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Course aims and objectives

Introduction

The course material is designed to meet the requirements of the manufacturers for the installation, inspection, testing, commissioning and provision of information for fixed Domestic Ventilation Systems for both new and existing buildings currently available in the UK.

Whilst this document has been designed specifically to address Approved Document F, Volume 1. for England and Approved Document F, Volume 1. for Wales, the guidance given is equally applicable to Scotland.

The installation, inspection, testing, commissioning and provision of information for Domestic Ventilation Systems is work that can be carried out by competent plumbing, heating or electrical engineers, and the aim of the training course is to ensure individuals have the knowledge and skills required to undertake this specialist work. Work on ventilation systems in dwellings is covered by the Building Regulations and is notifiable to a building control body.

This training material will serve both as a means of learning, as well as a tool of reference for future use.

Training course objectives

The objectives of this training course are to enable delegates to:

Install any of the common types of Domestic Ventilation Systems in the UK in a safe and workmanlike manner

Inspect and test any of the common types of Domestic Ventilation Systems in the UK

Commission and provide information for any of the common types of Domestic Ventilation Systems in the UK

It should be noted that the syllabus covers the majority of existing types of Domestic Ventilation Systems that an installer in the UK is likely to come across. The course emphasises the most common systems of configurations that most trades-people are likely to encounter. Less common systems will be covered, but to a lesser extent.

We highly recommend that this training material is used in conjunction with the Building Regulations for England and Wales, and the Technical Handbook for Scotland in addition to Chapter 8.3 of the NHBC Standards and also BSRIA Guide BG 46/2013 – A guide to measuring airflow rates.

Due to time constraints, the syllabus does not aim to cover material that should already be known to plumbing, heating and electrical engineers. Repetition of existing knowledge is only likely to occur in areas which are regarded as critical, including legal and safety issues.

Target market

The training/assessment course is targeting candidates looking to widen their skills set by adding this specialist trade. The following background is essential:

- Candidates with a number of years' experience in plumbing, heating or electrical engineering
- Candidates who hold a formal qualification at NVQ Level 3 in plumbing, heating or electrical engineering
- Candidates who are currently undertaking a course in plumbing, heating or electrical engineering, which will lead to a formal qualification such as NVQ Level 3 in plumbing, heating or electrical engineering

How to use this training manual

BPEC Services Ltd recommends that you use this training manual as a pre-course study pack to prepare you for training and assessment at a BPEC approved training and assessment centre.

The training manual allows you to study the material in your own time, at your own pace, to reduce the time spent on the training course to a minimum. It is important that you study the content of the manual prior to attending the course to ensure that you are properly prepared and can take part in discussions during the course.

Most modules contain self-assessment questions, which enable you to check your progress as you work your way through the manual. You are strongly encouraged to attempt each question and you should only progress from one module to the next once you feel comfortable with its content. Please make note of any areas where you feel uncertain, so these can be raised with the tutor during the training/assessment course.

Course training and assessment

The training and assessment course will run over 2 days, and will include both theoretical training as well as practical exercises.

At the end of the course, there is a multiple choice assessment that each individual candidate needs to pass. The assessment is closed book.

Module 1

Domestic ventilation in context

Module objectives

The aim of this module is for you to appreciate the advantages and disadvantages of each type of domestic ventilation system and their relationship to the Building Regulations.

On completion of this module you should be able to:

- Understand the requirement to ventilate effectively
- Understand the principles of ventilation
- Appreciate energy efficiency in its relationship to ventilation
- Identify the main types of domestic ventilation system
- Identify the advantages and disadvantages of different domestic ventilation systems

Introduction

All dwellings need a supply of fresh outdoor air, not just for the health and comfort of the occupants, but also to control condensation, displace pollutants and to ensure the safe and efficient operation of open-flue appliances. The amount of fresh outdoor air should match the needs of individual dwellings and the people living within it.

To achieve an energy-efficient standard of ventilation requires consideration of both the building fabric and the efficiency of the ventilation system. Nowadays, for designs of new or existing buildings under consideration, ventilation should be thought of as part of an integrated design approach for achieving energy efficiency.

Traditionally, many UK dwellings have relied on natural air infiltration to provide ventilation.

This can result in excessive ventilation rates that greatly increase energy consumption for space heating, and cause discomfort to occupants from cold draughts.

Energy loss from ventilation can account for a fifth or more of space-heating energy demand in older poorly insulated dwellings.

In new energy-efficient houses with high levels of fabric insulation and air tightness, the proportion of space-heating demand due to ventilation increases to around a third. As air tightness increases, natural air infiltration alone can result in very low levels of ventilation. This leads to poor indoor air quality and other, more readily visible impacts such as condensation damage and mould growth on indoor surfaces.

Why ventilate?

Indoor air quality

Ventilation is necessary to provide a healthy and comfortable internal environment for a dwelling's occupants. The main task of ventilation is to remove polluted indoor air from a building and replace it with fresh outdoor air.

There are many different types and sources of pollution within the home, for example:

- Moisture e.g. from washing, cooking. On average, per day, each household member will add around 5 litres of moisture into the indoor air
- Carbon monoxide (CO) and oxides of nitrogen e.g. from combustion appliances, smoking
- Volatile Organic Compounds (VOCs) e.g. from aerosols, air fresheners and formaldehyde found in MDF, new furniture and carpets
- Allergens e.g. from house dust mites. It is mainly the waste product from house dust mites that trigger asthmatic reactions in sufferers.
- Odours e.g. from cooking, body odour, pets
- CO2 e.g. from humans, pets and also combustion appliances
- Environmental Tobacco Smoke (ETS)

Note: Ventilation is not seen as an adequate means to protect the health of non-smokers in the vicinity of tobacco smoke, because environmental tobacco smoke is a carcinogen and there is no known safe level. Concentrations of benzene, toluene and airborne particulate matter (PM10) can all be expected to be significantly higher than is considered safe in smokers' homes.

Moisture is probably the most significant of household pollutants because of the high rates generated by activities such as cooking and bathing (particularly showering), and because of the associated problems of condensation and mould growth.

Research has shown that if relative humidity levels exceed 70% for prolonged periods, there is a high probability that mould growth will occur on any surface. Also, it is generally accepted that both house dust mites and black mould thrive at higher humidity levels (>70%RH).

Interstitial condensation is another effect of high levels of humidity. This occurs within dwellings where warm humid air is allowed to permeate through gaps and cracks in the building fabric. The warm moist air cools and condenses as it passes through the building fabric, which may result in rotting of timber or corrosion of metal components. Over time this frequently results in extensive damage, which may ultimately be structural, and occurs without visible indications.

In recent years, the airtightness of dwellings has become an increasingly important issue as part of the drive to provide thermal comfort and reduced energy consumption. However, as dwellings are made more airtight, internal pollutant sources can have a greater impact on indoor air quality and occupants may experience adverse health effects unless the ventilation is effective.

In addition, the emission of pollutants from increased activities in urban areas (most notably from increases in traffic), have led to the outdoor air quality deteriorating. It is therefore important to minimise the levels of pollutants entering the building by effective design and operation of the ventilation. Furthermore, in noisy environments it may be necessary to incorporate sound attenuating within the ventilation system.

Household pollutants

Dust mites

Example of black mould damage

Spreading of infection

The role of ventilation in reducing the potential for cross infection of occupants within a building was noted by SAGE in the recent COVID pandemic. No given ventilation rate can provide a defined level of protection as there are many factors that influence viral load, however, good ventilation was noted as key in mitigating far-field transmission. It was also noted that many buildings were poorly ventilated when compared to the requirements of the Building Regulations. It is therefore suggested that meeting the requirements on the building Regulations will provide an adequate level of protection for normal levels of occupancy and activity levels. If occupancy levels or activity levels, i.e. singing, exercise, etc. increase, the ventilation rate should be increased accordingly.

Overheating

As buildings become more airtight and better insulated, the risk of dwellings becoming too hot increases. When the level of overheating becomes excessive the health of the occupants can be endangered, and at the very least, sleep can be disturbed, resulting in increased stress levels.

Overheating is a result of excessive heat gains coupled with a lack of ability of residents to reject the heat effectively. The primary means of rejecting heat in UK dwellings is through ventilation.

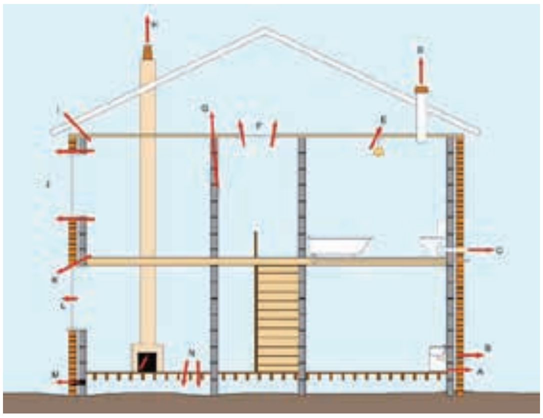
A new Building Regulation, Approved Document O, Overheating, covers residential buildings and sets out the need for ventilation provision for removing excess heat. It must be noted that the rate of ventilation required to remove heat is potentially up to 10 times greater than that required to maintain a good level of indoor air quality. As ventilation may be required to provide both roles, the two Approved Documents should be considered when the ventilation system is being designed.

Energy efficiency

There are two main ways in which ventilation uses energy. The major one is the continual need to heat the incoming air (during the heating season) and its subsequent loss as it leaves the building via purpose-provided openings and air leakage. In addition, any form of mechanical ventilation requires electrical power to operate.

Air leakage is the uncontrolled movement of air, both into and out of the dwelling, through the cracks and gaps in the building envelope.

Common leakage paths



A: Gaps between wall and floor, **B:** Gaps around kitchen waste pipes, **C:** Gaps around bathroom waste pipes, **D:** Roof vents, **E:** Ceiling service penetrations, **F:** Gaps around loft hatches, **G:** Gaps in and behind service penetrations, **H:** Open flues and chimneys, **I:** Gaps at eaves, **J:** Gaps around window frames, **K:** Paths through ceiling voids and cavity, **L:** Leaks around window and door seals, **M:** Floor grilles, **N:** Gaps in and around timber suspended floors.

The standard of airtightness achieved within a dwelling will have significant impact on the overall ventilation rates achieved. Approved Document L (Conservation of fuel and power in new buildings) of the Building Regulations for England and Wales puts a limiting value of 8 $m^3/(h.m^2)$ at 50 Pa on air permeability (air leakage). In Scotland the recommendation is that buildings are designed to achieve a value of 7 $m^3/(h.m^2)$ at 50 Pa or better. In Approved Document F, for the purposes of calculation, a permeability figure of <5 is considered airtight and >5 is considered 'less airtight', i.e. leaky. It is generally accepted that a figure of <3 is the most appropriate for a dwelling to be fitted with an MVHR system to ensure that the majority of replacement fresh air passes through the heat exchanger. For reference, the German Passivhaus Institut aims to achieve an air change rate of less than 0.6 at a pressure difference of 50 Pa (referred to as n50) in their certified energy-efficient dwellings.

Pressure testing of new home

Ventilation rate is the rate at which air within a building is replaced by fresh air. It may be expressed as:

- The number of times the volume of air within a space is changed in one hour (air changes per hour or ach)
- The rate of air change in volume and time, e.g. litres per second (l/s)

The energy efficiency of the ventilation system can be improved by employing mechanical ventilation with heat recovery (MVHR), efficient types of fan motor and/or energy saving control devices in the ventilation system.

Specific fan power is the power consumption in Watts of the fan divided by the airflow through the system, expressed in Watts per litre per second (W/l/s)

All mechanical systems require electrical power to operate, including power to the fans, transformers and control and safety devices. The term 'specific fan power' is used to compare the total electrical energy use for different ventilation systems as installed i.e. taking into consideration duct system resistance at a defined air flow rate.

A well designed ventilation system should minimise this energy usage. In addition, during installation it is important to minimise unwanted pressure losses in the ventilation system. For example, flexible ducting increases flow resistance, so it should either not be used or the lengths minimised. Where it is necessary to use flexible duct it should be pulled taut and kept straight, with as few bends and kinks as possible to minimise flow resistance.

Additionally, an MVHR system will help to reduce the amount of energy needed to heat up the incoming air to room temperature. This benefit must always be balanced against the additional electrical power requirements needed to run two fans, supplying and extracting air from the dwelling. As noted previously, such systems work best in airtight homes, where most all of the ventilation air passes through the heat exchanger.

Nowadays, virtually all heat recovery units for dwellings are air to air types. These recover heat from the exhaust air stream and use it to pre-warm the fresh incoming air from outside. The effectiveness of these units is given by the heat exchange efficiency, i.e. the proportion of waste heat that is usefully recovered by the process and typically expressed as a percentage.

The amount of ventilation needed in a room depends on the pollution level in that room and, in some cases, whether anyone is present. Automatic controls can be included with all types of ventilation system e.g. humidity sensor, occupancy/usage sensor, detection of moisture/pollutant release. These reduce the level of ventilation if the source of pollution and/or the pollution level is low, and thus save energy.

Poor workmanship or a lack of understanding by installers can substantially affect the correct operation of ventilation systems.

Installation issues vary with each system type and it is important to size the system correctly to ensure the correct airflow is provided when installed i.e. allowing for all resistance in the system. **The manufacturers' design and the installation/commissioning instructions should be followed carefully.**

How is ventilation achieved

Ventilation of dwellings:

The following section describes the approach to ventilation taken by the 2021 edition of the English Building Regulations, Approved Document F.

The overall strategy is based on the following combination:

The principles of ventilation

Ventilation is the replacement of indoor air with fresh outdoor air through purpose-provided openings, and through cracks and gaps in the building envelope.

As insulation standards have improved, ventilation heat losses have increased as a percentage of total dwelling heat loss. As previously suggested, in well insulated dwellings, the ventilation losses can be responsible for around one third of the total heat loss.

The objective of a good ventilation strategy is therefore, to provide a balance between energy efficiency and indoor air quality. This has led to the concept of 'build tight – ventilate right'. In other words – minimise the amount of uncontrolled air leakage through the building envelope and install a controllable ventilation system to provide the necessary level of ventilation both where and when it is needed.

Approved Document F (Means of ventilation) of the Building Regulations for England and Wales recommends the following three-pronged strategy for ventilation:

Extract ventilation *from rooms where most water vapour and/or pollutants are released, e.g. due to activities such as cooking or bathing. This is to minimise their spread to the rest of the dwelling. This extract may be either intermittent or continuous.*

Whole dwelling/building ventilation *is intended to provide fresh air to the dwelling and to dilute and disperse residual water vapour and pollutants not dealt with by extract ventilation as well as removing water vapour and other pollutants which are released throughout the dwelling e.g. by building materials, furnishings, activities and the presence of occupants.* ***Whole dwelling/ building ventilation*** *provides nominally continuous air exchange. The ventilation rate may be reduced when the dwelling is not occupied. It may be necessary to purge the air when the dwelling is re-occupied.*

Whole dwelling/building ventilation is nominally continuous ventilation of rooms or spaces at a relatively low rate to dilute and remove pollutants and water vapour not removed by operation of extract ventilation, purge ventilation or infiltration, as well as supplying air into the building.

Purge ventilation is manually controlled ventilation of rooms or spaces at a relatively high rate to rapidly dilute pollutants and/or water vapour. **Purge ventilation** may be provided by natural means or by mechanical means.

Purge ventilation *is intended to aid removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating or accidental releases such as smoke from burnt food.* ***Purge ventilation*** *is intermittent, i.e. required only when such occasional activities occur.* ***Purge ventilation*** *provisions may also be used to improve thermal comfort, i.e. to remove heat in summer and reduce levels of overheating.*

Terminology used for ventilation system components.

Term	Description
Fan	This could be a simple extract fan or a supply and extract fan with heat exchanger
Fan spigot	The fitting on the casing of the fan that allows duct to be securely connected to the fan
Duct	The large pipe used to transport air from one point of the system to another
Main duct	The duct connected to the fan.
Branch duct	Ducts that separate from the main duct and connect the distributed sections of the system to the main duct.
Rigid duct	Ducts made from metal, plastic or other materials that do not allow the duct to be bent.
Semi-rigid duct	Ducts made of plastic that allow the duct to be bent. Internal surface of duct is smooth.
Flexible duct	Ducts made from plastic or thin metal that can be bent sharply. The shape of the duct is maintained by pulling the duct taught, but the duct is prone to sagging, crushing which very significantly increases resistance to flow.
Room supply and extract valve	Fixed or adjustable valves or similar used to supply to or extract air from a room. If the valve is fixed then commissioning of the air flow rate must be undertaken by installing valves or within the fan box.
Fresh air and exhaust air terminal	A vent that allows air to pass through the fabric of the building. Although these vents can be adjusted and closed, they must be open to provide adequate ventilation of internal spaces.
Background vent	A vent that allows air to pass through the fabric of the building. Although these vents can be adjusted and closed, they must be open to provide adequate ventilation of internal spaces.
Door undercut	The space between the base of an internal door and the finished floor that allows air to move between room within a dwelling without significant restriction.