Air distribution systems

CIBSE Commissioning Code A: 1996 (2006)

CIBSE

Air distribution systems

CIBSE Commissioning Code A

CIBSE

This edition first published August 1996; reviewed and confirmed August 2004. Reprinted June 2010.

ISBN 0 900953 73 X

Typeset by CIBSE Publications Department

Printed in Great Britain by Page Bros. (Norwich) Ltd., Norwich, Norfolk NR6 6SA

Note from the publisher

This publication is primarily intended to provide guidance to those responsible for the design, installation, commissioning, operation and maintenance of building services. It is not intended to be exhaustive or definitive and it will be necessary for users of the guidance given to exercise their own professional judgement when deciding whether to abide by or depart from it.

Foreword

Since the late 1960s when the CIBSE Commissioning Code A was first published, developments in design and changes in commissioning procedures have highlighted some shortcomings and inadequacies calling for a complete revision of the original format.

The new Code as prescribed in this document encompasses all the desirable aspects of the previous code with expansion, additions and revisions, where necessary.

The commissioning of modern building services systems, particularly in large and sophisticated projects, has become increasingly complex with significant demands placed on construction personnel, not least the commissioning specialist. Quite apart from the specific commissioning tasks to be carried out, commissioning requires careful liaison between all the parties concerned and the effective programming of specific activities. Contained within the revised Code is a flow chart highlighting the key stages involved in the commissioning of air distribution systems. It is hoped that this will help all construction professionals to appreciate the activities required to commission an air distribution system.

The Task Group has endeavoured to strike the right balance between commonly used commissioning procedures and contractual practices, without introducing formal contractual responses into the document.

A considerable amount of time, effort and debate from a wide range of interested professionals has gone into the production of this document. As a result, it is hoped that all concerned with the design, installation, commissioning and witnessing of air distribution systems will take up and adopt the recommendations of this Code.

I wish to acknowledge the assistance of all those who have contributed to the preparation of this Code, and in particular the individual Task Group members and the Commissioning Specialists' Association.

G H Peters (Chairman)

Task Group

J Coppin (Ove Arup & Partners)
T S Day (Commissioning Management Ltd.)
R Gooding (Secretary) (Commissioning Specialists' Association)
A T Muggleton (JPS Environmental Services Ltd.)
J O'Grady (O'Grady Technical Services)
R J Oughton (F C Foreman & Partners)
G H Peters (Chairman) (Applied Energy Ltd.)

TPC Liaison

D D Lawrence (formerly Laing Technology Group Ltd)

Editor

J Wilson

Co-ordinating Editor

R Yarham

CIBSE Publishing Manager

Jacqueline Balian

Contents

List of figures and table

Air distribution systems

A0 Introduction

A0.1 Scope

This Code deals with the work stages required to commission typical air distribution systems. The procedures represent a standard of good practice generally accepted in the building engineering services industry and are, therefore, presented in the form of recommendations and guidance.

The Code sets out generally to inform on 'what should be done'. Manuals published by the Building Services Research and Information Association (BSRIA) inform on 'how it should be done'.

The flow chart in Figure 1 illustrates the key stages involved in the commissioning of air distribution systems covered by this Code. Attention is drawn to the fact that there are other, subsequent stages that do not form part of this Code.

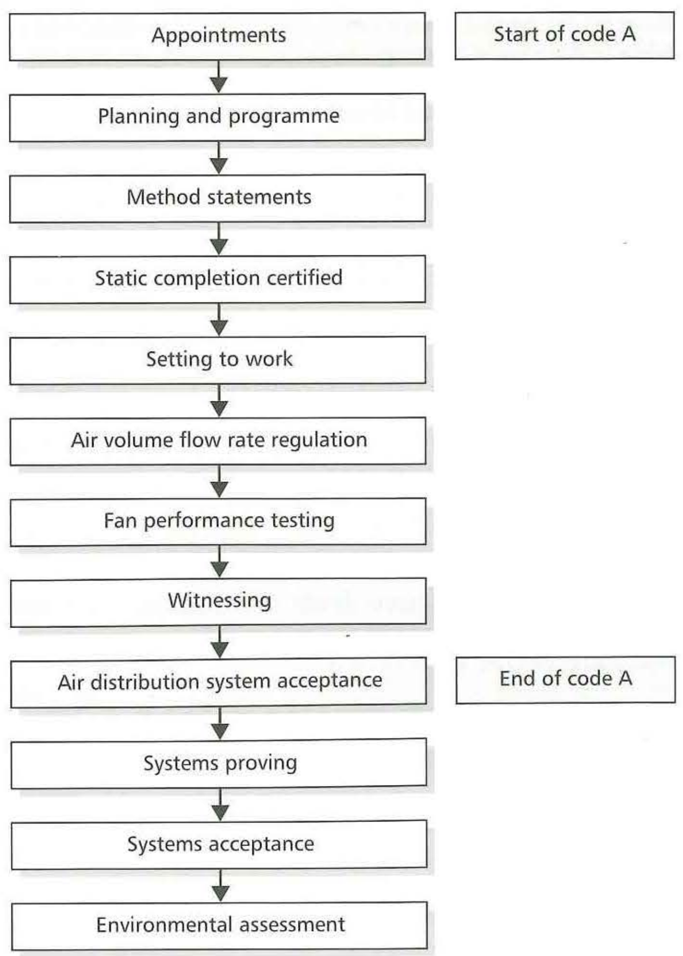

Figure 1 Key stages involved in the commissioning of air distribution systems

A0.2 Definitions

For the purpose of this Code the following definitions apply.

Accuracy

Accuracy is a compounding of the following factors: instrument accuracy, flow measuring device accuracy and operator accuracy. Refer to the BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[(1)] for further information.

Accuracy — flow measuring device

Variations in the reading arising from manufacturing tolerances of the flow measuring device.

Accuracy — instrument

Variations in the reading arising from manufacturing tolerances in the instrument.

Accuracy — operator

Any error introduced by the operator such as parallax in the reading of instruments or test points not ideally positioned.

Commissionable system

A system designed, installed and prepared to specified requirements in such a manner as to enable commissioning to be carried out.

Commissioning

The advancement of an installation from the state of static completion to full working order to specified requirements. It includes the setting to work of an installation and regulation of the system flow rates.

Commissioning management

The planning, organisation, coordination and control of commissioning activities.

Commissioning manager

The firm or person appointed to manage the commissioning process.

Commissioning specialist

The firm or person appointed to carry out specified duties in connection with commissioning.

Definitive air volume flow rate

The inferred volume flow rate derived from measurements taken using a pitot tube in accordance with defined techniques.

Design criteria

The specified environmental conditions, fluid flow rates and equipment outputs required to meet a particular design performance.

Diversity

A hypothetical aggregate simultaneous air volume flow rate at design maximum system performance, compared with the summation of the design maximum air volume output of all terminal units. The diversity ratio is often quoted as a percentage.

Fine tuning

Local adjustment to the system where usage and system proving have shown a need for it. This may also include the re-assessment of control set points and values to achieve optimum performance.

Hood

A proprietary or custom-made device used to capture air flow from an air distribution terminal for the purposes of measurement (flow or velocity).

Index (terminal/sub-branch/branch)

The terminal/sub-branch/branch in a distribution system which, prior to regulation of air flow, receives the lowest indicated percentage of design fluid flow rate.

Indicated air volume flow rate

The inferred volume flow rate derived from measurements, typically at terminal outlets, taken using proprietary instrumentation and devices (e.g. terminal air collection hoods).

Pressure and leakage testing

The process of measuring and recording specified pressure retention or permitted rate of leakage in an air distribution system or component part thereof.

Regulation

The process of adjusting volume flow rates of a fluid in a distribution system to achieve specified values (within tolerances).

Scan — final

The final set of recorded measurements taken of a system upon completion of the regulation process.

Scan — initial

The first set of recorded measurements taken of a system with all regulation devices in the fully open position prior to any regulaton.

Setting to work

The process of putting a static system into dynamic operation.

Specification

The document that prescribes the requirements for commissioning by reference to drawings, information schedules and relevant codes, manuals, guides and standards.

Static completion

The state of a system installed in accordance with the specification, ready for 'setting to work'. This includes cleaning and pressure leakage testing of the distribution system (where required).

System

A set of connected components for heating, cooling, ventilation or air conditioning consisting of plant, distribution ducting and terminal units together with arrangements to control their operation.

System proving

Measuring, recording, evaluating and reporting on the seasonal performance of a system against specified design criteria.

Testing

The measurement and recording of system parameters to assess specification compliance.

Tolerance

Permissible deviation from a specified design requirement.

A0.3 Commissioning method statements

To ensure that all technicians work to the same procedures and sequences, the commissioning specialist should compile a commissioning method statement particular to the project. This method statement should include particulars, in principle or in detail as appropriate, of the following:

(*a*) equipment and instrumentation to be used

(*b*) preliminary checks to be applied (e.g. sections A1.2 to A1.7)

(*c*) commissioning procedures to be followed (e.g. sections A2 and A3)

(*d*) tolerances to be applied in air flow regulation

(*e*) arrangements, where appropriate, for witnessing (e.g. the advance notice to be given).

In some instances, the commissioning specification may require the commissioning specialist to submit a method statement for approval. Where this is not a requirement, the commissioning specialist may nonetheless wish to make a formal submission of a particular method statement to the contractor/client. By this means, interested parties would be informed of the commissioning intent, thus providing scope for any concerns regarding methods or procedures to be addressed before commissioning is commenced.

A0.4 Specification

The Code assumes that the installation is complete and properly constructed to an agreed specification. The specification should state permissible tolerances within which the system should operate.

A0.5 Inspection and testing

The requirements of this Code do not replace the need for regular inspection of the installation which should be carried out during construction. All ductwork and mechanical and electrical plant should be tested as required by the specification and the test results recorded and documented. Testing carried out in accordance with the requirements of the specification, both on and off site, should be recorded and the documents made available to the commissioning specialist prior to the commencement of their works.

A0.6 Commissioning records

It is essential that all checks and measurements are recorded in writing at the time they are made. Breaks in the continuity of commissioning operations are likely, and proper records will show the state of progress at any stage. It is most important that commissioning records are provided as part of the 'hand-over' documentation. It is recommended that a standardised format be agreed for recording the necessary commissioning performance data for a particular project.

A0.7 Responsibility

The responsibility for commissioning is a contractual matter outside the scope of this Code. Nevertheless, it is recommended that the management of the whole commissioning process be under the guidance and control of a single authority. Total commissioning management may be considered as an option.

A0.8 Practical considerations

The measuring, regulating and apportioning of air flow in a distribution system as applied in the commissioning procedures described in this Code is a means to an end. The primary objective is to ensure that the performance of the commissioned installation is adequate to maintain the specified space environmental conditions with optimum efficiency.

It should be borne in mind that flow rate apportionment to unnecessarily close tolerances will result in high commissioning costs, with little or no practical advantage. Also, the use of additive tolerances (e.g. –0% +10%) could result in running cost penalties throughout the life of the installation. It is the responsibility of the designer to specify flow rate tolerances and to ensure that these are appropriate to the particular design, installation and application.

A1 Preliminary checks

A1.1 Objective

The purpose of the procedure given in this section is to check that the system is in a satisfactory and safe condition before starting up. All the following checks should be carried out in the sequence given before the initial running of fans.

A1.2 State of the building and system

Before starting regulation it is essential that the following conditions are fulfilled:

(*a*) the building is complete and windows and doors are open or shut consistent with their normal state (see section A3.5 when dealing with pressure related areas e.g. laboratories, operating theatres etc.)

(*b*) the air distribution system is complete and, where required by the specification, leakage testing is satisfactorily concluded, inclusive of builders' work ducts and shafts

(*c*) the requirements of this section, sections A1.3–A1.7 and A2.2–A2.5 have been met

(*d*) all main and branch heaters and coolers on supply systems are shut off to maintain consistent air density during testing. However, in cold weather and particularly on full outside air systems, some heating may be applied to the main airstream (which handles the total air flow) in order to temper the air delivered by the system (see also section A2.4).

A1.3 System cleanliness

Note: it is important to ensure a reasonable standard of system cleanliness before start-up. Debris may be entrained by air flow on start-up, significantly reducing the life of the filter media and other system components.

Prior to the fitting of filters, check the following for cleanliness:

(*a*) air intake screens
(*b*) fan and other equipment chambers
(*c*) fan internals
(*d*) heater and cooler batteries
(*e*) cooling coil condensate trays
(*f*) condensate drainage traps
(*g*) eliminators
(*h*) humidifiers
(*i*) volume control dampers and linkages
(*j*) fire dampers
(*k*) ducting and other airways
(*l*) sensing elements
(*m*) terminal units.

The commissioning specialist should formally report any instances of unsatisfactory cleanliness to the appropriate level in the project management.

A1.4 Air regulating devices and other components within airways

The following checks should be made:

(*a*) turning vanes, thermal insulation, acoustic linings, battery fins and sensing elements have been fitted and are undamaged
(*b*) heater and cooler batteries, humidifiers, filters, silencers etc. are installed correctly in relation to air flow
(*c*) volume control dampers are operating
(*d*) there is freedom of movement, throughout range, on motorised damper control linkages
(*e*) dampers throughout the system are secured in the fully open position (except where other requirements may be specified)
(*f*) there is free movement of fire dampers, together with the location of, access to and fitting of fusible link assemblies; all fire dampers are finally secured in the open position
(*g*) all adjustable louvres set without deflection, i.e. normal to face of grille; adjustable cones on diffusers set either all in the fully up or all in the fully down position
(*h*) test holes are provided at strategic points for the measurement of branch and total air volume flow rates.

A1.5 Visual checks for air tightness

Check to ensure that:

(*a*) builders' work ducts and shafts are sealed
(*b*) plant access doors are sealed around whole periphery
(*c*) ductwork joints, including flexible couplings, are air tight
(*d*) inspection covers are fitted
(*e*) drainage trap water seals are intact
(*f*) plugs or covers for test holes are fitted.

A1.6 Fan checks

The following should be checked:

(*a*) internal and external cleanliness
(*b*) all components, bolts, fixings etc. are secure
(*c*) impeller secured, free to rotate, of correct handing and correct clearances
(*d*) axial-flow-type fans installed for correct air flow direction and, where compounded, in correct order
(*e*) anti-vibration mountings and the removal of transit bolts and packing materials
(*f*) correct drive is fitted
(*g*) securing and alignment of pulleys and couplings
(*h*) belt tension and match
(*i*) where necessary, lubrication has been applied in accordance with manufacturer's requirements
(*j*) drive guards fitted, access for speed measurement provided
(*k*) where appropriate, satisfactory operation of inlet guide vanes and variable pitch fans over full range of movement.

A1.7 Electrical checks

Prior to the initial running of any electrically driven fan, electric air heater or automatically advancing filter, the following procedures should be adopted:

A1.7.1 With all electrical supplies isolated

Check:

(*a*) local isolation of motor and control circuits
(*b*) no unshrouded live components within panels
(*c*) panels and switchgear clean
(*d*) motor and surrounding area clean; air heaters clean
(*e*) transit packing removed from contactors and other equipment
(*f*) no mechanical damage to switchgear or air heaters
(*g*) all mechanical checks on fan, motor and automatic filter complete (see section A1.6)
(*h*) all connections tight on busbars and wiring
(i) internal links on starter correct
(*j*) all power and control wiring completed in detail to the circuit diagram (special attention to circuits for star-delta connected or specially wound motors)
(*k*) fuse ratings correct

(*l*) starter overloads set correctly in relation to motor nameplate full current rating
(*m*) insulation tests on motor satisfactory
(*n*) adjustable thermal cut-outs set correctly
(*o*) all cover plates fitted.

A1.7.2 With electrical supplies available

Check:

(*a*) declared voltage available on each supply phase
(*b*) motor starter systems prior to energising the motor.

A2 Setting to work

A2.1 Procedure

This section deals with the procedures for setting to work all air distribution systems.

A2.2 Preliminary checks

All checks listed in section A1 must be completed before applying this section.

Before any commissioning activities involving system operation are carried out, the commissioning specialist should check that the air distribution installation meets the following parameters:

(*a*) the duct system is complete and meets specified leakage limits and, in the case of high velocity systems, pressure testing is satisfactorily concluded
(*b*) the standard of cleanliness of system components detailed under section A1.3 is satisfactory.

A2.3 Precautions against airborne detritus

The system should be checked for cleanliness in accordance with section A1.3, but the following additional precautions should be considered before starting the fans for the first time:

(*a*) disconnect final flexible connections to terminal units that are susceptible to damage by ingress of foreign matter (e.g. induction units and variable air volume boxes)
(*b*) remove all high efficiency filters that are susceptible to rapid choking
(*c*) provide temporary protection for anything within spaces served by the system that could be damaged by an initial discharge of dust from supply outlets at first start-up
(*d*) install main inlet filter cells to avoid introducing dirt into the ductwork system after start-up
(*e*) provide temporary filters at extract or return air terminals to minimise contamination.

Note: specialist cleaning of ductwork distribution systems is outside the scope of this Code.

A2.4 Precautions against frost

Before starting fans in cold weather it is essential to ensure that any equipment susceptible to frost damage, such as in-duct air heating or cooling coils, is adequately protected from freezing or is drained. Consideration should also be given to the protection of spray systems and air washer sumps.

A2.5 Initial running of fan set

A2.5.1 Limiting the load

Wherever possible, the first start of any motor should be on light load. This may be achieved by limiting the air volume flow rate. A knowledge of the fan characteristic is required to ensure that excessive suction or delivery pressures are not applied to the ductwork system.

A2.5.2 Initial start

On starting the motor, check:

(*a*) direction of rotation of motor shaft
(*b*) motor, drive and fan are free from vibration or undue noise
(*c*) motor starting current for sequence timing adjustment (e.g. star-delta changeover point)
(*d*) motor running current on all phases, and that these are recorded
(*e*) no sparking at commutator or slip rings
(*f*) no overheating of motor
(*g*) no seepage of lubricant from housing
(*h*) no overheating of bearings
(*i*) oil rings running freely
(*j*) speeds and motor running currents over full range on multi-speed and variable speed motors, and that these are recorded.

A2.5.3 Initial run

A light load run should be sustained until the commissioning specialist is satisfied from the checks listed in section A2.5.2 and from motor insulation test readings that further load may be applied. Repetitive starting of the motor should be avoided to prevent overstressing of fuses, switchgear and motor.

A2.5.4 Start at normal load

Subsequent to the satisfactory conclusion of the initial light load run, the fan should be stopped and restarted at normal starting load and the checks listed in section A2.5.2 repeated. Again, avoid repetitive starting.

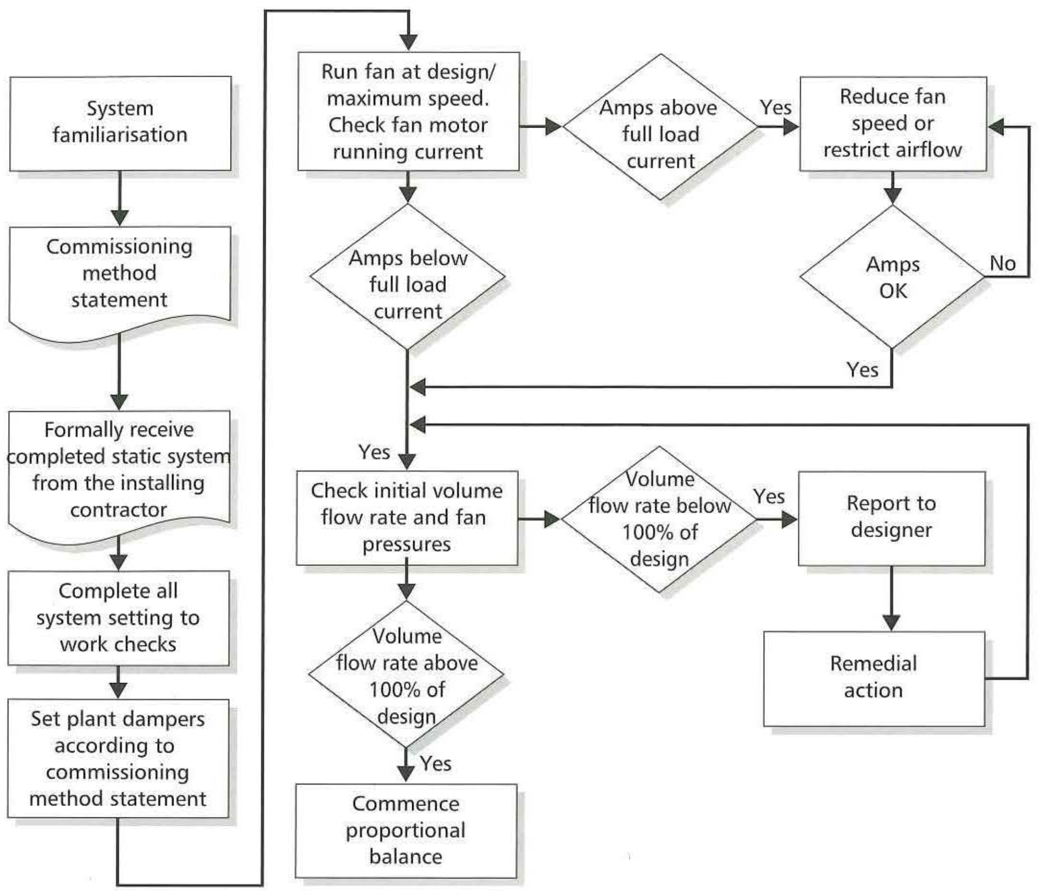

Figure 2 Flow chart for activities prior to proportional balancing

A2.5.5 Running-in period

After a short run at normal load (usually, a few minutes should suffice), any flexible connections, terminal filters etc. that were removed as suggested in section A2.3 should be reconnected. Subsequently, a running-in period should be sustained until the commissioning specialist is satisfied that the fan set is a reliable continuous-running machine that can safely be placed under the normal operation regime. The regulation of the air distribution system should be delayed until the running-in period (which may last some days) is completed satisfactorily.

A3 Regulation of air flow

A3.1 Principles

A3.1.1 Introduction

The key activities prior to commencing the regulation of air flow (commonly referred to as proportional balancing) are summarised in Figure 2. Regulation of air volume flow rates should be carried out in accordance with the following procedure. It is applicable to all air distribution systems that require manual regulation. Only the method of measuring air flow at the terminals is particular to the type of system involved. The instruments and methods of measurement to be employed on the various types of terminal, together with other information pertaining to the regulation of air flow, are detailed in BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[1].

A3.1.2 Fundamentals

The method is based on the principles defined in 'Balancing air flow in ventilating duct systems' (Harrison and Gibbard, 1965[2]). It consists essentially of working back to the fan from the remote branches, setting the correct proportional air flow at each junction of the system in turn (without regard for definitive flow rates) and so balancing the system. This done, the definitive air volume flow rates throughout the system are brought to their design values by adjusting the fan total volume flow rate (see Appendix AA3.4).

This principle is illustrated by consideration of air flow at the junction PQR in a system AZ as shown in Figure 3. Q is a dampered branch on the duct RP, and the required design volumetric rates of air flow are shown. With damper Q fully open, it might be found by measurement that P handles 1.4 m^3/s and Q handles 1.2 m^3/s — 70% and 120%, respectively, of their design rates of air flow. To balance this junction, damper Q should be closed until P and Q handle the same proportion of their respective

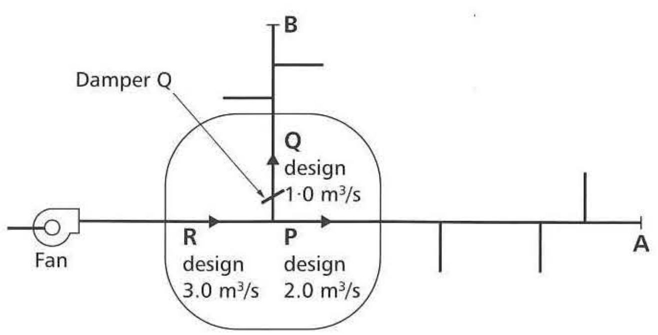

Figure 3 Air distribution junction

design air flow rates. This might result in a balance of P handling 1.6 m^3/s (80% of its design) and Q handling 0.8 m^3/s (80% of its design). It follows that R will now also be handling 80% of its design rate, i.e. 2.4 m^3/s.

Once damper Q is set — provided there is no alteration to any dampers in the system QB downstream of Q or in the system PA downstream of P — the air flow at R will be divided into the correct design proportions between P and Q at this junction PQR, i.e. two-thirds to P and one-third to Q. This holds true whatever the definitive value of the air flow at R.

Working back up the system towards the fan, adjusting dampers at other junctions between R and the fan, the definitive values of flows in R, P and Q will be changed but the ratios of those flows will remain unchanged at 3:2:1. Ultimately, when all the junctions have been balanced, the main damper (where provided) should be adjusted to obtain the design definitive flow rate in the main duct from the fan. This correct total flow will now be divided by the system, as set, in the correct proportions at each succeeding junction until R is reached, where 3.0 m^3/s will be flowing. This will now divide into 2.0 m^3/s in P and 1.0 m^3/s in Q, exactly as required by the design.

In practice, a particular routine is adopted when balancing successive junctions to avoid both cumulative errors and the need for test points and dampers in ducts between junctions. Referring to Figure 4, when A and B have been balanced, A, B and C are all handling the same proportion of their respective design air flow rates. Thus, when balancing the junction CDE, D can be balanced against A or B as well as against C. In practice, it is usual to select A as the reference point and the air flows in B, D and F are, in turn, balanced against the air flow in A.

Adjusting the distribution dampers to obtain only a proportional balance has an important implication: the definitive values of rate of air flow in any part of the system do not need to be known at this stage. Hence, the instrument used for measuring the air flow at the terminals or branches of a distribution system need not necessarily indicate the true value of air velocity. This means that inherent errors in the instrument that cause a consistently higher or lower velocity reading than the true value can be ignored. Also, provided the same method of measurement is used, factors such as those for effective grille areas are usually self-cancelling and can be disregarded.

The definitive value of the system total air flow rate does not need to be established until the entire distribution system has been proportionally balanced.

Note: while carrying out a proportional balance of a system it is advisable to maintain the balanced section of the system at between 70% and 130% of true design flow rate. If a system is balanced outside these limits, the proportional balance may be impaired when the system total flow rate is adjusted to the design value.

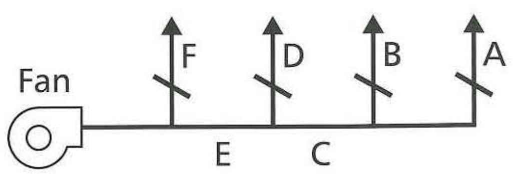

Figure 4 A typical branch duct configuration

A3.2 Procedures

A3.2.1 Preliminaries to regulation

Figure 5 illustrates a typical low velocity supply air system, but note that the following applies equally to all other types of system, including extract systems.

(*a*) Check that the dampers on all terminal grilles or diffusers 1, 2, 3, 4 etc. are fully open; also that sub-branch dampers AA, AB etc. and branch dampers A, B and C are all fully open. All adjustable louvres should be set without deflection (i.e. normal to face of grille). Adjustable cones on diffusers should be set either all in the fully up or all in the fully down position. Set automatic plant mixing dampers OA and RC to one extreme position (i.e. normally either full outside air or full recirculation).

(*b*) Run the fan and ensure the fan motor full load current is not exceeded. If necessary, take temporary measures to reduce the current drawn.

(*c*) Measure and record the fan total volume flow rate delivered. At this stage, it should be in excess of 100% of design. (Where there is a significant deficiency, this may indicate a problem with the system that should be investigated before proportional balancing proceeds.)

(*d*) Measure and record the indicated rates of air flow at all terminal grilles, diffusers 1, 2, 3, 4 etc., preferably using one instrument and method (see BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[1]), although where this is not possible refer to Appendix AA3.3. Express these initial measurements as 'indicated percentages of design'. It is important that the design rates of air flow (with which the measured rates of air flow are compared) are all based on a common datum of density, usually that of standard air or, occasionally, that of air at design density at fan inlet. During these initial measurements, the air must be of reasonably consistent temperature throughout the distribution system, although this temperature datum need not necessarily equate with the density datum adopted for the design values of air flow.

Variations in wind, stack effect, fan motor voltage, filter resistance etc. will all have some effect on the performance of the system. For this reason, the initial measurements (and the final measurements, see section A3.3.4) should be made in one continuous operation so that the readings will normally be truly comparable. Elsewhere in the procedure, performance changes of this type do not generally impair the validity of the regulation work for the reasons discussed in section A3.1.

Note: records of the system 'initial scan' are invaluable to indicate the extent of the balancing required on the system. They may be useful in the investigation of any problems, such as excessive noise or system resistance, experienced with the system once it is balanced.

(*e*) Study the general pattern indicated by the initial readings. It may be useful at this stage to submit the records of these to the designer or the commissioning manager. This will avoid time wasted attempting to balance a system where the initial

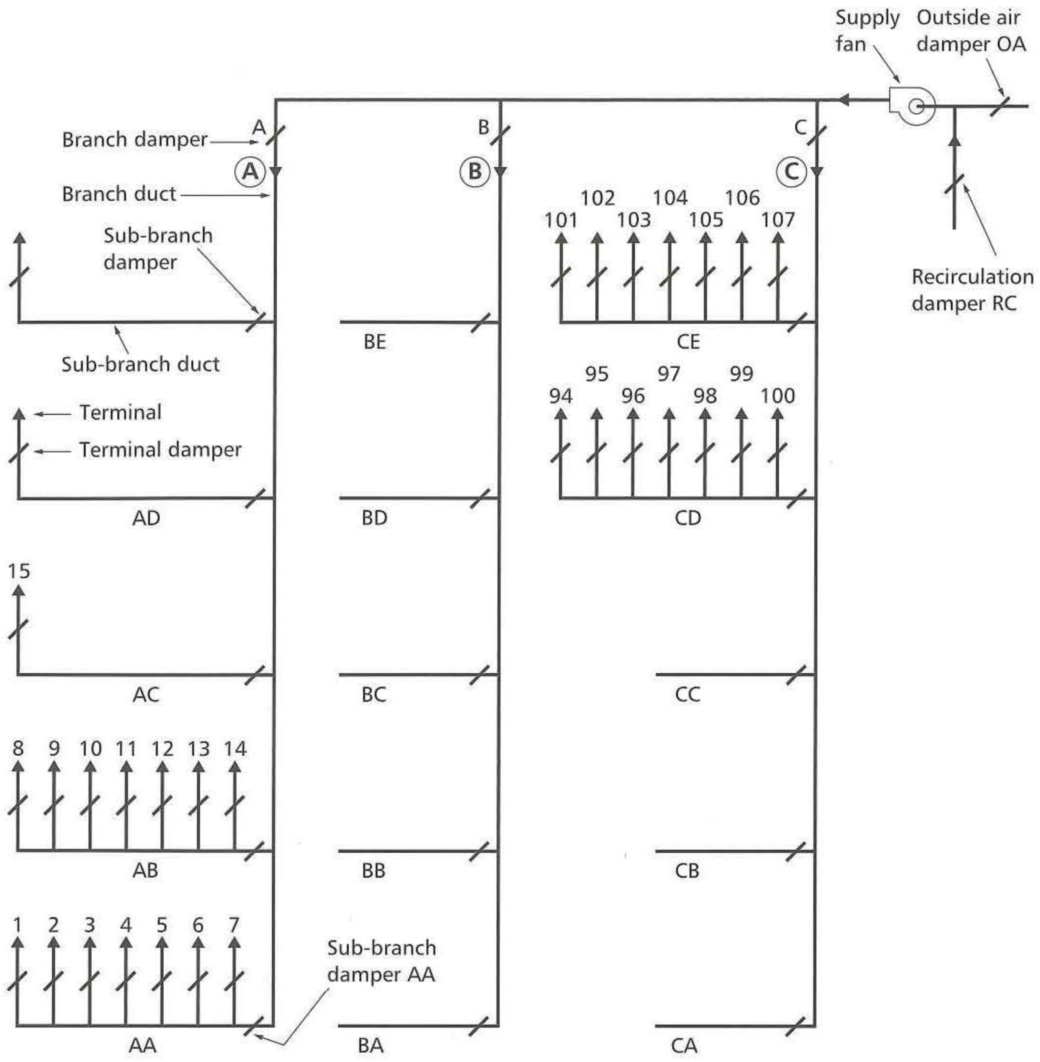

Figure 5 A typical air distribution system

indicated performance suggests that the prospect of successful balancing to design requirements is doubtful. The principal points of interest are:

(*i*) If the total rate of air flow handled by the system is less than 100% of the design air flow, physical changes to the air handling system will probably be necessary before regulation can begin. The fan performance curve will assist in the assessment of the problem and give an indication of the scope for enhancing fan performance.

(*ii*) Are there any obvious faults such as possible blockages, leakages or design errors indicated by, for example, large differences in air flow readings between apparently similar branches and terminals? Such faults will require correction.

(*iii*) What are the indicated values of air flow in relation to design requirements in each branch A, B, C and each sub-branch AA, AB etc. of the system (obtainable by totalling appropriate sub-branch values)? This will usually determine the order in which branches and groups of terminals are tackled in the regulation procedure.

(*iv*) What is the location of the least favoured terminal (i.e. the terminal with the lowest indicated percentage of design air flow) on each sub-branch AA, AB etc. of the system? This information is necessary for deciding the optimum sequence for the regulation of terminals.

A3.2.2 Proportional balancing

(*a*) On any branch A, B or C of the system, the first task is to regulate the terminal dampers on that branch. The order in which this work is tackled will normally be decided from the initial readings described in section A3.2.1 paragraph (*d*) ensuring that the balanced part of the system remains as close to 100% design air flow as possible. To help to achieve this, the terminals on the branch with the highest indicated flow rate may be balanced first.

(*b*) The fan total volume flow rate may be adjusted from time to time during the balancing process (ensuring that the fan motor does not become overloaded) in order to maintain the balanced portion of the system within the limits suggested in the Note to section A3.1.2

Note: if a portion of the system to be balanced is below the desired percentage of design, other unbalanced sections of the system may be temporarily regulated down to increase the air flow rate to 'starved' sections of the system. However, the commissioning specialist should be alert to the possibility that a branch with a low initial flow rate may not reach the specified design performance and should report significantly low readings immediately. The designer can then define physical changes to the system or revise tolerances on air flow rates without delay.

(*c*) Assume that it has been decided to commence the system balance at sub-branch CE for the reasons given above. For the regulation of terminal dampers, the group of terminals on each sub-branch of the system will be treated independently of groups of terminals on other sub-branches. Thus on sub-branch CE, dampers on terminals 101 to 107 will be adjusted to obtain the same indicated percentage of design flow (within specified tolerances) at each of the terminals within this group. (This percentage could be, say, 120%.) On sub-branch CD, the dampers on terminals 94 to 100 will be adjusted to obtain the same indicated percentage of design flow (within specified tolerances) at each of the terminals within this group. (This percentage could be, say, 110%.) During the regulation of groups of terminals, all the sub-branch dampers (and the branch dampers) will be left untouched in the original, fully open position.

(*d*) When all the groups of terminals on the chosen branch C have been adjusted in this way, the next task is to regulate the group of sub-branch dampers CA to CE on branch C. The sub-branch dampers CA to CE will be adjusted to obtain the same indicated percentage of design flow at each sub-branch within this group. Now, for the first time, each terminal on branch C will be handling the same percentage of design flow (within specified tolerances) as every other terminal, in whatever group, on branch C.

(*e*) When the regulation of both terminal and sub-branch dampers on branch C has been completed, the branch with the second highest indicated percentage of design flow may be identified from the initial readings as, say, B and the procedure described in paragraphs (*a*), (*b*) and (*c*) repeated for this branch, and so on for all other branches. The preferred sequence is in descending order of indicated percentage of design flow, based on the initial readings.

Note: throughout this procedure, branch dampers A, B and C are normally left untouched in the fully open position.

(*f*) When the regulation of terminal and sub-branch dampers has been completed on all branches, the next task is to regulate the branch dampers A, B and C to obtain the same indicated percentage of design air flow in each branch (this could be, say, 115%). Each terminal on the entire system will now be handling the same percentage of design air flow (within specified tolerances) as every other terminal in the entire system.

(*g*) Finally, when the regulation of all branch dampers has been completed, the fan output should be adjusted to obtain the specified definitive air flow (within the required tolerance) in the main duct.

Note: the order of working suggested is usually the best one but, if necessary, a different order may be adopted provided that this basic rule is not broken: at any junction in the system (e.g. the junction of terminal with sub-branch or sub-branch with branch) no damper which regulates the air flow to any one branch of that junction should be adjusted until all dampers on any branch farther from the fan have been adjusted. For example:

(*i*) Branch damper C should not be adjusted until branch dampers A and B and sub-branch dampers CA, CB, CC, CD and CE have all been adjusted.

(*ii*) Sub-branch damper CE should not be adjusted until terminal dampers 101 to 107 and sub-branch dampers CA, CB, CC and CD have all been adjusted.

(*iii*) Terminal damper 107 should not be adjusted until terminal dampers 101 to 106 inclusive have all been adjusted.

Note: the procedure is normally broken down into a series of self-contained operations; for example, one group of terminals is balanced without relation to conditions elsewhere in a large system, perhaps on another day. This minimises the errors in regulation work due to the effect of variations in filter resistance, wind effect, stack effect etc. on system performance over a prolonged period. Furthermore, errors due to shorter term variations (e.g. an instantaneous change in fan motor voltage) are minimised by regulating the air flow at each branch or terminal to balance proportionally with the concurrent air flow at the reference terminal.

A3.3 Techniques

A3.3.1 Regulation of terminals

Assume that the initial system volume flow rate has been measured and noted, the 'initial scan' has been recorded and analysis of these readings shows no obvious reason why balancing should not commence. It has been decided, in the way described in section A3.2, that balancing will commence on sub-branch CE. Assuming that the least favoured terminal on this sub-branch is 101, the end terminal, then proceed as follows:

(*a*) Measure the indicated air flow at terminal 101, which will be used as the index terminal for this group. Express this measurement as an indicated percentage of design rate of air flow. This percentage will be used as the lower balancing limit for this group of terminals.

(*b*) With the same instrument and using the same method, measure the air flow at terminal 102 and express this also as an indicated percentage of design air flow.

(*c*) Compare the indicated percentages of design flow at terminals 101 and 102.

(*d*) If the indicated percentages of design flow at the two terminals are within the tolerances specified (see Appendix AA3.4), the dampers on these two terminals will require no adjustment.

(*e*) If the indicated percentages of design flow are outside the tolerances specified, close the damper on terminal 102 by a small amount.

(*f*) Measure the adjusted air flow at 102 and express this as an indicated percentage of design air flow.

(*g*) Return to 101 and measure the indicated air flow. Again express this as an indicated percentage of design air flow.

(*h*) Compare the indicated percentage of design air flow now handled by 101 and 102.

(*j*) If the indicated percentages of design flow at the two terminals are within the tolerances specified, the terminals are now in balance and the dampers on these two terminals will require no further adjustment.

(*k*) If the indicated percentages of design flow are still not within the tolerances specified, make a further careful adjustment of terminal 102 damper, take new readings of indicated air flow at 102 and 101 and make a further comparison.

With practice, a commissioning specialist will normally achieve a balance by a single adjustment of terminal 102 damper. The rule is to close 102 damper by the least amount necessary to bring the indicated percentage of design flow at 102 below the upper tolerance limit when compared with the reference terminal 101. By avoiding over-dampering at terminals, the increase in air flow at terminal 101 is kept small, making it easier to judge the value to which other terminals should be regulated.

(*l*) When terminal 102 has been regulated to balance with 101 (the group index terminal), balance terminal 103 against 101 in the same way.

(*m*) Terminals 104, 105, 106 and 107 should be regulated, in turn, to balance with terminal 101 until every terminal on that sub-branch CE has been regulated to balance with 101 within the specified tolerances. All terminals within this group are now in balance with each other within the tolerances specified and need no further adjustment.

Note: a change in setting of terminal damper 103 has less effect on the air flow at 101 (and 102) than a change in setting of damper 102 would have on the air flow handled by 101. Therefore, as the commissioning specialist proceeds away from group index terminal 101 towards the fan during the course of the regulation procedure, the effect that adjusting the setting of a terminal damper has on the air flow at the group index terminal 101 (and all other terminals already regulated) progressively diminishes. As successive terminals are regulated, it quickly becomes unnecessary to check air flow at the group index terminal after every adjustment.

(*n*) Where the least favoured terminal on the branch is not 101, but some intermediate terminal, close 101 damper until it is the least favoured (checking 101 against the intermediate terminal which was the least favoured), then regulate as described in paragraph (*a*) onwards, using 101 as the group index terminal.

(*o*) Regulate the terminals on each of the other sub-branches on this branch C, using the above procedure.

Note: the terminals on any one sub-branch will be treated as an independent group and will be regulated to balance with a reference terminal within the group; for example, on sub-branch CD, terminals 95 to 100 will be regulated to balance with group index terminal 94. All sub-branch and branch dampers should be left in the fully open position throughout this procedure. The group of terminals on each sub-branch is now in a state of proportional balance within the specified tolerances. The next step is to regulate the sub-branch dampers so as to bring all the sub-branches on branch C into balance with each other within the specified tolerances.

A3.3.2 Regulation of branches

The method used is similar to that for the regulation of terminals (see section A3.3.1).

(*a*) Measure the indicated air flow handled by each of the dampered sub-branches CA to CE and express this as an indicated percentage of design air flow. Wherever possible, establish this percentage by measuring the indicated air flow from the sub-branch index terminal. (This should remain the terminal on the sub-branch with the lowest indicated percentage of design flow rate, but within the specified tolerance.)

The definitive duct air flow is not normally measured, except where the type of terminal on some sub-branches differs from the type of terminal on other sub-branches. If this is the case, measurements will have to be made so that indicated rates of air flow at the differing types of terminals can be compared satisfactorily.

(*b*) Regulate the sub-branches CA to CE by applying the same procedures described in section A3.3.1 (i.e. by considering each sub-branch as a terminal grille on the branch duct C), but using the appropriate specified balancing tolerances (see Appendix AA3.4). The sub-branch CA will be used as the index sub-branch for this operation in exactly the same way that terminal 101 was used as the group index terminal for the regulation of terminals 101 to 107.

Note: throughout this procedure, the branch damper C should be left untouched in the fully open position. At the conclusion of the work, the sub-branch dampers will have been adjusted to achieve the same indicated percentage of design flow (within the required tolerances) in each of the sub-branches CA to CE.

(*c*) When the regulation of both terminal and sub-branch dampers on branch C has been completed, the next branch will be selected, which in this example is branch B. Once again, the first task is to regulate the groups of terminals on this branch as described in section A3.3.1 and, subsequently, to regulate the sub-branch dampers as described above in paragraphs (*a*) and (*b*).

This procedure will be repeated for all branches in turn, leaving the least favoured branch (in this case branch A) to the last. During this work, branch dampers A, B and C are normally left untouched in the fully open position.

(*d*) When the regulation of terminal and sub-branch dampers has been completed on all branches, the branch dampers A, B and C will be regulated to achieve the same percentage of design flow (within

the specified tolerances) at each branch. The method used will be that described for the regulation of sub-branches in paragraph (*b*) above (i.e. each branch of the system should be considered as a terminal grille on the main duct) and the procedure described in section A3.3.1 adopted.

Once again, the indicated percentage of design flow at each branch should be established, wherever possible, by measuring the indicated air flow at the index terminal. Branch A will be used as the index branch for the regulation procedure in exactly the same way that terminal 101 was used as the group index terminal for the regulation of terminals 101 and 107. During this work, any main damper or other arrangement for regulating fan performance may be adjusted to ensure that balancing is carried out at approximately the specified design air flow rates.

All terminals, on whatever branch or sub-branch, are now in a state of proportional balance within the tolerance required and it remains only to adjust the fan output to achieve the design definitive rates of flow to all parts of the system.

A3.3.3 Regulation of total rate of air flow

(*a*) Measure the definitive value of the total air flow, preferably in the main duct. Where a reliable reading cannot be obtained in the main duct, the total air flow can be established by adding together the branch rates of air flow.

(*b*) Compare the measured total air flow with the specified design requirement. If necessary, adjust the fan output until the measured value is within the specified tolerance on the design value of total air flow (see Appendix AA3.4). Record in full the results of the final measurement. At the same time, measure and record the fan motor current, the fan rotational speed, the fan suction and discharge static pressures, the resistance of any air filters and the (manual) settings of any automatic modulating dampers.

Note: with systems that contain fabric filters, or more particularly 'absolute' or high efficiency filters, the dirtiness of the filter may have a significant effect on the total rate of air flow. As the clean filter condition is the only state that can be readily identified and selected on site, measurements of total air flow should be made, wherever possible, with clean filters and the results compared with the specified design requirements.

(*c*) Where the plant contains automatically operated dampers for varying proportions of outside/exhaust/recirculation or face and by-pass air, measurement of the total air flow and regulation of the fan output should be conducted with these dampers in the full outside air, full exhaust or full face positions, provided that this mode of operation is within the design intent. The proportions and the total air flow handled at the other extreme of the damper cycles must then be investigated, recorded and, where necessary and where facilities are provided, adjusted to meet the specified design air flow (without further adjustment of the fan output).

The characteristic of the automatically operated dampers will, of course, determine what change, if any, in total air flow occurs at intermediate damper positions.

Note: wherever one air handling system is directly connected with another system (e.g. a supply system connected with an extract system via a recirculation duct with fixed or variable mixing dampers), first proportionally balance the distribution networks of both systems independently, then regulate the total air flow in both systems with the dampers set as described above. Finally, the proportions of outside/exhaust/recirculation air can be checked, adjusted and recorded with the dampers set in the minimum outside air condition, taking care not to alter previously established settings.

(*d*) When the regulation of total air flow is complete, all branches and terminals on the system will be handling the required design definitive rates of air flow, within the sum of the tolerances accumulated during the balancing procedure.

A3.3.4 Conclusion to regulation

(*a*) After a satisfactory proportional balance has been established and the correct total air volume flow rate achieved, in accordance with the tolerances specified, final system readings should be recorded in one continuous operation. The results on the record/test sheets should show velocity and indicated percentage of design flow rate.

Readings should be taken at each terminal device, preferably using one instrument.

Where there is more than one type of terminal device on the system, the appropriate factors must be applied to the readings and noted on the record/test sheet.

The terminal flow rates are not, of course, definitive rates of air flow at terminals; their purpose is merely to indicate a satisfactory proportional balance between terminals.

Note: random alterations to damper settings should not be made in an attempt to correct imbalances: any corrective action will require careful planning to minimise the amount of rebalancing needed. If any adjustments are made, then a total rescan of the final readings will be required to ensure that the recorded results are truly representative of the adjusted system balance.

(*b*) Once proportional balancing and total volume flow rates have been satisfactorily established, all dampers should be locked in their final positions and the damper regulating mechanisms scribed or indelibly marked in an approved manner.

(*c*) Finally, all adjustable louvres, cones or other air direction devices should be adjusted to create the correct air distribution patterns as predetermined and specified or advised by the designer.

The flow chart in Figure 6 summarises the main activities involved in proportional balancing.

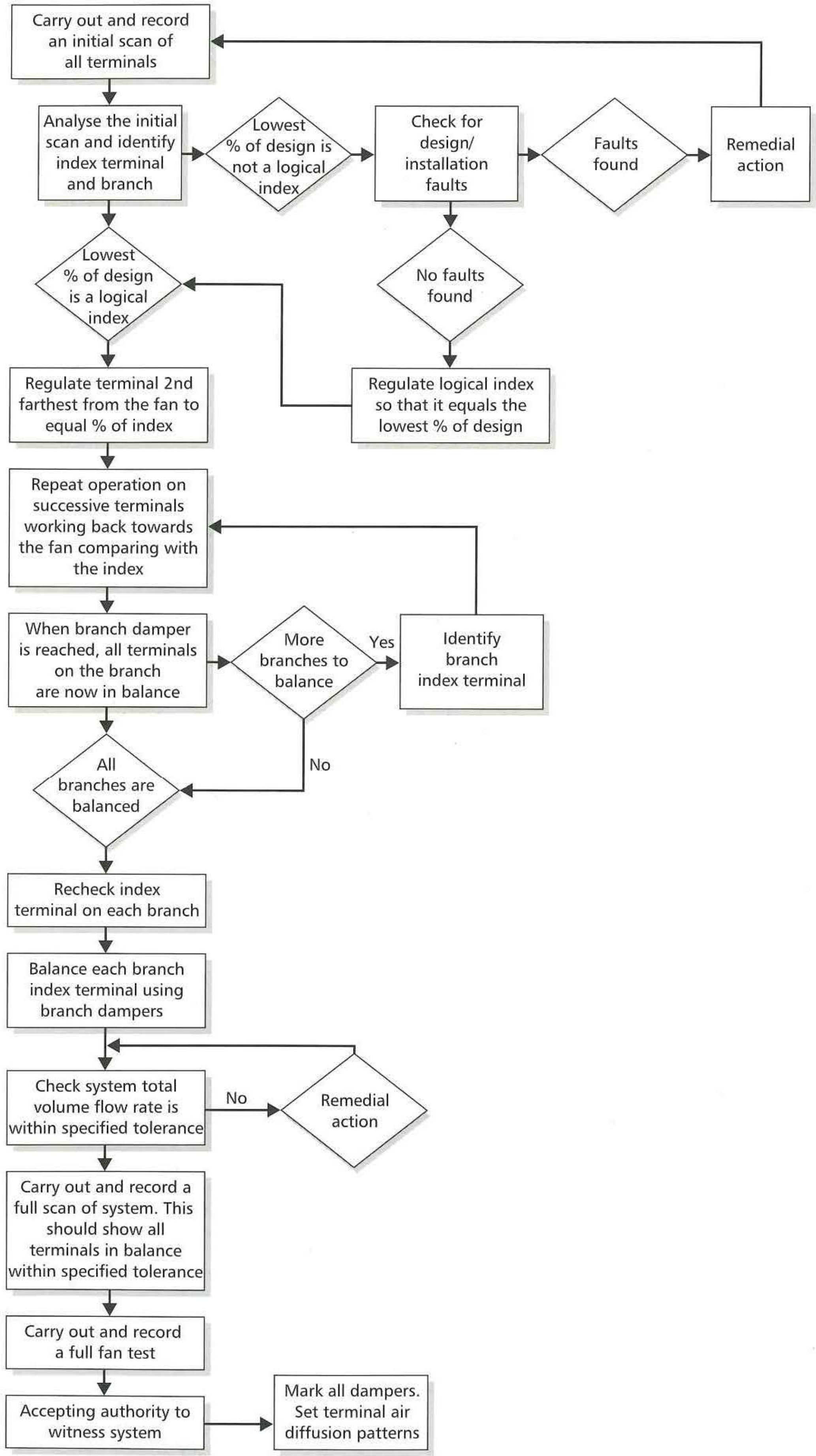

Figure 6 Flow chart for proportional balancing and testing of air systems

A3.4 Variable air volume systems

A3.4.1 Introduction

Variable air volume (VAV) systems are dynamic air distribution systems and, as their name implies, the air volume flow rate is varied according to various parameters to achieve the required design conditions. vav systems can employ many different combinations of components and control methods, and new terminal unit designs and concepts are regularly introduced. The fact that vav systems are designed to vary system performance imposes a number of specific tasks on the commissioning specialist, which must be carried out in order to achieve satisfactory overall performance.

Proprietary units may employ a variety of means of regulating air volume flow rate including motorised dampers, inflating bellows, restricting flexible duct sections or a combination of such devices.

System control actuators may be driven by duct pressure (self-powered), electronic or pneumatic means based on local control elements or a central building management system, or a combination of these.

Control sensors may measure air flow by means of pressure differential, pitot tube, flow grid or thermal anemometer using spot or averaging sensors.

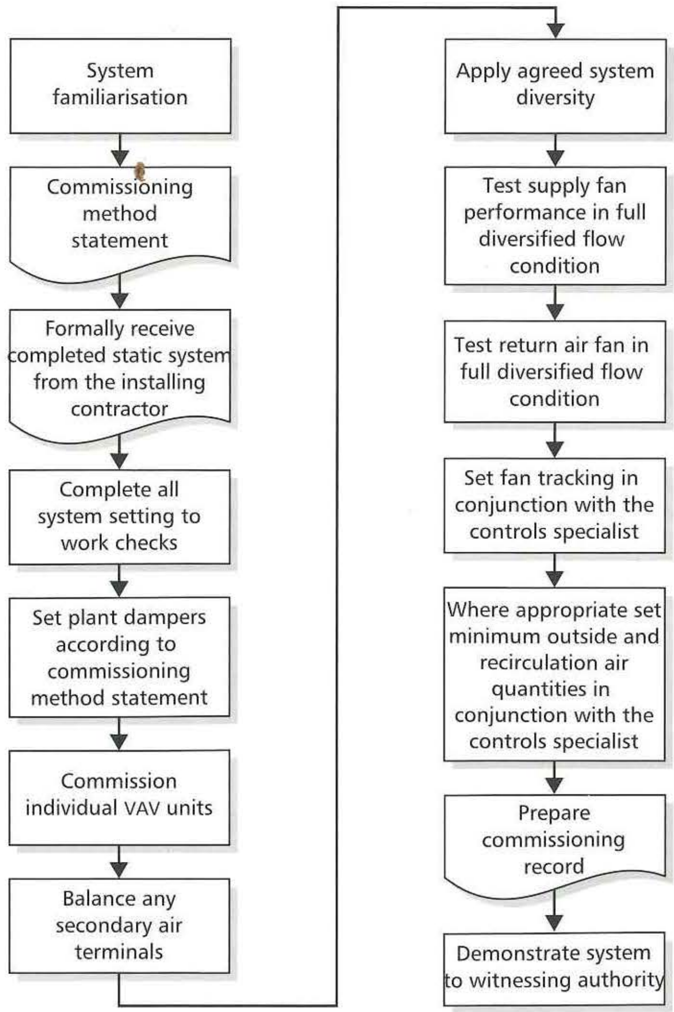

Figure 7 Flow chart for commissioning of VAV systems

Clearly, no single method of commissioning VAV systems will suit all the above options. The guidance in this section is intended to outline a suitable method of approach to be adopted by the commissioning specialist in regulating a VAV system. The guidance is not system-specific, because the detailed tasks associated with one system type may not be the same for another type. As an overall guide, the flow chart in Figure 7 illustrates the key activities involved.

A3.4.2 Commissioning method statement

Each system should be considered on its own merits and a detailed commissioning method statement produced and agreed with the designer and/or witnessing authority prior to commissioning. VAV system technology offers such a wide range of design options and proprietary components that the resulting installations are likely to require different commissioning techniques.

It is particularly important that the designer provides full information on all relevant aspects of the design of the VAV system in sufficient detail that the commissioning specialist can produce a suitable method statement.

To ensure that the appropriate commissioning procedures are employed, the commissioning specialist should carefully review the recommendations of the equipment suppliers. When optimum procedures for the particular equipment and components have been ascertained, these should be incorporated within the commissioning method statement.

A3.4.3 System components

VAV systems typically comprise the following components, some of which may require specialist commissioning by the manufacturer in addition to general commissioning as part of a complete air distribution system:

- variable performance supply fan
- variable performance extract fan
- fan performance control system
- outside/recirculation/exhaust air dampers and associated automatic controls
- supply and extract distribution ductwork systems, primary and secondary as appropriate
- variable volume terminal units, supply and extract as appropriate
- filters, heat exchangers, humidifiers etc. and associated automatic controls.

A3.4.4 Preliminary checks

(*a*) All checks required in section A1 should be carried out.

(*b*) Additional checks may be made for accessibility:

  (*i*) for easy detachment of flexible connections from terminal units

  (*ii*) to access panels in terminal units and for associated controls.

(c) A particular check should be made to ensure that distribution ductwork internals are clean throughout. (Any dust present may be entrained by the air stream. Should this settle out in the terminals it may interfere with the proper operation of these units.) If there is any doubt regarding the state of system cleanliness, the commissioning specialist should formally draw attention to this.

A3.4.5 Commissioning sequence

The particular sequence applied to a VAV installation should be appropriate to the system design and other relevant considerations. The following may be useful as a general guide:

— setting to work
— VAV terminal units
— secondary air distribution
— return air spigots
— system diversity
— fan design performance check
— system performance checks:
  (a) fan tracking (coordination of supply and extract fan performance)
  (b) minimum outside air.

A3.4.6 Setting to work

On completion of all setting to work checks (see section A2) and prior to any testing, the commissioning specialist should set or fix the outside/exhaust/recirculation air dampers in either full outside air or full recirculation positions (as detailed in the commissioning method statement).

The supply and extract fan systems should be set to their minimum speed conditions by manual operation of the automatic fan speed control or other suitable means, and started in the sequence required by the design. With the supply and extract fans operating simultaneously, the running speed should be increased gradually. Motor running current checks should be made at various increments, and the results recorded for each fan, to assess performance and prevent overloading of the motor.

The static pressure checks should preferably be made at, or close to, the position specified by the designer for the pressure sensor for automatic regulation of fan speed, and also at terminals near to the fans, to prevent overpressurisation of system components.

If excessive static pressures occur during this operation, the fan setting should be returned to minimum speed conditions using the automatic control. The fans should then be stopped and made safe so that the cause of the static pressure irregularity can be investigated and rectified by the appropriate personnel before proceeding further. It is essential to avoid overpressurisation of the system.

The running speed of the fans should be increased until there is sufficient static pressure in the system to commence commissioning of individual VAV terminal units, again carefully monitoring the pressure at terminal units near the fans. If the vav return air system consists of ducted spigots, the VAV return air fan should be run up to maximum design speed/volume while ensuring the motor running current does not exceed the motor full load current.

Note: during the commissioning of the individual vav terminals, it may be necessary to further fine-tune the fan speed to compensate for any system pressure variations.

A3.4.7 Terminal units

All procedures and techniques to be applied in checking terminal unit volume flow rates should be in accordance with the manufacturer's instructions and should be incorporated into the commissioning method statement.

Proprietary VAV units may be 'factory set' to the required specified flow rates, or provided with an easy means of setting to meet the specified performance requirements. Verification of these arrangements is necessary, and the number of VAV terminal units to be checked should be defined within the project commissioning specification.

Note: at the outset of the VAV terminal checks, the commissioning specialist should select a number of units with inlet duct configurations suitable for in-duct flow measurements to be taken. Volume flow rate checks by pitot-static duct traverse should be conducted on these terminals to validate the method of flow rate measurement adopted within the commissioning method statement, for example, measuring across terminal differential sensing grid or voltage at the controller.

Volume flow rate measurements should be carried out and the results recorded:

(a) at maximum specified volume flow rates

(b) at minimum specified volume flow rates

(c) at any intermediate settings that may be required by the specification.

A.3.4.8 Secondary air distribution

In some instances, VAV terminal units may be arranged to deliver air to a number of secondary outlets which in turn discharge the air to the conditioned space. With such an arrangement, the commissioning specialist must balance proportionally each of the secondary terminals by the methods detailed in section A3.2 so that they discharge the specified proportion of the volume of air delivered by the vav terminal, within the specified (or appropriate) tolerances as detailed in Appendix AA3.4. This exercise should be completed with the terminal unit set to maximum design volume and the details recorded.

A3.4.9 Return air spigots

Air inlets to the return air system may comprise any of the following arrangements:

(a) VAV return air terminals

(b) return air registers in the space served by ducted connections

(c) return air duct spigots drawing from a plenum (e.g. ceiling void).

For all the above arrangements, regulation of the return air inlets must be carried out to achieve a proportional balance within the specified tolerance limits (see Appendix AA3.4).

A3.4.10 System diversity

It may be necessary to impose a reduced air flow condition on a number of terminals to achieve the required design diversity. The means of arranging this will depend on the proprietary terminals and on their associated control provisions. Where necessary, guidance should be obtained from the unit supplier or manufacturer and close liaison with the designer is recommended to take account of any particular arrangements that may be required.

A3.4.11 Fan design performance check

The commissioning specialist should conduct a check on the supply and extract fan systems to ensure that they are capable of stable operation while delivering the design maximum volume flow rate, with the system diversity applied.

With the required design system diversity applied, total flow rates should be measured and recorded by pitot traverse. Ductwork branch flow rates to zones or floors should be measured and recorded. In conjunction with this, the static pressure at the least favoured unit should be monitored and the system operating pressure set to its optimum point, i.e. the lowest system operating pressure that still satisfies the least favoured unit. When this has been achieved, the static pressure should be measured and recorded at the least favoured unit and at the static pressure controller sensor position(s).

With the system in this mode, the pressure drop across each component of the air handling unit should be measured and recorded.

With the fans at their minimum specified performance settings, a further check of the static pressure at the fan control sensor position(s) should be made to ensure that this remains at the previously recorded level.

A3.4.12 System performance checks

(a) *Coordination of supply and extract fan performance (fan tracking)*

It is important to ensure that the sensors intended to provide automatic control of fan performance are so located that they offer responsive, stable and reliable regulation across the full range of fan operation.

Indicative positioning should be specified by the designer, based on the distribution ductwork system layout and the calculated system resistance characteristics.

The performance of the extract system must follow that of the supply system in a stable manner. It is, therefore, necessary to set up the fan performance controls for checking both maximum and minimum volumes, in addition to checking the equivalent performance at other intermediate points. All results should be recorded.

Note: limitations of instrument accuracy at low velocities may make it impossible to achieve repeatable measurements of fan performance at minimum volume (see BSRIA Application Guide 1/91: *Commissioning of vav systems in buildings*[(3)]).

Note: unless the fan control systems employ accurate air volume flow rate measurement, the extract system may not follow precisely the supply system performance between the two set point (pressure or velocity) extremes. Such discrepancies are normally due to the differing pressure/volume characteristics of the supply and extract systems.

The setting of the automatic control system should be finalised by the controls specialist in liaison with the commissioning specialist. The set point should provide optimum operation of the commissioned system.

(b) *Minimum outside air*

With the supply and extract fans delivering their design maximum air volumes, adjust the outside air damper until the required design volume flow rate is achieved. With the system in its fully turned down condition, the minimum outside air quantity should be checked to ensure that the correct ratio has been maintained. Note and record the position of the outside and recirculated air control dampers at this setting.

Note: where air velocities in the outside air duct militate against stable measurement, it may be possible to record total and recirculated air volume flow rates and establish the difference between these as the outside air volume flow rate.

The setting of the minimum outside air requirement should be finalised in conjunction with the controls specialist.

A3.5 Pressure regimes

A3.5.1 General

The design objective for certain mechanical ventilation systems may be to achieve a pressure differential between areas served, either for purposes of isolation or containment. In some instances, the required pressure differential may be simply notional while some applications may require a specific pressure gradient. The purposes of pressure differential may be described as:

(a) Isolation, where it is necessary to prevent ingress of possibly contaminated or unconditioned air to an area (such as an operating theatre, clean room or pressurised escape route).

(b) Containment, where it is necessary to prevent egress of contaminated air from an area. In its simplest form this applies to kitchen and toilet areas but, more importantly, to laboratories and similar areas where there may be chemical, biological or radioactive contamination.

The pressure differential between adjacent spaces may be controlled by the use of self-acting or automatic pressure stabilising devices.

A3.5.2 Preparation

A written commissioning method statement should be prepared and agreed formally by all relevant parties including the witnessing authority. The statement must take account of the detailed procedures that need to be undertaken to meet the specified acceptance criteria.

It is essential that before commencing commissioning of the system(s), all building works, doors, door undercuts, windows, floor finishes etc. are complete and in their final, normal operational state and that the commissioning specialist is given sole access to the entire area served by the system(s).

A3.5.3 Procedure

The following procedure is suggested as suitable for the commissioning of typical ventilation systems designed to produce pressure regimes within a space. The flow chart in Figure 8 illustrates the process.

(*a*) With all doors, hatches etc. between the pressurised areas open, and a suitable path for spill or make-up air provided, run either the supply or extract systems. It is advantageous to choose the system that is simplest (least terminals) or that which is expected to be the most stable.

(*b*) Carry out a proportional balance of all terminals on this system and set the total volume flow rate of the fan to the specified design requirement. Tolerances in this case should be kept to the minimum possible.

(*c*) Close all doors etc. so that the entire area served by the system(s) is in its normal operating condition.

(*d*) Running both supply and extract system fans, carry out a proportional balance of the previously unbalanced system and set the fan total flow rate to the specified design requirement, adjusting to a similar tolerance to that previously allowed in (*a*) above. Set up/commission any pressure control devices such as pressure stabilisers in accordance with the manufacturer's instructions.

(*e*) Recheck the system balance described in (*a*) and (*b*) above and, where necessary, make adjustments to reinstate the balance of the previously set total volume flow rate.

Note: Where no adjustments are found necessary, proceed to (*f*) below. Where adjustments have been made, the system set up as described in (*b*) above must also be rechecked.

(*f*) This procedure should be repeated until there is no necessity to make further adjustments to the system.

(*g*) Measure and record the pressure differentials between all adjacent spaces using a suitable instrument and compare the measurements with the specified design requirements.

At this stage the results obtained should be submitted to the designer or accepting authority.

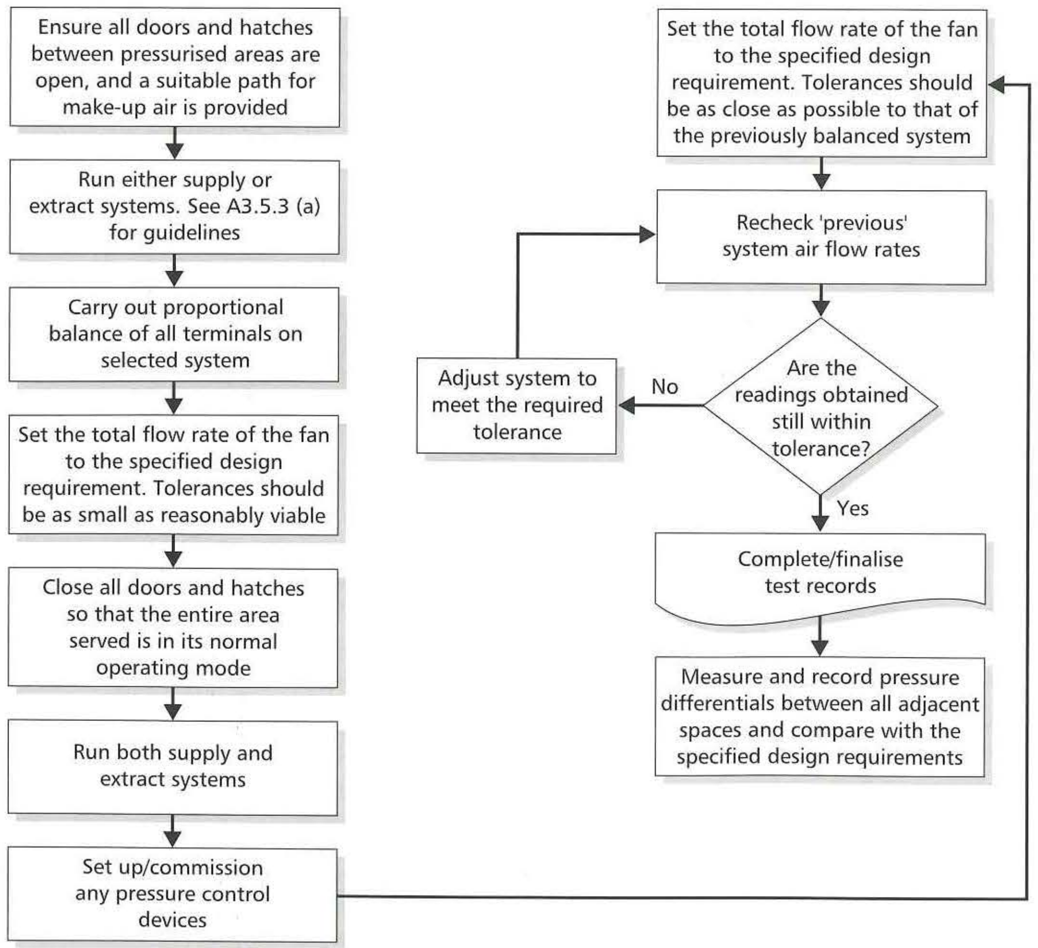

Figure 8 Flow chart for commissioning of typical ventilation systems designed to produce pressure regimes within a space

It should be recognised that a system can be proportionally balanced in accordance with the tolerances and procedures described in section A3.2 but still require further adjustment to establish the specified pressure regimes.

If the results obtained do not indicate a correct or acceptable pressure regime, the designer may need to plan remedial attention to the ventilation systems or building fabric. This may consist of revisions to the design air flow rates or alterations to the building components or fabric to modify air leakage paths.

Once acceptable conditions are obtained, it is imperative to record final balance figures including air volume flow rates and pressure differentials. These should also be verified by the accepting authority.

A4 Commissioning documentation

A4.1 Content

Documentation should be prepared recording all the salient details of the installed air distribution systems that have been subjected to the commissioning procedures set out in the specification and/or described in any method statement.

All commissioning documentation, including method statements, should be collated for retention and future reference by interested parties.

Commissioning documentation should be logical and unambiguous and should provide space for relevant comments by the commissioning specialist.

A4.2 Format

It is not the objective of this Code to set out the format and typographical style of such commissioning documentation, but the general intent of such records should be to provide clear identification of each main component by means of its:

- design description
- plant reference number
- location
- manufacturer
- type
- serial number
- design performance parameters
- actual performance parameters.

Any particular requirements as to the presentation of commissioning records, including the number of copies required, should be stated in the specification. All such proforma documentation should be completed neatly by hand (or by the use of an on-site laptop computer) by the commissioning specialist at the time of carrying out the tests and should, preferably, not be retyped subsequently. (Any transcription of these records, including typed presentation, would introduce scope for error and could detract from their significance.)

The format of the test record sheets to be used should be agreed in advance of commissioning with the designer and witnessing authority.

A5 Witnessing

A5.1 Introduction

For most projects, the specification requires the commissioning results to be approved as a condition of system acceptance. The most common form of acceptance procedure is to undergo a process of witnessing as a means of ensuring that the air distribution systems have been commissioned to meet the specified requirements.

Witnessing is defined as the repetition of specific commissioning results in the presence of the witnessing authority such that the witnessing authority can observe, confirm and countersign the results.

This section of the Code outlines recommendations concerning witnessing generally.

A5.2 Objective

The objective of the witnessing stage is to enable the witnessing authority (typically, the building services consulting engineer or an agent acting on behalf of the engineer) to establish a level of confidence in the commissioning results being presented. Unless the designer has specifically called for all commissioning aspects to be witnessed, an assessment of a proportion of results should satisfy this requirement.

The specification should define any aspects or parameters requiring special attention.

Witnessing duties should include verification that the recorded commissioning results are:

- repeatable
- within the specified tolerances
- in accordance with the overall design requirements.

A5.3 Selection of the witnessing authority

The witnessing authority should be conversant with the requirements of the air distribution system under consideration, this Code and, where appropriate, any relevant statutory requirements. The witnessing authority should also be experienced in commissioning procedures generally.

The witnessing authority should be provided with formal terms of reference for the role, together with clearly stated responsibilities and reporting procedures. The extent of the witnessing authority's role should be made clear to the commissioning specialist and other relevant parties.

The witnessing authority should be able to make a considered comparison between the measured performance and the design requirements and associated tolerances, and to arrive at an assessment of their acceptability.

A5.4 Programme

The witnessing of air distribution systems commissioning will require a specific amount of time to be allocated within the overall construction programme. Liaison should take place with the other relevant parties involved in the construction process such that the implications of commissioning in general, and the commissioning and demonstration stage in particular, can be properly coordinated into the overall project programme.

A5.5 General

To ensure that all parties understand the requirements, the overall extent and scope of witnessing should be set out at the design stage.

Scope for subjective judgement should be minimised because this can lead to disputes. The principles and bases for any allowable deviations from specified tolerances or standard methods of testing should be established and agreed in advance of witnessing.

The witnessing authority should be available to discuss and establish an understanding of any problems that arise during the course of commissioning. The following factors will, typically, have a bearing on the scope of commissioning works:

— the extent and complexity of the air distribution system

— the requirements of the specification

— the project timescales.

Where it is necessary to superimpose artificial conditions on installed plant in order to 'demonstrate' the design level of performance, the practical on-site implications of this should be given careful consideration by the relevant parties. This is particularly important in the case of dynamic systems such as vav systems.

A5.6 Witnessing arrangements

It is recommended that, prior to proceeding to witnessing, the witnessing authority should arrange a meeting with the commissioning specialist. The purpose of the meeting should be to provide an opportunity for the commissioning specialist to summarise and explain his/her experience with the work on the system and to highlight points considered to be noteworthy. Similarly, the witnessing authority has an opportunity to explain objectives and to agree with the commissioning specialist the optimum strategy for achieving these. The meeting should include a joint tour of inspection of the system and its associated plant and equipment.

When presenting a commissioned system for witnessing, the commissioning specialist should aim to replicate the conditions under which air balancing was carried out. Thus, results recorded during the commissioning process can be repeated and demonstrated to the witnessing authority without undue influence from other factors that could jeopardise the outcome.

When carrying out spot checks on recorded data, the witnessing authority should recognise that, because of prevailing conditions, identical results are unlikely to be achieved. It would be prudent therefore to expect a deviation (of, say, ±5%), provided that this does not increase the tolerances specified or suggested in Table A1 (see Appendix AA3.4).

To permit a full assessment of implications on system design performance, records of the witnessed results should be copied to the designer.

A5.7 Air distribution system acceptance

Appropriate documentation should be provided by the commissioning specialist for the witnessing authority to countersign to confirm details of the tests observed and that the results are within the specified tolerances. When the documentation is completed, the system can be deemed to be commissioned in accordance with the recommendations of this Code.

It should be recognised that such certification is usually only part of the overall project acceptance procedures and, therefore, may not necessarily result in the completion of commissioning. However, the objective of the air distribution system acceptance should be to bring to a conclusion the activities detailed in this Code.

The 'accepted' air handling plant should be left in an agreed state of operation and control, with defined responsibility for its operation.

Note: air distribution system acceptance infers only the satisfactory completion of commissioning in accordance with this Code. It should not be confused with handover which may have other implications outside the scope of commissioning.

Appendices

AA1 Design implications

AA1.1 Introduction

Commissioning is not an optional process and the designer must accept the implications of the commissioning procedures to which the air distribution system will be subjected. In particular, inadequate commissioning of an air distribution system could result in poor environmental performance, energy wastage, draughts and noise.

The notes that follow are given as general guidance to the design implications of the procedures described in this Code. They are intended to serve to remind designers of the pertinent points of design that have a direct bearing on the commissionability of air distribution systems. The guidance in this appendix is intended to supplement the design information provided in other CIBSE related publications (to which the designer should make reference). It is not intended to be a design guide and, therefore, does not reproduce or summarise design procedures contained in such guides.

AA1.2 Design requirement

Commissioning in general, and the regulation of air flow rates in particular, will be considerably influenced by the facilities afforded by the design. In the context of this Code, the designer's objective must be to design an air distribution system where the arrangement of ductwork and the selection and disposition of components within airways, particularly the means of air flow regulation, will promote a stable and balanced air flow. Following the guidance given in this appendix will help to ensure that the design incorporates the necessary provisions for access and other factors that affect commissionability, including the location of test points.

To ensure that the design aspects are properly and effectively communicated to other parties involved in the construction process, it is recommended that an unequivocal specification be prepared to describe the works. Early discussions with commissioning specialists may prove to be helpful to the designer in optimising the practical aspects of testing and balancing.

AA1.3 Design information

AA1.3.1 General

The production of the information identified in this appendix may become the responsibility of various parties involved in the design and construction process. It is not the task of this Code to assign such responsibilities, but to point out that the overall objective should be to ensure that the information is properly communicated to the commissioning specialist. Failure to provide the commissioning specialist with complete information will seriously limit the effectiveness with which the various tasks associated with commissioning as prescribed by this Code can be carried out.

AA1.3.2 Schematic drawings

A properly prepared and detailed schematic drawing or 'functional diagram' is an extremely useful method for passing the designer's intent to the commissioning specialist.

Such a drawing should show the general disposition and sizes of the distribution ductwork, including the positions of:

— test points

— branch dampers

— fire dampers

— fans

— louvres

— control sensors

— grilles (together with details)

— heater/cooler batteries

— filters

— terminal units

— energy recovery devices.

Design flow rates (including any special tolerances) and pressure drops should be recorded on the drawing, ideally at the positions of selected test points.

Such a drawing should enable the commissioning specialist to visualise the system and gain a broad understanding of the commissioning requirements at a glance.

AA1.3.3 System description

A clear, specific and concise description of the system, including all operational modes and the overall control philosophy, should be part of the package of information provided to the commissioning specialist.

AA1.3.4 Layout drawings

Layout drawings are primarily intended to show how the air distribution system is to be fitted into the structure and, as such, have a different purpose from the schematic drawing, which serves mainly to locate components within the air distribution system. Many layout drawings are normally needed to show how the installation is to be achieved, whereas the aim of a schematic drawing is to show the complete system on as few drawings as possible (ideally on one).

AA1.3.5 System specification

A specification should be provided detailing materials, construction methods, controls, site erection and commissioning requirements. The specification should identify any specific commissioning and testing activities that may be required.

It is essential that all airways have a high degree of air tightness. For high velocity ductwork systems, recognised air leakage tests should be specified.

AA1.4 Design development considerations

AA1.4.1 General

It is particularly important that the designer gives careful consideration, during design development, to the many factors that can have a significant effect on the commissionability of an air distribution system. Reference to the following factors should assist the designer in ensuring that the commissioning process is not adversely affected by design team decisions.

AA1.4.2 Accessibility

When positioning plant within a structure, sufficient access should be provided to enable the commissioning specialist and, ultimately, maintenance operatives to carry out their duties safely. For example, the configuration of ductwork should be such that a pitot tube can be inserted, which typically requires clearances of at least 1.5 times the duct diameter/width.

The ductwork should include access panels where items such as dampers, sensors etc. are located so that these items can be inspected and, where necessary, set up during the commissioning process. The access panels should be of a size that allows safe and effective inspections to be carried out.

AA1.4.3 System flow rates

Consideration should be given to the method of ductwork sizing. Typical methods are based on velocity or pressure drop, but whichever method is used, the designer should ensure that the resulting velocities at specified test points or control sensor locations are readily measurable and as stable and uniform as possible. Ductwork configurations that give rise to excessive air turbulence should be avoided.

AA1.4.4 Test point positions

The position of test points and how the necessary measurements are to be taken at such locations need to be considered. Locations for test points should be selected where there is sufficient straight ductwork upstream to ensure stable and uniform air flow. See BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*(1).

AA1.4.5 VAV systems

Operating principles of VAV systems are necessarily more complex and, therefore, merit more careful explanation by the designer.

As part of the design basis for VAV systems, the designer should determine a VAV diversity ratio (see section A0.2).

Consideration should be given by the designer as to how the diversity is to be imposed on the system during commissioning. All such information should be included in the package of information provided to the commissioning specialist.

AA1.4.6 Grilles and diffusers (terminals)

Where the design incorporates terminals, such as slot diffusers, that do not lend themselves to the process of air volume flow rate measurement, the designer should consider carefully how final terminal air velocity measurements can be made. An assessment should be made of the impact that factors such as the accuracy of these measurements may have on the system performance and how this might affect design requirements. The designer should also address how air distribution patterns within the conditioned space will be set up and, if necessary, measured and/or visualised to ensure they meet the design concept.

Note: ensuring that all terminals on any one branch are of the same type will simplify proportional air balancing.

AA1.4.7 Controlled space pressures

The specific requirements for pressure differentials between various parts of a building (e.g. between sterile and non-sterile facilities) need to be considered, including how the pressure differentials are to be set up, measured and demonstrated. This will invariably require an analysis of the performance of building fabric elements such as doors and windows.

Pressure regimes are often difficult to set up because they involve many factors, some of which may be outside the direct control of the commissioning specialist. Consequently, there is an even greater requirement for effective communication between the various parties involved. Detailed, agreed commissioning method statements are essential.

Where it is the designer's intent to pressurise one section of the building with respect to another, the required area-to-area pressure differentials should be clearly defined in both the design and acceptance criteria for the associated ventilation systems.

AA1.4.8 Specialised products and fitments

The location in the air distribution system of specialised items (e.g. energy recovery devices) and their effect on system pressure and flow rate should be considered. (Provision for measurement of flow and pressure across such equipment is necessary for the effective trouble-shooting of performance problems, either during commissioning or in later operational stages.) Access to such equipment requires special consideration to enable operatives to perform trouble shooting and measurement tasks safely.

Proprietary self-regulating devices and commissioning (measuring) aids, e.g. constant volume dampers, flow grids and orifices, will provide their full performance potential only if installed in strict accordance with manufacturer's information. Any limitations specified by the manufacturer must be taken into account by both designer and installer if such devices are to be used successfully.

AA1.4.9 Specialised testing methods

Specialised testing procedures can range from the simple to the very elaborate, with a consequent effect on the overall commissioning process. Should the designer require any specialised testing to be carried out, requirements should be clearly identified in the specification, along with the objectives of the tests and how they are to be performed

Smoke visualisation techniques, for example, can be helpful during the final setting up of a system to ensure that the desired air flow patterns are achieved.

AA1.4.10 Avoidance of draughts

It is important that air distribution to occupied spaces is achieved without causing draughts, particularly where people are likely to be sedentary. Draughts from air distribution systems can be a source of nuisance to a building's occupants and the choice of terminal outlet, and how it is to be commissioned, should be considered at an early stage and clearly specified.

Note: airflow impingement on occupants may be desirable where metabolic activity rates are high.

AA1.4.11 Avoidance of noise

Design consideration should be given to ensure that plant noise is minimised and that the system can be correctly set up by the commissioning specialist without the introduction of regenerated noise.

AA1.4.12 Manufacturer's information

Manufacturer's information should be made available to the commissioning specialist at the outset of the work.

Where a particular product is specified, it is important to ensure that the means are provided to enable the commissioning specialist to commission it as part of the whole system, either directly or in conjunction with the manufacturer's commissioning personnel.

AA1.4.13 Witnessing

Careful consideration should be given to the scope of the witnessing requirements. Such factors might include the nomination of the witnessing authority and specification of witnessing procedures and reporting arrangements. The requirement for commissioning management should also be addressed.

AA2 Installation

AA2.1 Introduction

Installers must accept that commissioning is not an optional process and should, therefore, pay particular attention to the installation of facilities that affect the commissionability of a system.

The recommendations that follow are given as general guidance to assist in the achievement of a satisfactory installation, such that the recommendations of this Code can be properly implemented by the commissioning specialist.

Such guidance is intended to supplement the installation information provided in CIBSE and other similar guidance.

AA2.2 Requirements

The installer should have a thorough understanding of the specified commissioning requirements prior to commencing installation, including the implications of the programme, ease of access and facilities to be provided.

The installation objective is to interpret the design requirements correctly and so bring the system to static completion. Installation includes any cleaning and leakage testing of the distribution ductwork in accordance with the specification, prior to the commissioning process being implemented.

When preparing working drawings and physically positioning plant and ductwork within a structure, sufficient access should be provided to enable the commissioning staff and, ultimately, the maintenance operatives to go safely about the tasks of measurement, regulation and servicing. This entails particular considerations, such as the provision of suitable access for pitot traverses for air flow rate measurements. (Note that, typically, a clearance of 1.5 times the duct width/diameter is required to insert a pitot tube into a duct.)

Early consultation with the commissioning specialist is helpful.

AA2.3 Cleanliness

During the installation of air distribution systems it is of prime importance to prevent the ingress of general building debris. The installing contractor should promote a 'good housekeeping' initiative to protect open-ended ducts, terminal devices and air handling units from contamination. Ductwork risers should be capped to prevent use as rubbish chutes.

Terminal devices such as constant and variable volume regulators should be disconnected from the distribution system until such time as the main ductwork has been cleaned, inspected and tested.

In some instances, decontamination (disinfection) procedures may need to be implemented. Where this requirement applies, facilities should be provided for the work to be carried out.

AA2.4 Inspections

Commissioning does not include the detailed inspection of ductwork systems for defects and deficiencies. Regular inspections by the relevant authority should take place during, and at completion of, the installation of all systems to ensure readiness for commissioning to commence (see section A0.5). These inspections should ensure that ducts, dampers, terminal devices, hangers, flexible connections etc. are installed in accordance with the project specification and the manufacturer's recommendations.

Particular attention should be paid to the order, aspect and direction of air flow through air system components, as well as to the general cleanliness of the installation.

All main, branch and terminal unit dampers should be inspected for free operation and be left in the fully open position in preparation for the commissioning process.

AA2.5 Ductwork leakage testing

It is essential that all airways have an appropriate degree of air tightness.

Where required by the specification, ductwork leakage testing should be carried out in accordance with DW142 *Specification for sheet metal ductwork: Low, medium and high pressure/velocity air systems*[4] or other related standards, as specified. (See also DW143: *A practical guide to ductwork leakage testing*[5].)

Ductwork leakage testing is normally carried out during installation with remedial action undertaken, where necessary, by the installer prior to the commencement of commissioning. The test results should be properly documented and the records included with the commissioning information.

All leakage testing should be carried out prior to the installation of false ceilings, cladding of risers or application of thermal insulation. Precise records must be kept of the location of temporary blanking plates, which must be removed immediately on successful demonstration of system integrity for the section under test.

Where systems are not subject to a recognised leakage test, meticulous ongoing visual inspections should be carried out during installation to ensure that jointing arrangements are satisfactory.

AA2.6 Static completion certification

The installer should carry out a formal inspection procedure so that the static completion of each system or group of systems can be established and certified. Any commencement of commissioning prior to the static completion of a system is likely to be abortive and to result in cost penalties for both the installer and the commissioning specialist.

The installer should provide the commissioning specialist with copies of all relevant documentation verifying the static completion of each system prior to commencement of the commissioning process. This should include certification of air leakage test acceptances where appropriate.

AA3 Measurement of air flow and calibration of instrumentation

AA3.1 Equipment, instruments and measuring techniques for typical applications

The BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[1] provides details of equipment, instrumentation and procedures for optional on-site flow measuring techniques for a range of air flow applications.

The options offered are well proven techniques which, in general, are universally acceptable for the particular application. The commissioning specialist should select the appropriate option from the range of techniques available, ensuring that this satisfies the specification or meets the approval of the witnessing authority.

AA3.2 Instrument calibration

The commissioning specialist should ensure that all instrumentation to be used on a project meets the calibration requirements of the specification. In the event of any doubt, the commissioning specialist should prepare a detailed schedule of the instrumentation proposed for use and seek formal approval of this.

Instrument calibration is an expensive process and it is therefore desirable to ensure that calibration requirements are appropriate to the application.

AA3.3 Comparison of two or more methods of measurement

Where an air distribution system incorporates differing sizes or types of terminals which dictate different methods of measurement, the following procedure should be adopted to compare the indicated rates of air flow at terminals.

Choose one terminal of each type that is preceded by sufficient straight ductwork of a uniform size to enable a satisfactory measurement of air flow to that outlet alone to be made. For each of the chosen terminals, the indicated rate of air flow is measured first at the terminal in the manner appropriate to its type and then within the duct connection to the outlet by means of a pitot-static tube and manometer. In both cases, the methods described in the BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[1] should be used. Corrections for air density will not normally be necessary in this instance.

The ratio of indicated values of rate of air flow thus obtained is the factor relating the measurement at the terminal to its 'equivalent pitot' measurement at that rate of flow. The rate of air flow at the terminal should then be altered and the operation repeated to obtain the factors relating terminal and 'equivalent pitot' measurements over a range of rates of air flow appropriate to the particular system concerned. For convenience, the measured data may be plotted in graphical form to provide ready reference to 'equivalent pitot' flow rates within the range of the comparative measurements made.

This done, any measurement at terminals of indicated rates of air flow can be expressed in terms of their 'equivalent pitot' values by applying the factors already established. Once expressed in this common equivalent value form, the readings obtained at different types of outlet by different methods of measurement can be compared.

AA3.4 Tolerances for regulation of air flow

During the regulation of a group of terminals or branches (see sections A3.3.1 and A3.3.2), the adjustment of dampers to obtain identical indicated percentages of design air flow for all outlets or branches within the group is both unnecessary and impractical. Nor is it necessary or practical during the regulation of total air flow (see section A3.3.3) to make adjustments to obtain a definitive value of total air flow which is precisely the design total air flow. In all cases, realistic tolerances must be defined which, while satisfying the ultimate design requirements, provide targets that can be attained with reasonable economy during the regulation procedure. Suitable tolerances that may be considered good practice for general use on most air distribution systems are suggested in Table A1. The tolerances for a particular system may vary from those suggested, depending on the layout and prevailing requirements.

The responsibility for defining the tolerances rests with the designer of the system, who should recognise that unnecessarily close tolerances, if attainable at all in practice, will add significantly to the cost of commissioning the system.

The commissioning specialist should report to the designer at the earliest opportunity any difficulty in meeting the specified tolerances, so that a decision may be taken as to whether to widen the tolerances or to modify the system.

It must be noted that the tolerances detailed in Table A1 are based on repeatable, reproducible air flow measurements. Any error inherent in the instrumentation or resulting from the technique or operator are excluded. An indication of the likely magnitude of such errors may be estimated from the details given in BSRIA Application Guide 3/89.1: *The commissioning of air systems in buildings*[1] and from the data provided by the instrument manufacturer. It must be borne in mind that the various elements of possible error may or may not be cumulative.

Note: the tolerances given in Table A1 for terminals or branches are suggested as the allowable increase over the lowest measured indicated percentage: that is, if the lowest terminal on a low performance effect system indicates 80% of design, then the highest terminal should be no more than $80+(80 \times 20\%) = 96$. Tolerances given for total flow rate are suggested allowable deviations from definitive design volume flow rate.

Where the supply total air flow rate tends toward the limit, i.e. 100% or 110%, the associated extract total air flow rate should be regulated toward the same limit. Tolerances shown for terminal balance are those accumulated during terminal and sub-branch regulation.

Table A1 Cumulative tolerance limits for regulation of air flow

Type of system	Performance effect	Terminals	Branches	Total airflow
Mechanical ventilation Comfort cooling	Low	+20% of lowest terminal	+10% of lowest branch	+10% −5%
Air conditioning Pressurisation of escape routes	Medium	+15% of lowest terminal	+8% of lowest branch	+10% −0%
Close control air conditioning	High	+10% of lowest terminal	+5% of lowest branch	+5% −0%

Where a separate branch balance is not carried out and the total system terminals are scanned in one continuous operation, the permissible tolerance for the terminal balance would normally be the sum of the figures shown in Table A1 for terminal and branch balance.

AA4 Health and safety arrangements

AA4.1 Introduction

Although the health and safety arrangements summarised below do not form part of the commissioning procedures prescribed in this Code they are important, fundamental requirements that should be borne in mind by the commissioning specialist. For full details of the requirements, reference should be made to the appropriate Approved Codes of Practice published by the Health and Safety Commission, and to the CIBSE Technical Memoranda TM20: *Health, safety and welfare in the built environment*[6].

With the advent of *The Construction (Design and Management) Regulations 1994*, much of what was previously good practice in health and safety has now become a formal, statutory requirement.

AA4.2 Contractor's duties

All contractors on a construction project, including subcontractors and any specialists engaged by them (e.g. the commissioning specialist), must be able to satisfy the person appointing them that they are competent to carry out or manage the work for which they are responsible. This competence would include all health and safety aspects. To meet this general requirement it may be construed that all contractors should have a health and safety policy, together with management procedures for health and safety, covering all aspects of their work sector package. All contractors must also be able to demonstrate their procedures to develop and implement the project health and safety plan. This plan may either be that prepared by the project design team, or the base plan as already developed by the main (principal) contractor.

The contractor must also be able to demonstrate the approaches to be adopted to deal with any high risk areas of the work and the arrangements for monitoring the work to ensure compliance with health and safety legislation. Personnel employed by the contractor to carry out or manage the work must have the requisite skills and training and be allocated time to complete their work without risks to health and safety.

The preparations that a contractor is required to make include formal risk assessments of the work to be planned or carried out under their contractual responsibility. Where the work entailed is generic or typical (e.g. working at heights) these assessments may form part of the contractor's standard documentation. The principles for carrying out risk assessments as detailed in *The Management of Health and Safety at Work Regulations 1992. Approved code of practice*[7] form a useful basis, but it should be borne in mind that a construction site environment is likely to be more hazardous than established workplaces.

In addition to the requirements outlined above, which are generally of a preparatory nature, the contractor when on site is required to:

(*a*) cooperate with and comply with the directions of the main contractor

(*b*) comply with the project health and safety plan

(*c*) provide the main contractor with any information that might affect health and safety and notify the main contractor of any accident

(*d*) ensure that all employees are aware of the name of the main contractor and the project planning supervisor and of all relevant content of the project Health and Safety Plan.

References

1 Parslow, C J *The commissioning of air systems in buildings* Application Guide **3/89.1** (Bracknell: Building Services Research and Information Association) (1992)

2 Harrison E and Gibbard N Balancing air flow in ventilating duct systems *JIHVE* **33** p 201 (1965)

3 *Commissioning of VAV systems in buildings* Application Guide **1/91** (Bracknell: Building Services Research and Information Association) (1991)

4 *DW142 Specification for sheet metal ductwork: Low, medium and high pressure/velocity air systems* (Penrith: Heating and Ventilating Contractors' Association) (1982, amended 1988)

5 *DW143 A practical guide to ductwork leakage testing* (Penrith: Heating and Ventilating Contractors' Association) (1994)

6 *Health, safety and welfare in the built environment* CIBSE Technical Memoranda **TM20** (London: Chartered Institution of Building Services Engineers) (1993)

7 *Management of Health and Safety at Work Regulations 1992. Approved code of practice* HSE Legal Series **L21** (Sudbury: Health and Safety Executive) (1992)

Index

The Chartered Institution of Building Services Engineers
222 Balham High Road, London SW12 9BS
[redacted]