NEBB STANDARDS SECTION-8
AIR SYSTEM TAB PROCEDURES

8.1 INTRODUCTION

Testing, adjusting, and balancing of HVAC systems can best be accomplished by following a series of systematic procedures. The NEBB TAB procedures presented in this section are recommended current best practices for balancing HVAC systems. The procedures in this section address the majority of systems commonly installed. It is the responsibility of the NEBB Certified TAB Firm to determine appropriate procedures for systems not covered in this section.

It should be noted that the procedures listed herein may not be applicable to every project, therefore, it shall fall under the discretion of the NEBB Certified TAB Firm to determine which procedure is best utilized for the project specific systems.

8.2 PRELIMINARY SYSTEM PROCEDURES

8.2.1 Each type of HVAC system is designed to meet a set of performance parameters. This usually includes maximum heating capacity, maximum cooling capacity, and ventilation effectiveness. The NEBB Certified TAB Firm should normally set-up a system to its maximum capacity, or 'full load' condition, prior to the TAB process. It is this condition that presents the greatest challenge to a system's capacity to meet its design airflow requirements.

8.2.2 Not all system types are addressed in this section. Confer with the engineer of record to establish the proper set-up conditions for specific systems.

8.2.3 The following TAB procedures are basic to all types of air systems:

1. Verify that the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.
2. Record unit nameplate data as described in Section 6.
3. Confirm that every item affecting the airflow of a duct system is ready for the TAB work, such as doors and windows being closed, ceiling tiles (return air plenums) in place, etc.
4. Confirm that the automatic control devices will not adversely affect TAB operations. The control systems shall be installed and commissioned by others prior to starting the TAB work.
5. Establish the conditions for design maximum system requirements.
6. Verify that all dampers are open or set, all related systems (supply, return, exhaust, etc.), are operating, motors are operating at or below full load amperage ratings, and rotation is correct.

7. Positive and negative pressurization zones should be identified at this time.

8.3 ESTABLISHING FAN TOTAL AIRFLOW

8.3.1 The most accurate and accepted field test of airflow is a Pitot tube traverse of the duct. Procedures for conducting a Pitot tube traverse are found in Section 6. In situations where a Pitot tube traverse(s) is not available, the system airflow may be determined by alternate methods, such as anemometer or velocity grid traverses across coils and / or filters, or the summation of air outlet measurements. These alternative methods are subject to a greater degree of error than Pitot tube traverses and should be used with caution.

8.3.2 Additionally, if a Pitot tube traverse is available, a comparison of the total outlet airflow measurement with the Pitot tube traverse readings of the fan total airflow *may* assist in quantifying possible duct leakage. It is important to note that differences between total air outlet volume and Pitot tube traverse totals may be indicative of duct leakage, measurement errors, or incorrect area factors. Accurate assessment of duct leakage requires a specific duct leakage test, which is outside the scope of TAB work.

8.3.3 Fan curves can be used when other required data can be obtained, such as SP, rpm and bhp (W). Experience has shown, however, that often not all of the field readings will fall into place on the fan and design system curves due to S*ystem Effect* and measurement errors

8.3.4 If the fan volume is not within plus or minus 10 percent of the design airflow requirement, adjust the drive of the fan to obtain the approximate required airflow. At the conclusion of all system balancing procedures, measure and record the fan suction static pressure, fan discharge static pressure, amperage and air volume measurements. Confirm that the fan motor is not operating in excess of its full load amperage rating. Care must be exercised when increasing fan speeds to avoid exceeding the maximum rpm limit of the fan and the motor horsepower (W). (The motor power increases as the cube of the fan speed change.) When new systems do not perform as designed, new drives and motors often are required. Unless clearly specified in the contract documents, the responsibility for these items is outside the scope of the NEBB Certified TAB Firm.

8.3.5 When performing static pressure readings on fan systems, it is necessary to take the readings based on a common static reference point.

8.3.6 Using the methods outlined above, determine the volume of air being handled by the supply air fan, and return air fan if used. If a central exhaust fan system is used, also determine the airflow being handled by the exhaust fan. If several exhaust fans, such as power roof ventilators are related to a particular supply air system, it generally is not necessary to measure the airflow of each such exhaust fan until after the supply air system is balanced.

8.3.7 Verify the system test data with the supply air and return air fans in the 100% outside air (OA) and exhaust air (EA) mode. Use caution when ambient conditions may adversely affect system operation.

8.4 BASIC AIR SYSTEM BALANCING PROCEDURES

Balancing air systems may be accomplished in various ways. Two acceptable methods for balancing systems are presented. These methods are appropriate for supply, return and exhaust systems. Regardless of the method, the objectives remain the same and the system will be considered balanced in accordance with NEBB procedural standards when the following conditions are satisfied:

a) All measured airflow quantities are within ± 10 percent of the design airflow quantities unless there are reasons beyond the control of the NEBB Certified TAB firm. *Deficiencies shall be noted in the TAB report summary.*

b) There is at least one path with fully open dampers from the fan to an air inlet or outlet. Additionally, if a system contains branch dampers, there will be at least one wide-open path downstream of every adjusted branch damper.

8.4.1 PROPORTIONAL METHOD (RATIO METHOD)

This technique is initially described for a basic constant volume supply system ***without branch ducts***. It is also appropriate for exhaust or return duct systems.

a) Verify that all Grille, register and diffuser (GRD) dampers are wide open.

b) Set air outlet deflections as specified.

c) Determine total system airflow by the most appropriate method.

d) Calculate the percentage of actual airflow to design airflow.

e) Adjust the fan to approximately 110% of design airflow, if possible.

f) Measure the airflow at all GRD(s).

g) Compute the ratio of measured airflow to design airflow for each GRD.

h) The damper serving the GRD at the lowest percentage of design flow is not adjusted in this procedure.

i) Adjust the damper serving the GRD with the next (second) lowest percentage of design until both GRD(s) are the same percentage of design. These GRD(s) are now in balance.

j) Adjust the damper serving the GRD with the next (third) lowest percentage of design until all three GRD(s) are at the same percentage of design, and in balance.

k) Continue this procedure until all remaining GRD(s) have been adjusted to be in balance at approximately the same percentage of design airflow.

l) If necessary, adjust the fan speed to set all GRD(s) at design airflow, ± 10%.

m) Re-measure all GRD(s) and record final values.

n) Mark all GRD(s) with felt markers, spray paint, or in some other manner that is permanent, so that adjustment may be restored if necessary.

Where a basic constant volume supply system ***has branch ducts,*** the procedure is:

o) Follow above steps a) through f) for the GRD(s) on each branch.

p) Compute the ratio of measured branch flow to design branch flow.

q) The damper serving the branch at the lowest percentage of design flow is not adjusted in this procedure.

r) Adjust the damper serving the branch with the next (second) lowest percentage of design until both branches are the same percentage of design. These branches are now in balance.

s) Adjust the damper serving the branch with the next (third) lowest percentage of design until all three branches are at the same percentage of design, and in balance.

t) Continue this procedure until all remaining branches have been adjusted to be in balance at approximately the same percentage of design airflow.

u) If necessary, adjust the fan speed to set all branches at design airflow, ± 10%.

v) Perform the proportioning techniques specified in above steps a) through m) for the diffusers on each branch.

w) Re-measure all GRD(s) and record final airflow values.

x) Mark all dampers, with felt markers, spray paint, or other permanent technique, so that adjustment may be restored if necessary.

8.4.2 STEPWISE METHOD

This technique is initially described for a basic constant volume supply system ***without branch ducts.*** It is also appropriate for exhaust or return duct systems.

a) Verify that all GRD dampers are wide open.

b) Set air outlet deflections as specified.

c) Determine total system volume by the most appropriate method.

d) Calculate the percentage of actual airflow to design airflow.

e) Adjust the fan to approximately 110% of design airflow if possible.

f) Measure the airflow at all GRD(s).

g) Starting at the fan, as the GRD(s) closest to the fan will typically be the highest, adjust the GRD volume dampers to a value approximately 10% below design airflow requirements.

h) As the adjustment proceeds to the end of the system, the remaining GRD airflow values will increase.

i) Repeat the adjustment passes through the system until all GRD(s) are within ± 10% of design airflow requirements and at least one GRD volume damper is wide open.

j) If necessary, adjust the fan speed to set all GRD(s) at design airflow, ± 10%.

k) Re-measure all diffusers and record final airflow values.

l) Mark all dampers, with felt markers, spray paint, or other permanent technique, so that adjustment may be restored if necessary.

Where a basic constant volume supply system ***has branch ducts,*** the procedure is:

a) Follow above steps a) through e) for the GRD(s) on each branch.

b) Compute the ratio of measured branch flow to design branch flow.

c) Starting at the fan, as the branches closest to the fan will typically be the highest, adjust the branch volume dampers to a value approximately 10% below design airflow requirements.

d) As the adjustment proceeds to the end of the system, the remaining branch airflow values will increase.

e) If necessary, adjust the fan speed to set all branches at design airflow, ± 10%.

f) Balance the GRD(s) on each branch as described in steps e) through i) above

g) Re-measure all GRD(s) and record final values.

h) Mark all dampers with felt markers, spray paint, or other permanent technique, so that adjustment may be restored if necessary.

8.5 CONSTANT VOLUME SUPPLY SYSTEMS

8.5.1 BASIC CONSTANT VOLUME SYSTEMS

For the purposes of this Procedural Standard, a basic constant volume supply system is defined as having a single fan and connecting ductwork to the outlets and inlets. The following balancing procedures are appropriate for basic constant volume systems:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Record unit nameplate data as described in Section 6.

c) Confirm that the correct air filters have been installed. Review the specifications to determine if a temporary filter blockage is required to simulate partially loaded filters.

d) Barometric dampers should be checked for free operation. If the dampers are equipped with adjustable weights, they should be set to maintain the specified building static pressure. All exhaust systems should be balanced before adjusting barometric relief dampers.

e) Verify that all manual branch and outlet volume dampers are locked 100% open.

f) Measure the motor operating amperage.

g) Measure motor voltage.

h) Confirm that the voltage and amperage matches the motor rating.

i) Verify correct rotation.

j) Check for unusual noises indicating mechanical malfunction.

k) Measure fan RPM and compare to design RPM.

l) Air handling units (AHU) equipped with a fixed outside air damper should be set to an appropriate position as a starting point (caution should be used if freezing conditions are expected).

m) The OA damper for air handling units using mechanical cooling should be adjusted to a position estimated to equal the design minimum airflow.

n) The OA damper for units using only ventilation air for cooling should be positioned 100% open, with RA dampers closed.

o) Determine if the AHU is rated for total static pressure (TSP) or external static pressure (ESP). If the rating is for TSP, measure suction and discharge static pressure at the inlet and outlet of the fan. If the rating is for ESP, measure the suction and discharge static pressure at the return duct and discharge duct. The suction static pressure measurement point can be immediately adjacent to the unit. The discharge static pressure should be taken at a point 3 to 5 duct diameters downstream of the fan discharge, and upstream of any elbows or turning vanes.

p) If testing with partially loaded filters is specified, first measure the pressure drop across the air filter and then adjust a temporary blockage to meet specified requirements.

q) Measure the AHU total air volume by the most accurate method available. The method used is at the discretion and judgment of the NEBB Qualified TAB Supervisor based on the configuration of the unit and its ductwork.

r) Adjust fan airflow to meet design requirements if necessary.

s) Determine the method for adjusting outlets – proportional or stepwise, and balance the inlets and outlets in accordance with the prescribed procedures.

t) After the supply, return, and exhaust systems are properly balanced, the supply air fan capacity should be checked with 100 percent outside air if this alternative is included in the system design. Appropriate damper adjustments should be made if necessary.

u) At the conclusion of all inlet and outlet balancing, re-adjust the AHU minimum outside air ventilation rate, if required.

v) Record final unit data, prepare the report forms, and submit as required (see Section 5, *Standards for Reports and Forms).*

8.5.2 COMPLEX CONSTANT VOLUME SYSTEMS

For the purposes of this document a complex constant volume supply system is defined as having multiple fans (supply, return, exhaust) and may have active building static pressure control.

Systems with active building static pressure control require special attention by the NEBB Qualified TAB Supervisor. Building pressure can vary if the return / exhaust air fan volume does not respond adequately to changes in the supply air fan volume. Three common methods used are building static control, open loop control and closed loop control. These methods are discussed later in this section.

Balancing procedures for complex systems follow the same procedures as described for basic systems. The addition of powered return / exhaust fan(s) must be addressed in the set-up and balancing process.

There are many variations of unit fan and damper arrangements supplied by manufacturers, which the NEBB Qualified TAB Supervisor must understand before beginning the balancing process. This document does not attempt to provide specific guidelines for all possible system arrangements. A few of the more common configurations for complex constant volume systems are described below.

8.5.3 SYSTEMS WITH POWER EXHAUST

Follow the procedures specified previously for a *Basic Constant Volume Supply System* with the following modifications:

a) After all procedures specified for a basic constant volume supply system are complete, but before recording final system data, set the system to its maximum OA ventilation rate.

b) Measure building static pressure and compare to specified requirements.

c) Adjust the powered exhaust fan flow rate if necessary to achieve the required building static pressure.

d) Complete the final system measurement specified previously for basic systems, including all components of the tested system.

8.5.4 SYSTEMS WITH RETURN / EXHAUST FANS

Constant volume supply systems with return / exhaust fans are essentially two separate constant volume systems linked by an arrangement of dampers. Further, the return / exhaust system may or may not be ducted.

Systems with combination return / exhaust air fans require special attention by the NEBB Qualified TAB Supervisor. Building pressure will vary substantially if the return / exhaust air fan volume does not respond adequately to changes in the outside air ventilation rate introduced by the supply air fan. Three common methods used are building static control, open loop control and closed loop control. These methods are discussed later in this section.
Follow the procedures specified previously for a basic constant volume supply system with the following modifications:

a) Set the return / exhaust dampers for the maximum load condition, typically full return with minimum OA.

b) Perform the appropriate procedures described previously on both the supply side and the return / exhaust side of the system. This includes the inlets and outlets of both system components.

c) After the systems have been balanced in the maximum load condition, set the return / exhaust dampers to both extremes, i.e. full return - minimum exhaust mode and then minimum return - full exhaust mode.

d) In each condition, verify that the system is operating in compliance with specified requirements.

e) Measure building static pressure and compare to specified requirements.

f) If necessary, perform any necessary adjustments of existing equipment to achieve specified parameters.

g) Final System measurements: At the conclusion of all inlet and outlet balancing, re-adjust the AHU minimum outside air ventilation rate, if required.

h) Record final unit data, prepare the report forms, and submit as required (see Section 5, Standards for Reports and Forms).

8.6 MULTIZONE SYSTEMS

Follow the procedures specified previously for a basic constant volume supply system with the following modifications:

a) Confirm that the coils are sized for airflow equal to the fan design. If the coils are sized for less airflow than the fan, the bypass damper should be left open an amount equal to the excess fan airflow so that the total airflow will not be restricted.

b) Set the multizone unit dampers for design airflow through the cooling coil.

c) The outside air and return air (OA / RA) dampers should be postured prior to balancing. If the air handling unit (AHU) has a fixed outside air damper it should be set to the appropriate position as a starting point. (Caution should be used if ambient conditions present a risk of damage to the equipment or facility).
d) The OA damper for air handing units using mechanical cooling should be adjusted to a position estimated to equal the design minimum airflow.

e) The OA damper for units using only ventilation air for cooling should be positioned 100% open, with RA dampers closed.
f) If the cooling coil is sized for the full fan airflow, put all zones into full cooling by setting each zone thermostat to its lowest point.

g) Measure the airflow of each zone and total the results.

h) Make any required fan speed adjustments to obtain the design total airflow.

i) Adjust each manual zone balancing damper to obtain the proper airflow in each zone. This type of system cannot be properly balanced without manual zone balancing dampers. If the dampers are not provided, the NEBB Qualified TAB Supervisor should notify the appropriate project personnel to have them installed.

j) Once each zone has the correct airflow, the outlets can be balanced by using the previously described methods.

k) At the conclusion of all inlet and outlet balancing, re-adjust the AHU minimum outside air ventilation rate, if required.

l) Record final unit data, prepare the report forms, and submit as required (see Section 5, Standards for Reports and Forms).

8.7 INDUCTION UNIT SYSTEMS

8.7.1 OPERATION

Induction unit systems use high or medium pressure fans to supply primary air to the induction units. Check to see that the induction unit dampers, as well as the system dampers, are wide open before starting the HVAC unit primary air fan.

Airflow readings at induction units are taken by reading the static pressure at one of the nozzles and comparing it to the manufacturer's published data. The design static pressure and airflow will be shown on the manufacturer's submittal data for the various size units on the job.

Normally the flow of water in induction unit coils is automatically controlled to adjust room temperature. Some systems use the primary air source to power the controls and move a secondary air damper for adjusting room temperature. In such cases, it is extremely important that the manufacturer's minimum static pressure in the plenum of each unit be maintained.

8.7.2 PROCEDURES

Adjust the primary air fan using previously described methods for constant volume systems. With a new or wide-open system, allow for a reduction in airflow while balancing.

Adjust the nozzle pressure according to the manufacturer’s specifications to obtain the design primary airflow. Induction units can be balanced by using the proportional (ratio) method or stepwise method as described previously for balancing diffusers or registers.

8.8 VARIABLE VOLUME SYSTEM OVERVIEW

TAB procedures for a VAV system are similar to those for constant volume systems. The main difference is that a mechanism exists in the system to vary system flow in response to demand. The fan capacity is usually controlled to maintain a field determined duct static pressure. A static pressure sensor, usually located two-thirds of the way from the fan to the end of the duct system, senses the supply air duct static pressure and sends a signal back to the apparatus controlling the fan airflow volume. Another method of capacity control utilizes the capability of a DDC system to determine individual VAV box airflow requirements and adjust the system in response.

8.8.1 DIVERSITY

Diversity is a design concept in a VAV system that allows a system of terminal units to be served by a fan that is rated for a fraction (usually 80%) of the total system terminal unit capacity. VAV systems with diversity are frequently encountered in TAB work.

8.8.2 TERMINAL UNITS (VAV BOXES)

VAV systems incorporate terminal units (VAV boxes) that respond to local zone demand by controlling the amount of primary (system) air that is distributed to the local zone. There are two basic types of terminal units, *pressure dependent or pressure independent.*

Pressure dependent terminal unit: A pressure dependent terminal unit is not equipped to measure and maintain primary air discharge volume. Actual airflow through the terminal unit is a function of upstream static pressure and damper position

Pressure independent terminal unit: A pressure independent terminal unit is equipped with a flow sensing controller that can be set to limit maximum and minimum primary air discharge from the terminal unit.

There are many different variations of terminal unit function. Listed below are a few of the more common types.

8.8.3 COOLING ONLY UNITS

The simplest variety of VAV terminal unit has a damper that responds to zone demand by opening or closing to modulate the amount of primary air delivered to the zone. It may be either pressure dependent (PD) or pressure independent (PI). This type of terminal unit may also serve as a component of a variable volume variable temperature system, typically in a PD application. It is important to consult the manufacturers' specifications to obtain information regarding performance and operating characteristics.

8.8.4 COOLING ONLY UNITS WITH REHEAT

This is a cooling only terminal unit with the addition of an electric or hydronic heating coil. Units with electric heating coils are supplied with an airflow switch that shuts off the heating coil if the primary airflow across the heating elements falls below a certain value. This is to prevent damage to the unit or the heating coils.

8.8.5 FAN POWERED VAV TERMINAL UNITS

Fan powered VAV terminal units are VAV boxes that contain individual supply air fans.

Parallel Fan Terminal unit: This type of terminal is available in either pressure dependent (PD) or pressure independent (PI) configuration. Primary airflow through the terminal unit does not pass through the fan. The fans are usually equipped with a volume control device, i.e. speed controls, speed taps or discharge dampers. The fan is only operational in the heating mode, when primary air is at a minimum, or in the minimum ventilation mode to keep air circulation up in the zone. When demand for primary air increases above a threshold value the parallel fan is shut off by the terminal unit controls. When full cooling is no longer needed, the primary air begins to decrease. At a predetermined setpoint, the fan is energized and plenum air or return air is mixed with the primary air. In the full heating mode, primary air may be completely shut off. Consult project specifications for the specific sequence specified. Most parallel VAV boxes are pressure independent and include a primary air velocity sensor and controller. Heating coils may be provided at the return inlet or at the VAV box discharge.

Series Fan Terminal unit: This type of terminal is usually available in PI configuration. Primary airflow through the terminal unit passes through the fan. The fans are usually equipped with a volume control device, i.e. speed controls or speed taps. The fan operates while the terminal unit is in normal operation. The fan mixes plenum or return air from the space with primary air from the system to maintain a constant flow of air to the conditioned zone. This type of terminal unit can be equipped with electric or hydronic heat capability. Improper adjustment of the terminal unit may allow primary air to short circuit into the return air plenum.

8.8.6 DUAL DUCT TERMINAL UNITS

A dual duct VAV terminal unit consists of a plenum box with two primary air inlets, dampers or air valves with actuators, and an air discharge. When the VAV box is pressure independent, a primary air velocity sensor and controller also will be included, usually for each primary air inlet but other arrangements are possible. Each mixing box in dual duct systems is thermostatically controlled to satisfy the space and temperature requirements. The available sequences are numerous and it is imperative that the NEBB Qualified TAB Supervisor reviews the manufacturer’s operating sequence for the type of dual duct box being balanced.

8.8.7 CONSTANT VOLUME (VAV) TERMINAL UNITS

Some terminal unit applications use the previously described VAV terminals as constant volume devices. This is usually accomplished by setting the maximum and minimum primary air volumes to the same value. Dual duct terminal units achieve the same result by utilizing a flow control device on the discharge of the box to control the total air delivered by the box, and a flow sensor on one of the two primary inlets, usually the primary heating inlet.

8.8.8 INDUCTION VAV TERMINAL UNITS

Induction VAV terminal units use primary air from a central fan system to create a low pressure area within the box by discharging the primary air at high velocities into a plenum. This low pressure area usually is separated from a ceiling return air plenum by an automatic damper. The induced air from the ceiling is mixed with the primary air, so that the actual airflow being discharged from the box is considerably more than the primary air airflow. Most of these induction boxes are designed for VAV operation, but a few are constant volume.

Study the manufacturer's data before attempting to do the TAB work, because many operating sequences are available. Balancing will consist of setting the primary airflow, both maximum and minimum. The discharge air is a total of the primary air and the induced air. Some boxes have adjustments for the induction damper setting. After the box is set, the downstream air outlets can be balanced in the conventional manner.
8.9 Variable air Volume system Procedures

8.9.1 PRESSURE DEPENDENT VAV PROCEDURES WITHOUT DIVERSITY

It is important to note that VAV terminal units on pressure dependent systems may have airflow significantly different than design requirements. In this condition, the total existing airflow *at the time of the balancing procedure* becomes the design flow condition. The outlets may end up being proportioned at, for example, 60% or 250% of nominal design requirements. This is to be expected, and should be reported as such, while including the system conditions in the project summary.

To eliminate possible misunderstandings later, an agenda with the proposed balancing procedures should be submitted and approved by the system designer or authorized persons before the TAB work is started. This practice is recommended for all jobs, but it is critical on jobs with these particular systems.

The following balancing procedures are generally appropriate for variable volume systems with pressure dependent terminal units without diversity:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that the temperature control contractor's sequence of operation complements the terminal unit or VAV box manufacturer's installed control system.

c) Confirm that the correct air filters have been installed. Review the specifications to determine if a temporary filter blockage is required to simulate partially loaded filters.

d) Barometric dampers should be checked for free operation. If the dampers are equipped with adjustable weights, they should be set to maintain the specified building static pressure. All exhaust systems should be balanced before adjusting barometric relief dampers.

e) Verify that all manual volume dampers are locked 100% open.

f) Measure the motor amperage.

g) Measure motor voltage.

h) Confirm that the voltage and amperage matches the motor rating.

i) Verify correct rotation.

j) Measure fan RPM and compare to design RPM.

k) Posture the system OA and RA dampers for maximum demand.

l) Verify that adequate supply duct static pressure is available to allow balancing of VAV boxes.

m) Posture all VAV boxes in the maximum demand position.

n) If manual volume dampers are present at the inlet to each box, adjust the dampers to achieve the design airflow at each VAV box being balanced.

o) Balance the outlets on each terminal unit using either of the two recommended balancing procedures.

p) If the existing terminal unit controls allow a minimum airflow, adjust each VAV box to deliver the correct minimum airflow. This is a problematic issue with pressure dependent systems, as actual minimum flow rates are not controlled and may under or over ventilate the spaces served in minimum mode. Test and record the values of the downstream terminals with minimum airflow.

q) Identify the VAV terminal unit(s) that is (are) the most difficult to satisfy at the existing supply fan airflow and static pressure. Measure the static pressure at this unit. The entering static pressure at this VAV box should be no less than the sum of the VAV box manufacturer recommended minimum inlet static pressure plus the static pressure or resistance of the ductwork and the terminals on the discharge side of the VAV box. Adjust system static pressure to the minimum value necessary to maintain design airflow at this terminal unit(s). This setpoint information should be provided to the appropriate project personnel.

r) Measure the AHU total air volume by the most accurate method available. The method used is at the discretion and judgment of the NEBB Qualified TAB Supervisor based on the configuration of the unit and its ductwork.

s) If necessary, adjust fan airflow to meet design requirements.

t) Determine if the AHU is rated for total static pressure (TSP) or external static pressure (ESP). If the rating is for TSP, measure the suction and discharge static pressure at the inlet and outlet of the fan. If the rating is for ESP, measure the suction and discharge static pressure at the return duct and discharge duct. The suction static pressure measurement point can be immediately adjacent to the unit. The discharge measurement point should be taken 3 to 5 duct diameters from the discharge of the fan.

u) Test and record the operating static pressure at the sensor that controls the HVAC unit fan, if provided, and verify the operation of the static pressure controller.

v) If testing with partially loaded filters is specified, measure pressure drop across air filters and adjust a temporary blockage to meet specified requirements.

w) A return air fan (if used) should be adjusted to maintain a slightly positive pressure in the building. This may be accomplished by damper adjustment and / or fan speed adjustment.

x) At the conclusion of all system balancing, adjust and verify the AHU minimum outside air ventilation rate, if required.

y) Record final unit data, prepare the report forms, and submit as required (see Section 5, *Standards for Reports and Forms).*

8.9.2 PRESSURE DEPENDENT VAV PROCEDURES WITH DIVERSITY

The NEBB Certified TAB Firm should determine if the VAV system has a diversity factor. The diversity factor is an arithmetic ratio of the fan's rated airflow capacity divided by a summation of all VAV terminal unit's design maximum airflow. A system with a fan rated at 8,000 CFM (4000 L/s) and a VAV terminal combined maximum design of 10,000 CFM (5000 L/s) would be considered to have a diversity factor of 80%.

VAV systems with diversity can be the most difficult to balance satisfactorily. Any procedure used will be a compromise, and shortcomings will appear somewhere in the system under certain operating conditions. The NEBB Qualified TAB Supervisor should expect that some fine-tuning will be necessary after the initial TAB work is complete.

The following balancing procedures are generally appropriate for variable volume systems with pressure dependent terminal units with diversity:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that the temperature control contractor's sequence of operation complements the terminal unit or VAV box manufacturer's installed control system.

c) Confirm that the correct air filters have been installed. Review the specifications to determine if a temporary filter blockage is required to simulate partially loaded filters.

d) Barometric dampers should be checked for free operation. If the dampers are equipped with adjustable weights, they should be set to maintain the specified building static pressure. All exhaust systems should be balanced before adjusting barometric relief dampers.

e) Verify that all manual volume dampers are locked 100% open.

f) Measure the motor amperage.

g) Measure motor voltage.

h) Confirm that the voltage and amperage matches the motor rating.

i) Verify correct rotation.

j) Measure fan RPM and compare to design RPM.

k) Posture the system OA and RA dampers for maximum demand.

l) Verify that adequate supply duct static pressure is available to allow balancing of VAV boxes.

m) VAV systems with diversity factors should be initially postured to operate at maximum system airflow with all peak load terminal units wide open and all non peak terminal units closed to the minimum position. Distribute the reduced airflow terminal units throughout the system so that they are not all one major branch.

n) If manual volume dampers are present at the inlet to each box, adjust the dampers to achieve the design airflow at each VAV box being balanced.

o) Balance the outlets on each terminal unit using either of the two recommended balancing procedures.

p) Set the non-peak VAV boxes to a full flow condition, and close as many peak boxes as necessary to match the design flow of the non peak boxes.

q) Balance the outlets on each terminal unit using either of the two recommended balancing procedures.

r) If the existing terminal unit controls allow a minimum airflow, adjust each VAV box to deliver the correct minimum airflow. This is a problematic issue with pressure dependent systems, as actual minimum flow rates are not controlled and may under or over ventilate the spaces served in minimum mode. Test and record the values of the downstream terminals with minimum airflow.

s) Identify the VAV terminal unit(s) that is (are) the most difficult to satisfy at the existing supply fan airflow and static pressure. Measure the static pressure at this unit. The entering static pressure at this VAV box should be no less than the sum of the VAV box manufacturer recommended minimum inlet static pressure plus the static pressure or resistance of the ductwork and the terminals on the discharge side of the VAV box. Adjust system static pressure to the minimum value necessary to maintain design airflow at this terminal unit(s). This setpoint information should be provided to the appropriate project personnel.

t) Measure the AHU total air volume by the most accurate method available. The method used is at the discretion and judgment of the NEBB Qualified TAB Supervisor based on the configuration of the unit and its ductwork.

u) If necessary, adjust fan airflow to meet design requirements.

v) Determine if the AHU is rated for total static pressure (TSP) or external static pressure (ESP). If the rating is for TSP, measure the suction and discharge static pressure at the inlet and outlet of the fan. If the rating is for ESP, measure the suction and discharge static pressure at the return duct and discharge duct. The suction static pressure measurement point can be immediately adjacent to the unit. The discharge static pressure measurement should be taken 3 to 5 duct diameters from the discharge of the fan.

w) Test and record the operating static pressure at the sensor that controls the HVAC unit fan, if provided, and verify the operation of the static pressure controller.

x) If testing with partially loaded filters is specified, measure pressure drop across air filters and adjust a temporary blockage to meet specified requirements.

y) A return air fan (if used) should be adjusted to maintain a slightly positive pressure in the building. This may be accomplished by damper adjustment and/or fan speed adjustment.

z) At the conclusion of all system balancing, adjust and verify the AHU minimum outside air ventilation rate, if required.

8.9.3 PRESSURE INDEPENDENT VAV PROCEDURES WITHOUT DIVERSITY

The manufacturer's published data provides the static pressure operating range and the minimum static pressure drop across each terminal unit for a given airflow. Use this data to verify that adequate pressure is available for the terminal unit to function properly.

The objective of balancing pressure independent VAV boxes is the same, regardless of the type of controls used. They must be adjusted to deliver the specified maximum and minimum airflows.

For simplification, consider each pressure independent VAV box and its associated downstream ductwork to be a separate supply air duct system. Because of terminal unit pressure independent characteristics, it is possible to balance all of the boxes on a system, even if the system pressure is low. If there is adequate static pressure and airflow available at the VAV box inlet, the box and its associated outlets can be balanced. When there is inadequate static pressure, set the adjacent boxes into the minimum airflow position to increase the static pressure to simulate design conditions. This method of simulating or providing adequate static pressure also applies to balancing systems with diversity.

The following balancing procedures are generally appropriate for variable volume systems with pressure independent terminal units without diversity:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that the temperature control contractor's sequence of operation complements the terminal unit or VAV box manufacturer's installed control system.

c) Confirm that the correct air filters have been installed. Review the specifications to determine if a temporary filter blockage is required to simulate partially loaded filters.

d) Barometric dampers should be checked for free operation. If the dampers are equipped with adjustable weights, they should be set to maintain the specified building static pressure. All exhaust systems should be balanced before adjusting barometric relief dampers.

e) Verify that all manual volume dampers are locked 100% open.

f) Measure the motor amperage.

g) Measure motor voltage.

h) Confirm that the voltage and amperage matches the motor rating.

i) Verify correct rotation.

j) Measure fan RPM and compare to design RPM.

k) Posture the system OA and RA dampers for maximum demand.

l) Verify that adequate supply duct static pressure is available to allow balancing of VAV boxes.

m) Calibrate the volume controllers on each VAV terminal unit using the manufacturer's recommended procedures.

n) Balance the outlets on each terminal unit using either of the two recommended balancing procedures.

o) Identify the VAV terminal unit(s) that is (are) the most difficult to satisfy at the existing supply fan airflow and static pressure. Measure the static pressure at this unit. The entering static pressure at this VAV box should be no less than the sum of the VAV box manufacturer recommended minimum inlet static pressure plus the static pressure or resistance of the ductwork and the terminals on the discharge side of the VAV box. Adjust system static pressure to the minimum value necessary to maintain design airflow at this terminal unit(s). This setpoint information should be provided to the appropriate project personnel.

p) Measure the AHU total air volume by the most accurate method available. The method used is at the discretion and judgment of the NEBB Qualified TAB Supervisor based on the configuration of the unit and its ductwork.

q) If necessary, adjust fan airflow to meet design requirements.

r) Determine if the AHU is rated for total static pressure (TSP) or external static pressure (ESP). If the rating is for TSP, measure the suction and discharge static pressure at the inlet and outlet of the fan. If the rating is for ESP, measure the suction and discharge static pressure at the return duct and discharge duct. The suction static pressure measurement point can be immediately adjacent to the unit. The discharge measurement point should be taken 3 to 5 duct diameters from the discharge of the fan.

s) Test and record the operating static pressure at the sensor that controls the HVAC unit fan, if provided, and verify the operation of the static pressure controller.

t) If testing with partially loaded filters is specified, measure pressure drop across air filters and adjust a temporary blockage to meet specified requirements.

u) A return air fan (if used) should be adjusted to maintain a slightly positive pressure in the building. This may be accomplished by damper adjustment and/or fan speed adjustment.

v) At the conclusion of all system balancing, adjust and verify the AHU minimum outside air ventilation rate, if required.

w) Record final unit data, prepare the report forms, and submit as required (see Section 5, *Standards for Reports and Forms).*

8.9.4 PRESSURE INDEPENDENT VAV PROCEDURES WITH DIVERSITY

Follow the procedures for pressure independent VAV systems without diversity. When the VAV box balancing procedures are complete, the total system airflow is measured by adjusting a combination of VAV boxes to maximum and minimum airflows to match the design fan airflow. Fan performance is then measured by methods previously described.

Complete the reporting requirements as previously specified.

8.9.5 COMBINATION SYSTEMS

Some system applications may incorporate pressure independent VAV boxes and pressure dependent VAV boxes on the same system, either with or without diversity. Balancing procedures will have to be tailored to each job. It is recommended that the pressure independent boxes are balanced first, since once they are balanced, they will not be affected by changing static pressures as the rest of the system is being balanced, provided that adequate main duct static pressure doesn't drop below a minimum value.

If a system has many pressure dependent boxes, they may consume most of the system airflow and static pressure on the initial system start up, since they will be wide open. Either set some of these boxes to a minimum airflow position or partially close the inlet dampers on some boxes to build up the static pressure in the system. After setting all of the pressure independent VAV boxes, use the procedures detailed previously for pressure dependent systems and balance the downstream air outlets.

8.10 DUAL DUCT SYSTEMS

Dual duct systems use both a hot air duct and a cold air duct to supply air to mixing boxes. Mixing boxes may operate in a constant air volume mode or in a variable air volume mode. They are usually pressure independent, but they may be either system powered or have external control systems. There are many operational schemes for these types of units. The NEBB Qualified TAB Supervisor should review the specific manufacturer's setup instructions for these units.

8.10.1 CONSTANT VOLUME DUAL DUCT SYSTEMS

Each constant volume mixing box has a thermostatically controlled mixing damper to satisfy the space temperature requirements. A mixture of the hot and cold air is controlled to maintain a constant airflow to the space.

The following balancing procedures are appropriate for constant volume dual duct systems:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that the temperature control contractor's sequence of operation complements the terminal unit or VAV box manufacturer's installed control system.

c) Confirm that the correct air filters have been installed. Review the specifications to determine if a temporary filter blockage is required to simulate partially loaded filters.

d) Barometric dampers should be checked for free operation. If the dampers are equipped with adjustable weights, they should be set to maintain the specified building static pressure. All exhaust systems should be balanced before adjusting barometric relief dampers.

e) Verify that all manual volume dampers are locked 100% open.

f) Inspect primary air ducts to ensure adequate entry conditions to the terminal units.

g) Start the fan and immediately measure the motor running amperage.

h) Measure motor voltage.

i) Confirm that the voltage and amperage matches the motor rating.

j) Verify correct rotation.

k) Measure fan RPM and compare to design RPM.

l) Posture the system OA and RA dampers for maximum demand.

m) Determine if the AHU is rated for total static pressure (TSP) or external static pressure (ESP). If the rating is for TSP, measure suction and discharge static pressure at the inlet and outlet of the fan. If the rating is for ESP, measure the suction and discharge static pressure at the return duct and discharge duct. The suction pressure static measurement point can be immediately adjacent to the unit. The discharge measurement point should be taken no closer to the discharge than 3 to 5 duct diameters.

n) If testing with partially loaded filters is specified, measure pressure drop across air filters and adjust a temporary blockage to meet specified requirements.

o) Place all of the dual duct boxes and the supply air fan in a full flow condition. It is common practice to set all the mixing boxes to their full cold airflow position for setting the fan volume, but first verify that the cooling coil is designed to handle the same airflow as the HVAC duct system. It may be designed for less airflow creating a diversity that will require some mixing boxes to be set in a heating position for a total system flow test.

p) Measure the AHU total air volume by the most accurate method available. The method used is at the discretion and judgment of the NEBB Qualified TAB Supervisor based on the configuration of the unit and its ductwork.

q) If necessary, adjust fan airflow to meet design requirements.

r) Balance the dual duct boxes using procedures described in the following Paragraph 8.11.4. The NEBB Qualified TAB Supervisor should use these procedures as a guide, and modify the procedures as required by the individual projects.

s) Test and record the operating static pressure at the sensors that control the HVAC unit fan or fans, if provided, and verify the operation of the static pressure controllers.

t) Final System measurements: At the conclusion of all system balancing, adjust and verify the AHU minimum outside air ventilation rate, if required.

u) Record final unit data, prepare the report forms, and submit as required (see Section 5, Standards for Reports and Forms).

8.10.2 VARIABLE VOLUME DUAL DUCT SYSTEMS

These systems share many features of a dual duct constant volume system and with minor variations the procedures to TAB these systems are the same.

a) The boxes are calibrated in both heating and cooling modes.

b) The terminal outlets are to be balanced in only one mode.

c) System setup procedures are similar to those required for constant volume dual duct systems, and should be adapted as necessary by the NEBB Qualified TAB Supervisor to suit the particular system being balanced.

8.11 VARIABLE VOLUME TERMINAL UNIT PROCEDURES

8.11.1 COOLING ONLY TERMINAL UNITS

Pressure Dependent:

a) Set the VAV box to maximum airflow.

b) Test the total airflow delivered by the VAV box using one of the following methods:
- Total of air being delivered from the outlets.
- Inlet velocity sensor

c) Adjust the VAV box total airflow with available devices.

d) Adjust the outlets using either the proportional or the stepwise method.

e) Adjust the VAV box minimum airflow with available devices.

Pressure Independent:

a) Set the volume controller to design maximum airflow.

b) Test the total airflow delivered by the VAV box using one of the following methods:
- Total of air being delivered from the outlets.
- Inlet velocity sensor

c) Calibrate the controller, by appropriate methods, to the measured airflow.

d) Balance the outlets using either the proportional or the stepwise method.

e) Set the volume controller to the design minimum airflow.

f) Calibrate the controller for the required minimum if applicable.

Note that some VAV control systems may require the minimum airflow set point to be calibrated before the maximum airflow set point. Confirm with the control system supplier.

8.8.4 COOLING ONLY TERMINAL UNITS WITH REHEAT

These boxes are balanced as described for cooling only terminal units, with the possibility of distinct heating airflow set point(s). The heating airflows shall be verified and reported.

8.11.3 FAN TERMINAL VAV UNITS

Parallel Type (Pressure Independent or Dependent):

a) The primary airflows are balanced as discussed previously for a cooling only terminal unit.

b) Set the controls to operate the fan with the primary air valve at minimum flow.

c) Adjust the fan airflow to design airflow by adjusting the fan speed or dampers, whichever is provided.

d) Verify heating airflow and report.

Series Type (Pressure Independent):

a) Set the VAV box to the design maximum cooling set point

b) Set the fan speed to design airflow by measuring the outlet total airflow and comparing to design requirements.

c) Adjust the primary damper to obtain a neutral condition at the return inlet. When the inlet is neutral, the fan airflow is equal to primary airflow.

d) Balance the air outlets using an appropriate method.

e) Place the VAV box to the minimum position and adjust the primary airflow (L/s) to design requirements.

f) Verify the heating airflow and report.

g) On series VAV box systems only, volume dampers may be used to restrict airflow if fan airflow cannot be reduced, provided that a noise problem is not created.

Note that some VAV control systems may require the minimum airflow set point to be calibrated before the maximum airflow set point first. Confirm with the control system supplier.

It should be noted that design primary airflow may not always equal design fan airflow. In these situations an appropriate calibration procedure should be developed.

8.11.4 DUAL DUCT TERMINAL UNITS (CONSTANT OR VARIABLE VOLUME)

It is not practical to cover all of the various operating sequences here, and it is very important that the NEBB Certified TAB Firm review the control manufacturer's balancing procedures. If the control manufacturer's specifications do not address TAB procedures, the appropriate procedures should be developed. A generic pressure independent procedure is described below:

a) Set the cooling volume controller to design maximum airflow.

b) Set the heating volume controller to a fully closed position.

c) Test total airflow delivered by the box using one of the following methods:
   - Total of air being delivered from the outlets.
   - Inlet velocity sensor.

a) Calibrate the cooling volume controller, by appropriate methods, to measured airflow.

b) Balance the outlets using either the proportional or the stepwise method.

c) Set the cooling volume controller to a fully closed position.

d) Set the heating volume controller to design maximum airflow.

e) Calibrate the heating volume controller by appropriate methods, to measured airflow.

f) The control sequence should be tested to verify that the minimum ventilation requirements are provided.

8.12 UNDERFLOOR PLENUM SUPPLY AIR SYSTEMS

Under floor plenum supply air systems require extensive cooperation from all members of the construction team. The design team is responsible to carefully and completely specify what is required of all participating members of the construction team. The under floor system relies on the integrity of the floor plenum to transport the conditioned air to the occupied zone above the floor. Air leakage in the underfloor plenum is a critical determinant of system performance. The integrity of the underfloor plenum is commonly compromised by poor wall construction; penetrations of the plenum walls by electrical conduit, plumbing and piping systems; communication cabling, etc. It is the responsibility of the design team and construction team to specify and construct a plenum with minimal air leakage.

Floor tiles are usually designed to be removable, however the carpet tiles are frequently not compatible with the floor tiles and complicate the removal and replacement procedures. The installation of VAV terminals, for perimeter heating or special load applications, below the floor will require provisions for maintenance, especially if those terminals are equipped with filters for the plenum inlets.

Buildings with VAV floor diffusers, served by central station air handling systems typically have underfloor static pressure control systems. These control systems operate to maintain a constant static pressure in the under floor plenum. Control of the under floor static pressure allows the VAV diffusers to operate without adversely affecting the constant volume floor diffuser.

In general, an under floor system can be treated as a special case of a constant volume system. The NEBB Qualified TAB Supervisor should communicate to the design and construction teams the importance of the construction requirements regarding leakage. These systems often have hundreds of diffusers. In this case, it may be appropriate to report room or zone total airflows, rather than trying to provide a unique identifier for each of hundreds of floor diffusers.

8.13 RETURN AIR SYSTEMS

Constant volume ducted return air systems are balanced using the same principles and guidelines as for constant volume supply air systems. Follow NEBB procedures and incorporate the appropriate modifications to the procedures to accomplish the specified requirements.

Individual return grilles in open non-ducted return air systems cannot be balanced even if design return airflows are indicated on the plans

8.14 EXHAUST AIR SYSTEMS

8.14.1 GENERAL EXHAUST AIR SYSTEMS

Constant volume exhaust air systems are balanced using the same principles and guidelines as for constant volume supply systems. Follow NEBB procedures and incorporate the appropriate modifications to the procedures to accomplish the specified requirements.

8.14.2 KITCHEN EXHAUST AIR / MAKEUP AIR SYSTEMS

Kitchen makeup air systems must be in operation when the balancing takes place. Makeup air is achieved by means of relief or transfer grilles from adjoining areas, or by a dedicated makeup air system.

Velocity readings of the grease filters or slots, performed in accordance with the manufacturer’s specifications, are the most appropriate and generally accepted method to perform TAB procedures on a kitchen hood. Most kitchen hood exhaust ducts are made of heavy gauge metal, and are covered with a thick fire resistant insulation. Pitot traverses of grease exhaust ducts are not recommended. If a Pitot tube traverse of the exhaust duct is necessary, the access to the duct shall be provided by others. When the testing is complete, repairs to the duct and fire retardant enclosure shall be provided by others and shall be in accordance with applicable codes and industry practices.

When making velocity readings a correction for air density may be required if elevated temperatures are present or predicted.

8.15 LABORATORY FUME HOODS

> ***Warning:***
> *NEVER ENTER OR WORK IN A CLEAN SPACE OR BIOLOGICAL LABORATORY WITHOUT PERMISSION, AND ONLY AFTER APPROPRIATE SAFETY AWARENESS TRAINING.*

8.15.1 FUME HOOD PERFORMANCE

Containment of contaminants within the fume hood is based on the principle that a flow of air entering at the face, passing through the enclosure, and exiting into the exhaust system will prevent the escape of airborne contaminants from the hood into the room. The degree to which this is accomplished depends on the design of the hood, its installation, and its operation.

Air currents external to a hood easily disturb the hood's air pattern and may cause flow of contaminants into the breathing zone of the researcher. Cross currents are generated by movements of the researcher, people walking past the hood, thermal convection, supply air movement, and a rapid operation of room doors and windows. Terminal supply air velocity in the vicinity of the hood should be limited to 35 fpm (0.175 m/s). It is very important to avoid the location of the hoods near doors and active aisles.

Performance criteria for fume hoods are flow control / face velocity and spillage. Flow control (regulation of flow over the face opening of a hood) is obtained by adjusting the horizontal slots in the back baffle. One slot is at the bottom of the back baffle to draw air across the working surface; another is at the top to exhaust the canopy; and the third is frequently midway on the baffle. These adjustable openings permit regulation of exhaust distribution for specific operations.

Spillage (leakage outward through the face opening) of contamination from hoods into the laboratory can be caused by drafts in the room; eddy currents generated at hood opening edges, surface projections or depressions; thermal heads; and high turbulence operations (blenders, mixers) within the hood.

8.15.2 FUME HOOD PERFORMANCE TESTING

When conducting TAB procedures for fume hoods the NEBB Certified TAB Firm shall either:

a) Consult with the engineer of record to determine the specific criteria for acceptance of the fume hood performance tests (generally applicable to new construction).

b) Consult with the supervisory personnel for the laboratory where the fume hood to be tested is located to determine the specific criteria for acceptance of the performance tests (generally applicable to existing facilities).

Fume hood performance testing should be performed when the lab is operating under the following conditions:

a) Room operating under normal conditions.

b) All air systems balanced.

c) Pressure gradients to adjoining spaces at proper values.

d) Laboratory exhaust fume hood fans are operating satisfactorily.

8.15.3 FACE VELOCITY MEASUREMENT PROCEDURES

The intent of this test is to determine the actual average face velocity of the hood as it is typically used. The following procedures are the minimum recommended steps to achieve satisfactory fume hood performance, if any specific information regarding the face velocity measurement techniques for a fume hood is not available.

a) Verify that the room conditions are satisfactory.

b) Select the calibrated instrument for taking measurements.

c) Set the fume hood sash to the specified operating height.

d) A maximum 1.0 square foot (300 mm x 300 mm) grid pattern shall be formed by equally dividing the hood opening dimensions. Velocity readings shall be taken with a calibrated instrument at the center of the grid spaces. The instrument shall be mounted in a ring stand, or other appropriate device, in the plane of the hood sash and perpendicular to the opening. The technician shall not hold the instrument while taking a velocity reading. The technician shall assume a position away from the face of the hood to avoid influencing velocity measurements.

e) Face velocities shall be integrated over a period of at least five seconds. If an anemometer is used that measures instantaneous point velocities, a minimum of four readings shall be taken at each point.

f) The average of the velocity measurements shall be calculated, and the highest and lowest readings shall be noted.

g) If a Pitot tube traverse is taken in the exhaust duct prior to measuring face velocities, it may be necessary to allow approximately 10% to 15% for cabinet leakage, or a value as determined by the fume hood manufacturer.

h) Mark the hood sash opening and/or damper setting when final adjustments are made on fume hoods.

8.15.4 VISUAL METHOD PROCEDURES (IF REQUIRED)

The intent of this optional test is to render a visual observation of the hood performance as it is typically used. Smoke can be provided by means of a plastic bottle that contains an ampoule of liquid Titanium Tetrachloride. Other sources of persistent, neutral buoyancy aerosols could provide the same visualization of airflow.

a) A suitable source of smoke shall be in the center of the sash opening on the work surface 6" (150 mm) inside the rear edge of the sash. Note: Some smoke sources generate a jet of smoke that produces an unacceptably high directional component that may overcome the hoods exhaust air pattern leading to an erroneous conclusion.

b) Observe the air pattern from the side of the hood face. A release of smoke from the hood that is steady and visible is an indication of failure.

c) Airflow patterns and time for hood clearance shall be observed and noted.

d) Mark sash opening and / or damper setting when final adjustments are made on fume hoods.

8.16 BIOSAFETY CABINETS

Fume hoods and Bio Safety cabinets are similar in purpose as they provide a safe working environment for laboratory personnel. Due to the variety of configurations of Bio Safety cabinets, field performance testing shall be in strict accordance with manufacturer’s recommendations.

8.17 INDUSTRIAL EXHAUST HOODS AND EQUIPMENT

8.17.1 AIR AND FUME EXHAUST SYSTEMS

The current edition of the American Conference of Industrial Hygienists *Industrial Ventilation, A Manual of Recommended Practice* should be consulted for proper testing techniques. Industrial exhaust air systems with hoods fall into two categories. One group, similar in many respects to laboratory fume hoods, is used over vats such as dip tanks and plating tanks. Exhaust hoods are often placed at one end above the tank and make up air hoods are placed at the opposite end. This permits vapors to be swept from the tank surface but still leaves the top open for overhead handling equipment. Often an exhaust duct will be connected directly to a piece of equipment with no external hood. Other times, hoods may be used just to remove heat from equipment. Heat recovery systems also are being used more frequently. In these situations, makeup air becomes critical and air density must be corrected in calculations.

The balancing procedure is basically the same as any other exhaust air system. A Pitot tube traverse of the exhaust air duct is the preferred method where possible. The differences are mainly in how to test the various inlet openings. If an inlet opening velocity must be measured, obtain the free area opening by measuring it and then calculate what the velocity should be. Quite often this will not be possible due to irregular shapes and/or obstructions.

A thermal anemometer is a very valuable instrument for this type of work as the probe is small enough to get into obstructed places. Proper testing in these situations may require review of the equipment manufacturer's data, as the procedures for setting up and testing the equipment may be available.

8.17.2 MATERIAL HANDLING SYSTEMS

A second group of industrial exhaust air systems is used to remove and convey solid materials. Sawdust, wood chips, paper trimmings, etc., are transported at high velocities through these exhaust systems. These systems must be balanced so that velocities do not fall below predetermined transport velocities. To prevent damage to test instruments, all testing should be done without materials being transported.

Balancing of these systems is done with blast gates, which are installed in lieu of dampers and are used to temporarily shut off unused branches. In addition to velocity readings, static pressure readings of the pressure differential between the room and the hood should be recorded in a convenient reference point at each hood or intake device. This will permit easy future checks designed to spot any deviation in exhaust volumes from original volumes. When balancing is complete, score or mark all blast gates so that the system balance can be restored if it is disturbed.

> ***WARNING:***
> *Some industrial exhaust air systems generate an extreme static electricity charge. Contact the plant engineer or system operator to determine that the static electric charge has been dissipated in order to protect you from shock and your test instruments from damage.*

8.18 BUILDING STATIC PRESSURE CONTROL METHODS

There are three commonly applied methods of controlling building static pressure, described in the following paragraphs.

8.18.1 ACTIVE BUILDING STATIC PRESSURE CONTROL

Building static pressure controllers sense differential pressures between a typical room and outdoors, and increase the volume of air handled by the return / exhaust air fan as building pressure increases. This method controls buildings by sensing the value of the variable being controlled and adjusting return or exhaust fan flow as necessary. Typical commercial building static pressures range from +0.02 in.w.g. to +0.05 in.w.g. (5 Pa to 12.5 Pa).

8.18.2 OPEN LOOP CONTROL

Open loop, (non feedback), control uses an adjustable span and start point on the supply air and return air fan controls to sequence the return air fan operation with the supply air fan. This system requires close attention by the NEBB Qualified TAB Supervisor. If the system load varies significantly among the major zones the supply air fan serves, resistance in the return air system may not vary in direct proportion to resistance in the supply air system. Open loop control does not sense the effect of resistance variance between the supply air and return air systems, and building pressures may vary when major load variation occurs.

8.18.3 CLOSED LOOP CONTROL (FAN TRACKING)

The closed loop control senses changes in the volume of air the supply air fan delivers and uses a controller having a second input proportional to the return air fan flow to reset the return air fan. This is commonly referred to as fan tracking. Controlling return flow in response to changes to supply fan flow requires a thorough understanding of system and building performance in order for the resulting fan performance to be acceptable.

8.19 STAIRWELL PRESSURIZATION TESTING

Stairwell pressurization systems are designed to provide a smoke proof enclosure and a means of egress during a smoke control event. Stairwell pressurization testing is conducted to verify that shaft pressurization meets minimum requirements when the system is in operation. The local authority having jurisdiction (AHJ) is the ultimate source of approved testing protocols. This section is intended as a general guide procedure, to be used or modified as deemed appropriate by the AHJ.

Testing of the stairwell system should be conducted, for new construction, with the cooperation of the construction team. It is recommended that a preliminary test be completed before scheduling the AHJ to witness a final test.

The NEBB Qualified TAB Supervisor shall review with the AHJ and / or the engineer of record the minimum pressure differentials to be achieved, and the total number and locations of the pressure measurements to be performed. Complete the testing as follows:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that all related building construction is complete. If these conditions are not present, the test report should include a summary of test condition deficiencies. Stairwells shall be complete with all doors and exit hardware in their final condition.

c) Determine whether the AHJ wishes to test with the stairwell exit door closed or open. Testing with the exit door open simulates a real condition; i.e. occupants leaving a building due to a smoke control event are unlikely to close the stairwell exit door behind them.

d) Record unit nameplate data as described in Section 6.

e) Others shall start the shaft pressurization system. A smoke control event usually may be started by applying canned smoke or a magnet to a smoke detector.

f) All shaft pressurization systems shall be operational at time of testing. Additionally, all other HVAC systems shall be properly postured for a fire and smoke control event.

g) Testing *shall not* generate a false call to the fire department.

h) Confirm that the fan rotation is correct.

i) Measure fan motor amperage and voltage.

j) Verify that the motor is not overloaded.

k) Verify that all appropriate stairwell pressurization fans and dampers operate according to the approved sequence of operation.

l) Measure the pressure(s) from the stairwell to the reference point(s) as required by the AHJ or the engineer of record. A pressure differential of 0.05 in.w.g. (12.5 Pa) from the stair shaft to the reference point is generally considered to be the minimum acceptable pressure difference.

m) Adjust the fan speed, if required, to change the shaft pressurization to meet specified requirements.

n) Verify that the maximum door opening force does not exceed 30 pounds (13.6 kg) or a locally specified value. Use of a belt tension checker or other appropriate device is generally advised to test door-opening forces.

o) If the stairwell is equipped with a relief damper(s), verify its operation and measure the airflow exiting the stairwell through the damper. Compare the measured airflow to design requirements, and report discrepancies.

p) Report the actual test conditions and results to the AHJ and engineer of record.

8.20 ELEVATOR PRESSURIZATION TESTING

Elevator pressurization systems are designed to provide a smoke proof enclosure during a smoke control event. Elevator pressurization testing is conducted to verify that shaft pressurization meets minimum requirements when the system is in operation. The local authority having jurisdiction (AHJ) is the ultimate source of approved testing protocols. This section is intended as a general guide procedure, to be used or modified as deemed appropriate by the AHJ and / or the design engineer of record.

Testing of the elevator pressurization system should be conducted, for new construction, with the cooperation of the construction team. The presence of the elevator contractor is ***required*** due to the complexity of elevator systems. It is recommended to satisfactorily complete a preliminary test before scheduling the AHJ to witness a final test.

The NEBB Qualified TAB Supervisor shall review with the AHJ and / or the engineer of record the minimum pressure differentials to be achieved, and the total number and locations of the pressure measurements to be performed. Complete the testing as follows:

a) Verify the construction team responsibilities for system installation and startup as discussed in Section 3 are complete.

b) Verify that all related building construction is complete. If these conditions are not present, the test report should include a summary of test condition deficiencies. Elevator systems shall be complete.

c) Verify that the building shell is complete. Temporary closures of windows and doorways are not acceptable.

d) Record unit nameplate data as described in Section 6.

e) Others shall start the shaft pressurization system. A smoke control event usually may be started by applying canned smoke or a magnet to a smoke detector.

f) All shaft pressurization systems shall be operational at the time of testing. Additionally, all other HVAC systems shall be properly postured for a fire and smoke control event.

g) Testing *shall not* generate a false call to the fire department.

h) Confirm that the fan rotation is correct.

i) Measure fan motor amperage and voltage.

j) Verify that the motor is not overloaded.

k) Verify that all appropriate elevator pressurization fans operate. If isolation dampers are present verify proper operation during the pressurization event.

l) Verify that all elevator cars in the tested shaft return to the recall floor, and remain there with the doors open for the duration of the test.

m) Measure the pressure(s) from the elevator shaft to the reference point(s) as required by the AHJ. A pressure differential of 0.05 in.w.g. (12.5 Pa) from the elevator shaft to the reference point is generally considered to be the minimum acceptable pressure difference.

n) Adjust the fan speed, if required, to change the shaft pressurization to meet specified requirements.

o) Report the actual test conditions and results to the AHJ and engineer of record.