control saves energy and prevents over pressurising the duct system. The following procedures and equipment are some of the means used to control static pressure.

**Fan Control.**
**Discharge Damper.** Losses and noise should be considered.
**Vortex Damper.** Losses from inlet air conditions are a problem, and the vortex damper does not completely close. The minimum expected airflow should be evaluated.
**Variable Inlet Cones.** System loss can be a problem because the cone does not typically close completely. The minimum expected airflow should be evaluated.
**Varying Fan Speed Mechanically.** Slippage, loss of belts, cost of belt replacement, and the initial cost of components are concerns.
**Variable Pitch-in-Motion Fans.** Maintenance and preventing the fan from running in the stall condition must be evaluated.
**Varying Fan Speed Electrically.** Varying voltage or frequency to the fan motor is usually the most efficient method. Some motor drives may cause electrical noise and affect other devices.

In controlling VAV fan systems, location of the static pressure sensors is critical and should be field-verified to give the most representative point of operation. After the terminal boxes have been proportioned, static pressure control can be verified by observing static pressure changes at the fan discharge and the static pressure sensor as load is simulated from maximum to minimum airflow (i.e., set all terminal boxes to balanced airflow conditions and determine whether any changes in static pressure occur by placing one terminal box at a time to minimum airflow, until all terminals are placed at the minimal airflow setting). The maximum to minimum air volume changes should be within the fan curve performance (speed or total pressure).

## Types of VAV Systems

**Single-Duct VAV. -** This system uses a pressure-dependent or -independent terminal and usually has reheat at a minimal setting on the terminal unit, or a separate heating system.

**Bypass -** This system uses a pressure-dependent damper, which on demand for heating, closes the damper to the space and opens to the return air plenum. Bypass sometimes uses a constant bypass airflow or a reduced amount of airflow bypassed to the return plenum in relation to the amount supplied to the space.

No economic value can be obtained by varying fan speed with this system. A control problem can exist if any return air sensing is done to control a warm-up or cool-down cycle.

## VAV Using Single-Duct VAV and Fan-Powered, Pressure-Dependent Terminals.

This system has a primary source of air from the fan to the terminal and a secondary powered fan source that pulls air from the return air plenum before the additional heat source. In some fan-powered boxes, backdraft dampers allow duct leakage when the system calls for the damper to be fully closed. Typical applications include geographic areas where the ratio of heating hours to cooling hours is low.

## Double-Duct VAV.

This type of terminal uses two single-duct variable terminals. It is controlled by velocity controllers that operate in sequence so that both hot and cold ducts can be opened or closed. Some controls have a downstream flow sensor in the terminal unit. The total-airflow sensor is in the inlet and controlled by the thermostat. As this inlet damper closes, the downstream controller opens the other damper to maintain set airflow. Low pressure in the decks controlled by the thermostat may cause unwanted mixing of air, which results in excess energy use or discomfort in the space.

## Balancing the VAV System

The general procedure for balancing a VAV system is

1. Determine the required maximum air volume to be delivered by the supply and return air fans. Load diversity usually means that the volume will be somewhat less than the outlet total.
2. Obtain fan curves on these units, and request information on surge characteristics from the fan manufacturer.

3. If inlet vortex damper control is used, obtain the fan manufacturer's data on deaeration of the fan when used with the damper. If speed control is used, find the maximum and minimum speed that can be used on the project.
4. Obtain from the manufacturer the minimum and maximum operating pressures for terminal or variable-volume boxes to be used on the project.
5. Construct a theoretical system curve, including an approximate surge area. The system curve starts at the boxes' minimum inlet static pressure, plus system loss at minimum flow, and terminates at the design maximum flow. The operating range using an inlet vane damper is between the surge line intersection with the system curve and the maximum design flow. When variable-speed control is used, the operating range is between (1) the minimum speed that can produce the necessary minimum box static pressure at minimum flow still in the fan's stable range and (2) the maximum speed necessary to obtain maximum design flow.
6. Position the terminal boxes to the proportion of maximum fan air volume to total installed terminal maximum volume.
7. Proportion outlets, and verify design volume with the VAV box on maximum flow. Verify minimum flow setting.
8. Set the fan to operate at approximate design speed.
9. Verify the at all terminal boxes. Identify which boxes are not in control and the inlet static pressures, if any. If all terminal boxes are in control, reduce the fan flow until the remote terminals are just in control and within the tolerances of filter loading.
10. Run a total air traverse with a pitot tube.
11. Run steps (8) through (10) with the return of exhaust fan set at design flow as measured by a pitot-tube traverse and with the system set on minimum outdoor air.
12. Set terminals to minimum, and adjust the inlet vane or speed controller until minimum static pressure and airflow are obtained.
13. Temperature control personnel, balancing personnel, and the design engineer should agree on final placement of the sensor for the static pressure controller. This sensor must be placed in a representative location in the supply duct to sense average maximum and minimum static pressures in the system.
14. Check return air fan speed or its inlet vane damper, which tracks or adjusts to the supply fan airflow, to ensure proper outdoor air volume.
15. Operate the system on 100% outdoor air (weather permitting), and check supply and return fans for proper power and static pressure.

**Induction Systems**

Most induction systems use high-velocity air distribution. Balancing should be accomplished as follows:

1. For apparatus and main truck capacities, perform general VAV balancing procedures.
2. Determine primary airflow at each terminal unit by reading the unit plenum pressure

with a manometer and locating the point on the charts (or curves) of air quantity versus static pressure supplied by the unit manufacturer.

3. Normally, about three complete passes around the entire system are required for proper adjustment. Make a final pass without adjustments to record the end result.
4. To provide the quietest possible operation, adjust the fan to run at the slowest speed that provides sufficient nozzle pressure to all units with minimum throttling of all unit and riser dampers.
5. After balancing each induction system with minimum outdoor air, reposition to allow maximum outdoor air and check power and static pressure readings.

**Report Information**

To be of value to the consulting engineer and owner's maintenance department, the air-handling report should consist of at least the following items:

1. *Design*
    - Air quantity to be delivered
    - Fan static pressure
    - Motor power installed or required
    - Percent of outdoor air under minimum conditions
    - Fan speed
    - Input power required to obtain this air quantity at design static pressure

2. *Installation*
    - Equipment manufacturer (indicate model and serial numbers)
    - Size of unit installed
    - Arrangement of air-handling unit
    - Nameplate power and voltage, phase, cycles, and full-load amperes of installed motor

3. *Field Tests*
    - Fan speed
    - Power readings (voltage, amperes of all phases at motor terminals)
    - Total pressure differential across unit components
    - Fan suction and fan discharge static pressure (equals fan total pressure)
    - Plot of actual readings on manufacturer's fan performance curve to show the

  installed fan operating point.
- Measured airflow rate.

It is important to establish initial static pressures accurately for the air treatment equipment and duct system so that the variation in air quantity caused by filter loading can be calculated. It enables the designer to ensure that the total air quantity never is less than the minimum requirements. Because the design air quantity for peak loading of the filters has already been calculated, it also serves as a check of dirt loading coils.

*4. Terminal Outlets*

- Outlet by room designation and position.
- Manufacture and type.
- Size (using manufacturer's designation to ensure proper factor).
- Manufacturer's outlet factor [where no factors are available, or field tests indicate listed factors are incorrect, a factor must be determined in the field by traverse of a duct leading to a single outlet); this also applies to capture hood readouts
  - Adjustment pattern for every air terminal

*5. Additional Information (if applicable)*

- Air-handling units.
  - – Belt number and size.
  - – Drive and drive sheave size.
  - – Belt position on adjusted drive sheaves (bottom, middle and top).
  - – Motor speed under full load.
  - – Motor heater size.
  - – Filter type and static pressure at initial use and full load; time to replace.
  - – Variations of velocity at various points across face of coil.
  - – Existence of vortex or discharge dampers, or both.

- Distribution system.
  - – Unusual duct arrangements.
  - – Branch duct static readings in double – duct and induction system.
  - – Ceiling pressure readings where plenum ceiling distribution is used; tightness of ceiling.
  - – With wind conditions outside less than 5mph, relationship of building to outdoor pressure under both minimum and maximum outdoor air.
  - – Induction unit manufacturer and size (including required air quantity and plenum pressures for each unit) and test plenum pressure and resulting primary air delivery from manufacturer's listed curves.

- All equipment nameplates visible and easily readable.

Many independent firms have developed detailed procedures suitable to their own operations and the area in which they function. These procedures are often available for information and evaluation on request.

**Appropriate industry standards and regulations:**

Commissioning refers to the process of bringing a system into operation and ensuring that it is in good working order. On building projects, this refers primarily to building services. Some of the Industry Standards and regulations Include;

- The Health and Safety at Work Act.

- Association for Specialist Fire Protection (ASFP)

The ASFP strives to promote excellence in the design and installation of fire protection products through high quality and technical expertise.

- Building Services Research and Information Association (BSRIA)

BSRIA is an ISO 9001 Registered test, instruments, research and consultancy organisation, providing specialist services in construction and building services.
BG 49/2015 explains how to commission ducted air distribution systems in buildings.
The commissioning process mainly comprises the setting to work of the system fans and the regulation of system flow rates.

- Chartered Institution of Building Services Engineers (CIBSE)

CIBSE is the standard setter and authority on building services engineering. It publishes Guidance and Codes which are internationally recognised as authoritative, and sets the criteria for best practice in the profession. The Institution speaks for the profession and so is consulted by government on matters relating to construction, engineering and sustainability. It is represented on major bodies and organisations which govern construction and engineering occupations in the UK, Europe and worldwide.

- British Standards Institution (BSI)

We work with many different industries, businesses, governments and consumers to develop British, European and international standards.

**The Building Regulation 2010 F1 "Means of Ventilation"**
**The Building Regulation 2010 Conservation of Fuel and Power L2A, L2B.**

**The UK's Building regulations** are statutory instruments that seek to ensure that the policies set out in the relevant legislation are carried out. Building regulations approval is required for most building work in the UK. The Act in England and Wales permits detailed regulations to be made by the Secretary of State.
The detailed requirements of Building regulations in England (and Wales) are scheduled within 16 separate headings, each designated by a letter
For commissioning of non-domestic ventilation systems, the commissioning procedure approved by the Secretary of State is CIBSE Code M, available from www.cibse.org.

Commissioning is the documented process of verifying that the equipment and systems are installed according to specifications, placing the equipment into active service and verifying its proper action. The system is taken from a state of static completion to working order. Testing and adjusting, as necessary, ensure that the whole system uses no more fuel and power than is reasonable in the circumstances, without compromising the need to comply with health and safety requirements. For each system, commissioning includes the following: setting-to-work; regulation (that is, testing and adjusting repetitively) to achieve the specified performance; calibration, setting up and testing of the associated automatic control systems; and recording of the system settings and the performance test results that have been accepted as satisfactory.

Commissioning can benefit from the preparation of a commissioning plan, which according to BSRIA Guide BG 8/2009 Model Commissioning Plan should:

- Provide general information about the project.
- Identify the commissioning team members for each stage of the commissioning process.
- Define roles and responsibilities for each commissioning team member.
- Identify the systems to be commissioned.
- Create a schedule of commissioning activities for each stage of the process.
- Establish documentation requirements associated with the commissioning process.

The contract documents should set out:

- Who will be responsible for commissioning different building services.
- What methods, standards and codes of practice are to be used.
- What should happen to test results.
- Whether commissioning is to be witnessed and if so, whom.
- The documentation that is required.

A commissioning manager may be appointed to give advice during design, construction planning and installation and then to manage commissioning, testing and handover. Commissioning activities may include:

- Ensuring client access and providing client training and demonstrations.
- Completing operating and maintenance manuals, record drawings, software and test certification.
- Obtaining statutory approvals and insurance approvals.
- Manufacturers work testing.
- Component testing.
- Pre-commissioning tests.
- Set to work: this is the process of switching on (i.e. setting to work) items such as fans and motors to ensure that they are operating as specified (for example checking that fans are turning the right way).
- Balancing: this follows setting to work and involves looking at whole systems (rather than individual components) to ensure that they are properly balanced (ie water is coming out of all the taps at the correct pressure, air is coming out of the correct diffusers etc).
- Commissioning checks and performance testing.
- Post commissioning checks and fine tuning during occupancy.

NB The building regulations require that a commissioning notice is given to the relevant building control body (BCB) confirming that commissioning has been carried out according to a procedure approved by the Secretary of State.

Be aware of the site rules and company procedures, know the access and egress of the site while carrying out commissioning checks, understand and follow the risk assessment, protect the clients property
Follow RAMS set, be aware of different working environments could be confined space in a plant room, working at height, in a highly flammable area, special scaffold might be needed, protective measures of the clients property, e.g. In office space with computers above ceiling.

Commissioning is also intended to achieve the following specific objectives:
1; Document that equipment is installed and started per manufacturer's recommendations.
2; Document that equipment and systems receive complete operational checkout by installing contractors.
3; Document system performance with thorough functional performance testing and monitoring.
4; Verify the completeness of operations and maintenance materials.
5; Ensure that the owner's operating personnel are adequately trained on the operation and maintenance of building equipment.

**Roles and Responsibilities General Management Plan**

In general, the Commissioning provider coordinates the commissioning activities and reports to the owner's construction representative. The CP's responsibilities, along with all other contractors' commissioning responsibilities are detailed in the specifications. The Specifications will take precedence over this Commissioning Plan. All members work together to fulfill contracted responsibilities and meet the objectives of the Contract Documents.

**General Descriptions of Roles**

General descriptions of the commissioning roles are as follows:
- Commissioning Provider: Coordinates the commissioning process, writes and/or reviews testing plans, directs and documents performance testing.
- Project Manager: Facilitates and supports the commissioning process and gives final approval of the commissioning work.
- Maintenance Manager: Coordinates maintenance staff participation in commissioning activities.
- General Contractor: Facilitates the commissioning process, ensures that subcontractors perform their responsibilities and integrates commissioning into the construction process and schedule.
- Subcontractors: Demonstrate correct system performance.
- Maintenance Staff: Participate in commissioning tasks and performance testing, review O&M documentation, attend training.
- Architect and Design Engineers: Perform construction observation, approve O&M manuals and assist in resolving problems.
- Manufacturers: Equipment manufacturers and vendors provide documentation to facilitate the commissioning work and perform contracted startup.

When an HVAC system is installed, the final steps prior to completion are startup, test & balance, and commissioning. Startup When HVAC equipment is installed and electrical power wired complete, the equipment must be "started up." When HVAC equipment is started up, it will not blow the air the engineer intends for the HVAC system to work properly. The system must be "balanced" so that the correct air is present during normal system operation.

Testing, adjusting, and balancing (TAB) is the process of checking and adjusting all environmental systems in a building to produce the design objectives. This process includes (1) balancing air and water distribution systems, (2) adjusting the total system to provide design quantities, (3) electrical measurement, (4) establishing quantitative performance of all equipment, (5) verifying automatic control system operation and sequences of operation, and (6) sound and vibration measurement. These procedures are accomplished by checking installations for conformity to design, measuring and establishing the fluid quantities of the system as required to meet design specifications, and recording and reporting the results.

Effective and efficient TAB requires a systematic, thoroughly planned procedure implemented by experienced and qualified staff. All activities, including organization, calibration of instruments, and execution of the work, should be scheduled. Preparation includes planning and scheduling all procedures, collecting necessary data (including all change orders), reviewing data, studying the system to be worked on, preparing forms, and making preliminary field inspections.

Air leakage in the ductwork system can significantly reduce performance, so all systems must be designed, constructed, and installed to minimize and control leakage. During construction, all duct systems should be sealed and tested for air leakage.

TAB begins as design functions, with most of the devices required for adjustments being integral parts of the design and installation. To ensure that proper balance can be achieved, the design engineer should show and specify a sufficient number of dampers, flow measuring locations, and flow-balancing devices; these must be properly located in required straight lengths of duct for accurate measurement. Testing depends on system characteristics and layout. Interaction between individual terminals varies with pressures, flow requirements, and control devices. The design engineer should specify balancing tolerances. Minimum flow tolerances are ±10% for individual terminals and branches in noncritical applications and ±5% for main air ducts.

**Duct traversal airflow measurement**
**DETERMINE AVERAGE AIR VELOCITY OR VOLUME**

Many circumstances warrant measuring air velocities or air flow, and a duct traverse is the most precise method of obtaining that information. A duct traverse consists of a number of regularly spaced air velocity and pressure measurements throughout a cross sectional area of straight duct

Instruments for Testing and Balancing could Include; Manometer, Combination inclined/vertical manometer, Pitot tubes in various lengths, Rotating vane anemometer, Capture hood, Digital thermometers, Thermal anemometer. The pitot-tube traverse is the generally accepted method of measuring airflow in ductwork systems.

Some procedures for balancing could Include;

1. Before balancing, all leakage tests must be complete and acceptable.
2. Obtain as-built design drawings and specifications.

3. Obtain copies of approved drawings of all air-handling equipment.
4. Compare design to installed equipment and installation.
5. Walk the system from AHU to grilles.
6. Check dampers (both volume and fire) for correct and locked position and completeness of installation before starting fans.

**Commissioning Scoping Meeting**

The scoping meeting brings together all members of the design, construction, and operations team that will be involved in the commissioning process. Each building system to be commissioned is addressed, including commissioning requirements, and completion and start-up schedules. During the scoping meeting, all parties agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.

**Final Commissioning Plan**

The commissioning agent finalizes the draft Commissioning Plan using the information gathered from the scoping meeting. The initial commissioning schedule is also developed along with a detailed timeline. The timeline is fine-tuned as construction progresses. The general contractor will provide the commissioning agent with a set of equipment and system submittals. This equipment data includes installation and start-up procedures, O&M data, performance data and temperature control drawings.

**Site Observation**

The commissioning agent makes periodic site visits to witness equipment and system installations. Each site visit will have a specific agenda and will be coordinated with the general contractor site supervisor. The commissioning agent attends selected planning and job-site meetings in order to remain informed on construction progress and to update parties involved in commissioning. The general contractor provides the commissioning agent with information regarding any changes that may affect commissioned equipment or the commissioning schedule.

You can verify whether or not job information and documentation is current and relevant and that the plant, instruments, access equipment and tools are fit for purpose by checking that:

- the right revision of drawing is being used.
- you are working to the correct specification, using RAMS.
- PUWER regulation must be followed with the use of equipment, check tools, scaffolds, MEWPS, lifting equipment and safety equipment, e.g. safety harness, are all fit for the task and not damaged, safe working loads, test certificates.
- Pat testing can also be used.

The conditions of the working environment:

- You must be aware of the site rules and company procedures.

- Know the access and egress of the site while carrying out commissioning checks.
- Understand and follow the risk assessment.
- Protect the client's property.
- Follow RAMS set.
- Be aware of different working environments could be confined space such as in a plant room, working at height, in a highly flammable area, special scaffold might be needed, protective measures of the clients property, e.g. In office space with computers above ceiling.

Manufacturer instructions:

- Follow the manufactures guidelines when Inspecting and carrying out commissioning checks on equipment, e.g. AHU, fans, dampers, filters, FCU's, Ductwork systems.
- Follow specification guidelines and instructions, this also could include lifting and access equipment as well as components.
- Be aware of COSHH regulations.

There are many methods and techniques for commissioning the system and its associated equipment, components and accessories in accordance with:

- Commissioning is the documented process of verifying that the equipment and systems are installed according to specifications, placing the equipment into active service and verifying its proper action.
- Commissioning takes place at the conclusion of project construction but prior to validation.

The system's design:

Commissioning activities may include:

- Ensuring client access and providing client training and demonstrations.
- Completing operating and maintenance manuals, record drawings, software and test certification.
- Obtaining statutory approvals and insurance approvals.
- Manufacturers work testing.
- Component testing.
- Pre-commissioning tests.
- Set to work: this is the process of switching on (i.e. setting to work) items such as fans and motors to ensure that they are operating as specified (for example checking that fans are turning the right way).
- Balancing: this follows setting to work and involves looking at whole systems (rather than individual components) to ensure that they are properly balanced (ie water is coming out of all the taps at the correct pressure, air is coming out of the correct diffusers etc).
- Commissioning checks and performance testing.
- Post commissioning checks and fine tuning during occupancy.

It is important to obtain customer/client acceptance of the commissioned system and its associated equipment, components and accessories; this occurs by:

- Completing all handover documentation,
- Following all company procedures,
- Handover operating and maintenance manuals,
- Site rules and policies.
- Give all manufactures guidelines over to client,
- Carry out all legal and statutory responsibilities in the commissioning of the system.

The completion of all relevant documentation by:

- Following site rules and company procedures when completing all relevant documentation, e.g. site Induction access, RAMS set, permit to work, hazard cards, accident book, time sheets, delivery sheets, request forms.

TAB begins as design functions, with most of the devices required for adjustments being integral parts of the design and installation. To ensure that proper balance can be achieved, the engineer should show and specify a sufficient number of dampers, valves, flow measuring locations, and flow-balancing devices; these must be properly located in required straight lengths of pipe or duct for accurate measurement. Testing depends on system characteristics and layout. Interaction between individual terminals varies with pressures, flow requirements, and control devices.

Balancing devices should be used to provide maximum flow-limiting ability without causing excessive noise. Flow reduction should be uniform over the entire duct or pipe. Single-blade dampers or butterfly balancing valves are not good balancing valves because of the uneven flow pattern at high pressure drops.

Pressure drop across equipment is not an accurate flow measurement but can be used to determine whether the manufacturer design pressure is within specified limits. Liberal use of pressure taps at critical points is recommended.