Unit 26: Heating, Ventilation and Air Conditioning Design

Delivery guidance

Learners will gain knowledge about the operational characteristics, principles and effective installation of heating, ventilation and air-conditioning systems within modern commercial, residential or industrial buildings. The skills that they will gain focus on the design requirements for ducting and applying appropriate components.

Approaching the unit

Efficient ventilation is essential for healthy living and working. Design innovation, legislation and management are some of the exciting aspects of today's technology that ensure that modern buildings provide clean and comfortable environments for the people who use them.

While the overall emphasis of this unit is to give learners the knowledge and skills relating to ventilation and air-conditioning design and installations in modern buildings, this unit would benefit from employer involvement in the form of guest speakers, vocational visits and technical workshops assisted by staff from local construction organisations. This will ensure that the unit will engage learners' interest by giving them the opportunity to experience a real-life vocational environment and have contact with real employers.

This is an internally assessed optional unit for the Diploma in Building Services Engineering as well as the Extended Diploma in Building Services Engineering.

Delivering the learning aims

The key content areas for **learning aim A** are the consideration of appropriate ventilation and air-conditioning plants, equipment and materials and the use of air-terminal devices to comfortably and efficiently control airflow. Learners will study the characteristics and the selection of suitable ductwork materials and service components for ventilation and air-conditioning systems. Lastly, the learning aim considers the different elements of air-handling units and plants. There will be consideration of the benefits of these systems.

Learning aim B focuses on the key appropriate design considerations for heating and cooling, performance requirements and the evaluation of ventilation systems and methodologies.

The focus of **learning aim C** is the efficient and safe design of heating, ventilation and air-conditioning systems, as well as the selection and specifications of air-terminal devices, ductwork and fans so that they meet the system's performance requirements.

Emphasise learner progression and ensure the use of holistic delivery methods across all learning aims. This can be achieved through a varied approach, including presentations, tutor-led or group discussions, individual activities, group work, practical demonstrations, independent research and knowledge quizzes. Arrange for learners to visit different industrial settings within the heating, ventilation and air-conditioning sectors and/or by inviting guest speakers to talk to the group.

When delivering the unit content, ensure that activities are innovative and interesting, giving learners the necessary skills and knowledge while engaging their interest. Lessons should be varied and not identical in structure, conveying information in different ways using a range of different activities in each lesson. Another way of engaging learners' interest is to access online resources containing relevant information and images or videos from websites as well as using the recommended textbooks (see the 'Resources' section). The unit must be delivered in a setting that gives learners access to appropriate teaching and learning rooms as well as IT and practical equipment.

Within classroom-based activities and tasks, provide opportunities for learners to conduct research and do small group presentations. Consider using the latest technologies to engage learners and present current scenarios including the latest control systems.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Understand the operational characteristics of ventilation and air-conditioning requirements for buildings	**A1** Air-terminal devices **A2** Ductwork, jointing and systems **A3** Air-handling units	Analyse a brief in terms of the components used and their operational features.
B Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings	**B1** Requirements **B2** Design conditions **B3** Ventilation systems	Develop a ventilation and air-conditioning system for a scenario, from a set of criteria. Produce a ventilation and air-conditioning strategy and schematic drawings.
C Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment	**C1** Air flow rates and supply conditions **C2** Air-terminal devices **C3** Ductwork and fans **C4** Air-conditioning plant	

Assessment guidance

There is a maximum number of two summative assignments for this unit: one for **learning aim A** and the other for both **learning aims B and C**.

Learners will create a portfolio of evidence for each of the assignments. This could include annotated notes, accurate drawings, photographic evidence, ICT presentations and media clips.

Evidence produced for the assessment tasks for **learning aim A** could include a written report analysing a brief in terms of the components used and their operational features. For the assessment tasks for **learning aims B and C**, learners will develop a ventilation and air-conditioning system for a scenario from a set of criteria, as well as a ventilation and air-conditioning strategy with schematic drawings.

Getting started

This gives you with a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 26: Heating, Ventilation and Air Conditioning Design

Introduction

This unit will help learners to develop their knowledge and understanding of ventilation and air-conditioning design and installations in modern buildings. Many learners will have encountered ventilation and air-conditioning systems in everyday life (for example, in their homes, schools, colleges and workplaces) without appreciating the theory and practical requirements behind them.

Begin the unit with an introduction to the unit requirements: learning aims, assessment criteria and requirements for the summative assessments. You can also introduce any key terminology required for the unit via group discussions.

Learning aim A – Understand the operational characteristics of ventilation and air-conditioning requirements for buildings

- For **learning aim A1**, deliver a presentation or arrange an industrial visit to a local firm, explaining the operational characteristics of the ventilation systems. This should include reference to key terms, operational features and the different materials that can be used. Demonstrate or display working ventilation systems, if available, while learners make notes, draw diagrams and/or take photographs. You or local employers could hold a question and answer (Q&A) session to answer any learner queries. You could also use observation sheets or witness statements that learners can use for their portfolios.
- Deliver a presentation about the control of air quality and direction of air discharge in supply and extract devices, including operational features, installation requirements, materials, suction dynamics and hoods/other extract devices used in commercial kitchens or industrial applications. As the sessions progress, learners could develop their own glossary of key terminology, features and materials.
- Organise learners into small groups and give each group a case study about a company. They will create installation requirements and applications of supply and extraction air-terminal devices for the company. They can discuss their feedback with the rest of the group. Learners could then individually sketch out supply and extraction air-terminal devices.
- For **learning aim A2**, plan a technical workshop with support from a local employer where possible. Use a number of activities, including both written and practical tasks. You can also use tutor record of oral questioning focusing on:
    - the characteristics and features of jointing
    - the relationship between physical properties of ductwork and application
    - flexible and fire-rated ductwork
    - the criteria for selection of materials and shape
    - the published standards and specifications for ductwork.

- Deliver a presentation explaining the characteristics and selection of appropriate ductwork and materials. Working individually, learners then produce real or scale-model ductwork and create the appropriate sketches.
- Demonstrate the characteristics of appropriate ductwork service components. Learners then sketch out the ancillary components, such as vibration isolators, take offs, turning vane, and smoke and fire dampers. Facilitate a group discussion to answer any learner queries.
- Organise learners into small groups, then facilitate a practical session in which learners assemble and join different ductwork, with reference to standards and specifications.
- For **learning aim A3**, plan a technical workshop or a visit to an air-handling plant. Introduce fans, including their characteristics, operational features, their applications and the types of drive. Learners make notes and diagrams and produce photographic evidence. Facilitate a group discussion to compare learners' drawings and photographs and answer any queries.
- In groups, learners conduct online research to find out more about heater/cooler batteries and air-handling units. They then feed back their findings to the rest of the group.
- Deliver a presentation illustrating the general characteristics of heat-recovery devices. Learners identify and sketch out the components. Facilitate a group discussion to compare learners' drawings and answer any queries.
- Give a presentation illustrating the general characteristics of air-cleaning devices and humidifiers. Learners are to form into groups of two to research and present a factsheet for peer evaluation. The factsheet to include:
    - key terms
    - types of filter
    - filter testing methods
    - general characteristics, operational features and application of filters
    - dust collection/removal.
    - information on the installation and connection of these devices.
- Deliver a presentation illustrating the general characteristics of refrigeration units. Learners identify and sketch out the components. Facilitate a group discussion to compare learners' drawings and answer any queries.
- Help learners to prepare for their summative assignment for **learning aim A** by reinforcing the differentiated assessment criteria for summative assignment writing. Discuss the different units to be included (e.g. air-terminal devices, ductwork and air-handling units), relevant annotated diagrams or photographic evidence and how to avoid plagiarism.
- Address any learner misunderstandings through tutor/peer discussion sessions. This can include mini and end-of-session plenaries to evaluate learner performance by asking them what went well, what they could have improved or change for next time, and so on.

Learning aim B – Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings

- **Learning aim B** builds upon the work that learners completed throughout learning aim A. The summative assignment concerns both learning aims B and C in one assessment and explores the design work required for heating, ventilation and air-conditioning systems.
- Organise learners into small groups so that they can share educational and/or employment experiences of working with heating and cooling systems. They should discuss what they know, what they need to know and so on.
- Deliver a presentation or facilitate a group discussion on the requirements for the summative assignment.
- For **learning aim B1**, invite various guest speakers, such as educational organisation technicians, to talk to the group or arrange for vocational visits. These activities can form the basis of tutor-led discussions on:
    - reasons for heating and cooling systems
    - environmental requirements and considerations, e.g. noise limitation and visual aesthetics
    - statutory requirements such as health and safety
    - identification of locations with specific requirements, i.e. internal/external fitment air-conditioning, warm air-conditioning and so on
    - sources of heat gain to buildings
    - evaluation of different systems
    - performance requirements for proposed installations.
- Learners prepare a report on the key considerations, including appropriate diagrams, by independently researching these areas. This activity will give them the background knowledge required for the summative assignment.
- For **learning aim B2**, deliver a presentation on the methods of specifying ventilation rates and the selection of ventilation rates for specific locations.
- Organise learners into small groups so that they can complete worksheets on ventilation rates to reinforce understanding.
- In small groups, learners conduct online research into occupational exposure limits (OEL), workplace exposure limits (WEL) and maximum exposure limits (MEL) for contaminants. Each group can then develop a presentation on their findings and present to the rest of the group.
- Facilitate a group discussion to reinforce key points, explain key terminology or address any misunderstandings. Learners evaluate their performance so far with assistance from you and their peers.
- Arrange a guest speaker from industry or a site visit that will focus on the selection of internal and external design conditions for warm-air heated and air-conditioned rooms, as well as the impact of

velocity and temperature on comfort. A question and answer (Q&A) session could follow to answer learners' queries.

- In small groups, learners estimate heat gains and cooling loads using tabulated data and 'rules of thumb'. Facilitate a group discussion so that they can share their information and rank it in order of importance. Learners can then edit and improve their work following this activity.
- For **learning aim B3**, learners conduct independent research into the following key terms: natural ventilation, passive stack ventilation, mechanical ventilation, mixed-mode ventilation and local exhaust ventilation (LEV). They will include relevant diagrams with their definitions and explanations.
- In small groups, learners conduct online research to prepare a leaflet, factsheet or written report on different ventilation systems and methodologies. They must refer to the following criteria:
    - operating principles
    - key performance characteristics
    - evaluation of the selection of different methods, e.g. comfort, environmental considerations and installation.
- Organise learners into small groups. Give each group a practical environment (or case study if a practical environment is unavailable) and direct them to create installation requirements and applications of ventilation systems. They will need to document their evidence and complete independent research, which can be evidenced by tutor observation sheets.
- Throughout the sessions, plan in time for mini and end-of-session plenaries. This will allow you to hold Q&A sessions and address any learner misunderstandings. It will also allow learners to reflect on what they have learned, to amend their evidence to upgrade work and to evaluate their performance (e.g. things that went well and any areas of development).

Learning aim C – Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment

- **Learning aim C** builds upon the work covered by learners in learning aim B, as the summative assignment focuses on both learning aims B and C. Recap the content of learning aim B and outline the requirements for the completion of the summative assignment.
- For **learning aim C1**, deliver a presentation on air flow rates for mechanical supply and extract ventilation systems. Provide calculations for learners to solve using their notes on the presentation. Facilitate a mini plenary to check learning.
- Organise a site visit to investigate supply air conditions, both mass and volumetric. Learners take notes and practise appropriate calculations for a simple building that uses heating, ventilation or air-conditioning systems. Answer any learner queries.
- Demonstrate the reasons for the design and determination of appropriate air flow requirements (e.g. the mass and volumetric flow rates) for the maintenance of room conditions for warm-air heating and single-zone air-conditioning application. Show how to plot summer and winter psychrometric cycles. Learners complete a tutor-devised worksheet to practise these calculations.
- Organise an industrial visit, which focuses on good air distribution, the layout of efficient extractor devices and the examination of different ventilation systems and warm-air heating and air-

conditioning installations. Give learners some industrial diagrams. Learners take notes and continue to practise appropriate calculations for a simple building that uses a heating, ventilation or air-conditioning system. Answer any learner queries.

- For **learning aim C2**, learners work in small groups to prepare a presentation, either using presentation software or in other media format (e.g. a video about air-terminal devices). The presentation needs to cover the following points:
    - the selection of air-terminal devices and booths, canopy hoods and extractor devices
    - the use of manufacturer's catalogues or website and manufacturer's specifications
    - the consideration of throw, resistance and noise characteristics
    - the production of relevant air-terminal device specifications and schedules.
- Plan and facilitate mini plenaries or Q&A sessions to address any learner misunderstandings. End-of-session plenaries can also be used to focus on evaluating learners' performance, such as things that went well and things that can be improved. In addition, it is important to plan time within this learning aim for learners to reflect on their evaluations and add these to their summative assignments.
- For **learning aim C3**, deliver a presentation on the selection and parameters for ductwork. This presentation should focus on explaining different duct diagrams (e.g. a heating coil, an air-handling unit, air-conditioning for different rooms and return ducts). Ensure that learners include diagrams in their work and develop their own annotated drawings as a practice for the summative assignment.
- Arrange a site visit so that learners can 'work' with technicians to see the format of calculations for duct sizes.
- In small groups, learners complete a given practical task. In each environment (or case study if environments are unavailable), learners create installation requirements and applications of ductwork systems for a suitable building, considering pressure drops, fans, noise requirements and so on. They can continue this over several sessions, routing ductwork appropriately while considering the relevant legislation.
- Arrange an industrial visit so that learners can experience the application, installation, maintenance and testing of ductwork and fans. A Q&A session could follow, with the inclusion of witness statements for assessment.
- For **learning aim C4**, deliver a presentation on air-conditioning plants. Include space requirements, accommodation of air-handling devices, refrigeration/chiller plant and fans and structural and building work requirements.
- Organise learners into pairs. Each pair develops a spider diagram of the key points in you presentation. They then use this information to inform their design drawings, particularly their use of symbols and annotations.
- Learners conduct independent research into preventative maintenance and repairs. Follow this with a plenary session for learners to share and evaluate their information.
- Address any learner misunderstandings through mini and end-of-session plenaries. You can also use these plenaries to evaluate learner performance by asking them what went well, what they could have improved and what they would change next time.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- *Unit 14: Low Temperature Hot Water Systems in Building Services Engineering*
- *Unit 15: Measurement Techniques in Construction*
- *Unit 20: Quantity Surveying*
- *Unit 21: Building Services Science*
- *Unit 25: Building Services Control Systems*
- *Unit 27: Plumbing and Fluid Behaviour in Building Services Engineering*.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson- endorsed textbooks that support this unit of the BTEC Internnationals in Building Services Engineering. Check the Pearson website (http://qualifications.pearson.com/endorsed- resources) for more information as titles achieve endorsement.

Textbooks

Althouse, A., Bracciano, A., Bracciano, D. and Turnquist, C., *Modern Refrigeration and Air Conditioning* (20th edition), Goodheart–Willcox, 2016, ISBN 9781631263545

Cook, N., *Refrigeration and Air-conditioning Technology*, Macmillan Education, 1995, ISBN 9780333609583

Both of these textbooks are relevant for industrial, vocational and technical learners.

Videos

Search YouTube™ for the following videos:

'Duct Designing Software' by IBScad Info

'Prolisp – HVAC Utilities – Ductulator' by ProlispCAD

'Calculating Duct Size' by CTESkills.com

'Air Duct Calculators (Ductulator)' by MicroMetl Corporation

'How to Quickly Size Ductwork!' by David Jones

'Duct Size – How to size a duct system for a house' by SuperCool Slide Rule

Websites

'Arca 53' – this website includes notes (written by Stephen Frazer) used for lectures in the Building Services Engineering industry. Click on the 'Air Conditioning' tab, then the 'Psychrometrics: Page 16/17' to find examples of summer and winter cycle calculations (relevant for learning aim C).

'Comair Rotron®' – this website includes information on airflow rates for mechanical supply and extracts ventilation systems (relevant for learning aim C).Health and Safety Executive (HSE). Click on the 'COSHH' tab, followed by 'COSHH basics' and then 'Exposure limits' for information about exposure (relevant for learning aim B).

'Modernize' – search the Modernize's website for 'HVAC Ducting Size Calculations provides information on how to calculate square footage and use a HVAC ducting calculator. It includes an online friction loss calculator.

'The Engineering ToolBox' – search the website for 'Air Ducts Sizing' for information on the velocity method, constant pressure loss (or equal friction loss) and static pressure recovery methods.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.