Unit 13: Environmental Science in Construction

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Not so long ago, many buildings were too hot in summer, too cold in winter, draughty, poorly insulated, poorly lit and unhygienic. Today, a building must provide a comfortable, safe and hygienic internal environment, and a clear understanding of the issues involved in achieving this is essential for everyone involved in the design and construction of buildings and the provision of building services.

Architects and builders generally are responsible for the internal environment of small buildings such as a house or apartment, but the services of a professional building services engineer would generally be required for larger and more complex buildings.

Learners will develop an understanding of the factors that affect human comfort, and of the principles that underpin the use of heating, ventilation, acoustics, lighting, electrical supply and the flow of water in both pipes and drains. They will develop knowledge and understanding of how each of these contributes to producing a desired internal environment, and will be able to use underpinning scientific knowledge and principles to support the design the elements of a comfortable internal environment, including simple, safe and effective electrical and water installations.

Learning outcomes

On completion of this unit a learner should:

1 Know the factors that influence human comfort in terms of heating, ventilation, acoustics and lighting and how these factors are quantified and measured

2 Understand the scientific principles of heating, ventilation, acoustics and lighting and how they are integrated to provide a comfortable internal environment and prevent condensation

3 Understand the principles and practices used to generate, transmit and distribute electrical power in a safe and effective manner

4 Understand the properties of fluids and be able to select and use formulae to perform calculations relating to fluids at rest and in motion.

Unit content

1 **Know the factors that influence human comfort in terms of heating, ventilation, acoustics and lighting and how these factors are quantified and measured**

Heating and ventilation: physical factors (air temperature, mean radiant temperature, relative humidity, air movement); personal factors, eg clothing, age, gender, activity, metabolism; integrated thermal comfort temperatures, eg dry resultant, inside environmental, room-centre comfort, apparent; methods used to measure each factor, eg thermometer, globe thermometer, hygrometer, anemometer

Acoustics: factors (sound reduction indices, reverberation times, noise criteria indices); use of sound level meter to measure each factor

Lighting: factors (illuminance levels, daylight factors, glare indices); methods used to measure each factor, eg light meter, daylight meter

2 **Understand the scientific principles of heating, ventilation, acoustics and lighting and how they are integrated to provide a comfortable internal environment and prevent condensation**

Heating and ventilation: principles of heat in buildings (U values, thermal bridges, air changes, fabric and ventilation heat losses, heat gains, heat balance); principles of condensation in buildings (sources of water vapour in buildings, structural temperature profiles, dew-point temperature profiles, prediction of condensation, prevention of condensation); standard calculations to support the above

Acoustics: principles of sound (standard units, addition and averaging of decibel levels, difference between sound and noise, techniques used to control noise, difference between sound insulation and sound absorption, difference between airborne and impact sound, issues associated with flanking transmission, techniques used to provide adequate sound insulation, sound absorption coefficients, reverberation, actual and optimum reverberation times); standard calculations to support the above

Lighting: principles of illumination (standard units, differences between natural and artificial light, advantages and disadvantages of each, inverse square law of illumination, cosine law of illumination, lumen method of design, daylight factor, components of daylight factor, desktop methods to determine daylight factor, control of glare for both artificial and natural light sources); standard calculations to support the above

3 **Understand the principles and practices used to generate, transmit and distribute electrical power in a safe and effective manner**

Principles: nature of electricity; relationship between voltage, current, resistance and power; electro-magnetic induction; alternating current wave form; power losses during transmission at different voltages; consequent need to transform AC voltages; nature of three-phase supply

Practices: practical generation of alternating current; standard sources of heat energy used to drive generators, eg nuclear reaction or combustion of coal, oil or gas; transformation of alternating current; distribution of single-phase and three-phase electricity supplies to buildings

4 **Understand the properties of fluids and be able to select and use formulae to perform calculations relating to fluids at rest and in motion**

Fluids at rest: properties (pressure at a given depth equal in all directions, always acts at right angles to any containing surface, magnitude affected by depth but not by volume or shape); standard calculations (actual pressure at a depth, force acting on a retaining wall, position of depth of centre of pressure)

Fluids in motion in pipes and channels: properties (difference between laminar flow and turbulent flow, total energy a constant); principles and uses of flow measurement devices, eg venturimeters, orifices, notches, weirs, Pitot tubes; standard calculations to support the above, eg volume flow rate, continuity equation, Bernoulli's theorem, Chezy formula for self-cleansing flow; D'Arcy formula for loss of head due to friction

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describe the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify and describe four physical and four personal factors that influence human comfort in the internal environment	M1 compare the advantages and disadvantages of three integrated thermal comfort temperatures in general use	
P2 describe four methods used to measure factors that affect human comfort	M2 assess the effect of varying standard design options on the provision of heating, ventilation, acoustics and lighting and the prevention of condensation	
P3 identify and describe the basic scientific principles that underpin human comfort and identify acceptable comfort parameters		
P4 perform four separate calculations associated with the provision of a comfortable internal environment and the prevention of condensation		

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Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P5 describe the safe and effective generation, transmission and distribution of electricity in terms of underpinning principles	M3 explain why electricity is transformed for distribution and why this necessitates the use of alternating current	D1 justify the use of single-phase and three-phase distribution systems in both theoretical and practical terms
P6 differentiate between the properties of fluids at rest and in motion and select appropriate formulae to solve problems relating to fluids.	M4 use appropriate formulae to solve two problems in fluid mechanics and one in flow measurement.	D2 compare two different flow measurement devices in terms of accuracy and ease of use.

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and the use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject for learners.

Learning outcomes 1 and 2 are linked and form a logical, consistent and progressive structure. Learning outcomes 3 and 4 are not linked, either to each other or to learning outcomes 1 and 2. This implies three broad areas of delivery, each leading to a separate assessment instrument.

Teaching and learning strategies designed to support delivery of learning outcomes 1 and 2 should take an integrated learner-centred approach. This would involve the learner in taking readings, consulting standards, making decisions and suggesting alternatives.

For learning outcome 1, the delivery should emphasise the physical comfort of humans in the interior of buildings. This includes the various factors that comprise a comfortable internal environment, the parameters within which a given person will feel comfortable, the commonly accepted methods of measuring such factors, the important of using the correct units, and any indices used to integrate any of the various factors. Underpinning principles are not a requirement at this stage.

For learning outcome 2, the delivery should focus on the links between the knowledge and understanding of basic science gained at Key Stage 4, and the extension and application of those principles to the provision of a comfortable internal environment. The ‘hard science’ need only be of sufficient depth to support the practical applications of the scientific principles. A quantitative approach should be adopted to support the understanding of the basic principles.

The unit should not, however, be seen as a mathematical exercise. Calculations used to support the delivery process should always reflect real life and standard practices. For example, calculations on the lumen method of design should determine the number of fittings needed to give a design level of illumination, rather than the level of illumination provided by a given number of fittings. This principle applies in each of the broad areas that comprise the unit.

Standard spreadsheet applications will allow learners to assess the effect of altering window to wall ratios or the number of air changes/hour or the U value of components or the replacement of single glazed windows by doubled glazing. They could also be used to construct and interpret structural and dew-point temperature profiles, to determine actual and optimum reverberation times, and much more besides.

The effect of varying design options on heating, ventilation, acoustics and lighting should be considered for some or all of the following: sheltered sites, deep building shapes, narrow building plans, heavy building materials, increased window areas and the use of small sealed windows. These are, however, only suggestions and the list is intended to be neither exclusive nor comprehensive.

Mention may be made of the 2006 changes to Approved Documents F and L of the Building Regulations, and the uses of standard assessment procedures (SAP) where time allows, but a thorough treatment of these topics is deemed to be more appropriate to learners at Higher National or degree level and there is no requirement to deal with these topics in this unit, or to assess them.

For learning outcome 3, learners must be made aware that all power stations generate electrical energy using electromagnetic induction and that this always involves moving a coil through a magnetic field to produce an electro-motive force. The delivery needs be no deeper than that, and there is no requirement for a more advanced understanding of the basic physics, such as Faraday's laws or Lenz's law.

Learners should understand that the difference between coal-fired, oil-fired, gas-fired and nuclear power stations lies in the way in which the heat needed to drive the turbines is obtained. There is no requirement for learners to develop a detailed practical understanding of generators. Learners should, however, be made aware that the methods in general use today consume valuable fossil fuels at an unacceptable rate, and that this is a matter of some concern. There is no requirement for a description of alternative energy techniques at this stage in this unit.

Learners must know that an electrical current is simply a flow of electrons in a conductor, that power = voltage × current and voltage = current × resistance. They will need this knowledge and understanding to explain why we need to transform electricity during transmission. Learners must be made aware that it is possible to use three separate coils, each displaced from the other by 120°, in the same generator, and that this forms the basis of the standard form of three-phase, four-wire AC supply.

For learning outcome 4, learners must develop an understanding of what is meant by fluid pressure, fluid flow, friction losses in pipes and self-cleansing flow. They should be made aware of the difference between laminar and turbulent flow but there is no requirement for any treatment of turbulent flow, transitional flow or Reynolds' number and all flow can be considered to be laminar at this stage.

The delivery should include coverage of a variety of calculations designed to support all aspects of the unit content. Learners must be able to perform calculations relating to the flow of fluids in pipes and drains and the use of at least one flow measurement device. It will, however, be necessary to identify, describe and compare at least two flow measurement devices in order to meet the assessment requirements. The more different these are, the easier they will be to compare. The actual construction of such devices is not relevant at this stage.

Broad reference should be made to the Building Regulations wherever necessary. Learners should be encouraged to see how buildings have developed over the last 30 years and how the construction of a new building is different from the maintenance and adaptation of an older property. Wherever possible links should be forged with the industry, and in particular the house building companies, as this will provide an opportunity for learners to relate to buildings with which they are familiar, and to use this to inform their study of the design of the internal environment.

Under the 'Skills for Life' banner the Standards Unit of the DfES has produced a range of support information that will be useful in the delivery of this unit. Advice is available at the following sites standards.unit@dfes.gsi.gov.uk and www.successforall.gov.uk.

Unit 4: Science and Materials in Construction and the Built Environment, is a core unit. It will therefore feature in every Nationals programme. Learners who undertake this unit will benefit from prior achievement of it. It is therefore anticipated that this unit will be undertaken at a later stage of the programme.

Group activities are permissible, but tutors will need to ensure that individual learners are provided with equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be strictly reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken prior to practical activities. Centres are advised to read the *Delivery approach* section on page 24, and *Annexe G: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

Assessment

Evidence for this unit may be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments.

There are many suitable forms of assessment that could be employed. Some examples of possible assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable. General guidance on the design of suitable assignments is available on page 19 of this specification.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used, suitable evidence would be observation records or witness statements. Guidance on the use of these is provided on the Edexcel website.

The structure of the unit suggests that the grading criteria may be fully addressed by using three assignments. The first of these would cover P1, P2, P3, P4, M1 and M2, the second would cover P5, M3 and D1, and the third would cover P6, M4 and D2.

To achieve a pass grade learners must meet the six pass criteria listed in the grading grid.

For P1, learners must identify and describe four physical and four personal factors that influence human comfort in the internal environment. They must use the correct units for each variable. Evidence could be in the form of a presentation, a report or through oral questioning based on a tutor provided case study.

For P2, learners must describe four methods used to measure factors that affect human comfort. They should be able to describe the instruments, meters and methods used to measure the physical variables that influence human comfort. This could include thermometers, hygrometers, anemometers, sound level meters and light meters. Although there are obvious benefits in learners being given opportunities to use such equipment, there is no formal requirement for them to produce practical results to support evidence of this and the use of secondary sources is acceptable. Evidence could be in the same format as for P1.

For P3, learners must identify and describe the basic scientific principles that underpin human comfort and identify acceptable comfort parameters. Learners should be able to quantify acceptable values for comfort parameters. These must include air temperature, mean radiant temperature, relative humidity, air speed, rates of air change for a variety of rooms, airborne and impact sound reduction indices, reverberation times, illumination levels and daylight factors. Evidence should take the form of a report supported by images, tables, charts and calculations as appropriate.

For P4, learners must perform four separate calculations associated with the provision of a comfortable internal environment and the prevention of condensation. The answers to the calculations should be substantially correct, but small errors in calculation are acceptable, if they are corrected after feedback from the tutor. Such calculations should refer to the determination of U values from first principles, changes to the U values of existing structures, the calculation of fabric and ventilation heat losses and hence total heat losses.

They should also refer to the production of structural and dew-point temperature profiles, the addition and averaging of sound levels in dB, the determination of both actual and optimum reverberation times of an enclosure, the inverse and cosine laws of illumination for point sources of light.

Reference should also be made to the lumen method of design for luminaires mounted in a regular pattern, the use of daylight factors and basic exercises to determine the daylight factor for a room of rectangular plan with only one window. Evidence could be in the same format as for P3.

For P5, learners must describe the safe and effective generation, transmission and distribution of electricity in terms of underpinning principles. Learners must also produce a diagram of a typical alternating current output and use this to support an explanation of why AC constantly changes and reverses. Evidence could be in the same format as for P3.

For P6, learners must differentiate between the properties of fluids at rest and in motion and select appropriate formulae to solve problems relating to fluids. Evidence could be in the same format as for P1.

To achieve a merit grade learners must meet all of the pass grade criteria **and** the four merit grade criteria.

For M1, learners must compare the advantages and disadvantages of three integrated thermal comfort temperatures in general use. This should clearly indicate which variables have been incorporated into each index and how this influences the accuracy and usefulness of each index. Evidence could be in the same format as for P1.

For M2, learners must assess the effect of varying standard design options on the provision of heating, ventilation, acoustics and lighting and the prevention of condensation. Indicative examples are given in *Delivery*, but learners should feel free to devise their own design options. This part of the assessment is designed to be open-ended, but any reasoning used must be logical, and any procedures, methods or techniques recommended must be practicable.

For M3, learners must explain why electricity is transformed for distribution and why this necessitates the use of alternating current. Learners must explain how a transformer works, the importance of the alternating magnetic field in the core and the difference between step-up and step-down transformers. This explanation should be supported by diagrams and simple calculations.

For M4, learners must use appropriate formulae to solve two problems in fluid mechanics and one in flow measurement. The answers to the calculations should be substantially correct, but small errors in calculation are acceptable, if they are corrected after feedback from the tutor. Learners must include calculations relating to the flow of fluids in pipes and drains and the use of at least one flow measurement device.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria **and** the two distinction grade criteria.

For D1, learners must justify the use of single-phase and three-phase distribution systems in both theoretical and practical terms. They must be able to explain why the use of a three-phase supply reduces the number of cables required, and they must be able to justify how a four-wire supply is used to deliver both 240V and 415V to buildings. There is no requirement for any understanding of star and delta connections at this stage. Evidence could be in the same format as for P1.

For D2, learners must compare two different flow measurement devices in terms of accuracy and ease of use. This information should then be used to compare the various devices in terms of the advantages and disadvantages of each, how accurate the results are and how easy each is to use. This should not be confused with any problems associated with the construction of such measurement devices, which is not a consideration at this stage. Evidence could be in the same format as for P4.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes in this unit are closely linked with, for example, *Unit 4: Science and Materials in Construction and the Built Environment*, together with similar units at Higher National and degree level.

This unit may have links to the Edexcel Level 3 Technical and Professional NVQs for Construction and the Built Environment. Updated information on this, and a summary mapping of the unit to the CIC Occupational Standards, is available from Edexcel. See *Annexe D: National Occupational Standards/mapping with NVQs*.

This unit presents opportunities to demonstrate key skills in application of number, communication, information and communication technology, improving own learning and performance, problem solving and working with others. Opportunities for satisfying requirements for Wider Curriculum Mapping are summarised in *Annexe F: Wider curriculum mapping*.

Essential resources

Resources should include the equipment necessary to measure factors associated with human comfort including thermometers (mercury-in-air, globe, Kata), hygrometers, anemometers, sound level meters and light meters. This equipment should be used to demonstrate the standard range of acceptable values and underpinning concepts, principles and theories.

In general, instruments and items of equipment are available at a realistic cost and centres will not need to buy the very best equipment available in order to achieve the learning outcomes. Relatively low-cost meters of reasonable accuracy, that combine the measurement of temperature, relative humidity, sound levels and light levels in a **single** instrument, are available from specialist electrical suppliers.

Equipment such as avometers, dynamos, generators and transformers will help support the delivery of learning outcome 3, either as sectioned models, demountable kit or live installations.

Hydraulic benches, venturimeters, pipe friction apparatus and so forth will assist in the delivery of learning outcome 4, where they can be used to demonstrate underpinning concepts, principles and theories.

Spreadsheets will be useful in the teaching and learning strategies designed to address learning outcomes 2 and 4 and this implies the need for learner access to an ICT resource. The use of industry recognised software would be advantageous where available, but is not deemed essential.

Health, safety and welfare issues must be considered at all times and risk assessments should be undertaken for all demonstrations and experiments used in the delivery or assessment of the unit.

Indicative reading for learners

Textbooks

Burberry P — *Environment and Services, 9th Edition* (Longman, 2007)
ISBN 0582432324

McMullan R — *Environmental Science in Building, 6th Edition* (Palgrave Macmillan, 2007) ISBN 0230525369

Smith B, Philips G and Sweeney M — *Environmental Science* (Longman, 1983)
ISBN 0582416205

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3		
When learners are:	**They should be able to develop the following key skills evidence:**	
• performing separate calculations associated with the provision of a comfortable internal environment and the prevention of condensation.	N3.1	Plan an activity and get relevant information from relevant sources.
	N3.2	Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion c handling statistics d using formulae.
	N3.3	Interpret the results of your calculations, present your findings and justify your methods.

Communication Level 3		
When learners are:	**They should be able to develop the following key skills evidence:**	
• describing methods used to measure factors that affect human comfort.	C3.1a	Take part in a group discussion.
	C3.1b	Make a formal presentation of at least eight minutes using an image or other support material.
	C3.2	Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long.
	C3.3	Write **two** different types of documents, each one giving different information about complex subjects. One document must be at least 1000 words long.

Information and communication technology Level 3		
When learners are:	**They should be able to develop the following key skills evidence:**	
• identifying and describing four physical and four personal factors that influence human comfort in the internal environment.	ICT3.1	Search for information, using different sources, and multiple search criteria in at least one case.
	ICT3.2	Enter and develop the information and derive new information.
	ICT3.3	Present combined information such as text with image, text with number, image with number.

Improving own learning and performance Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• differentiating between the properties of fluids at rest and in motion and selecting appropriate formulae to solve problems relating to fluids.	LP3.1 Set targets using information from appropriate people and plan how these will be met. LP3.2 Take responsibility for your learning, using your plan to help meet targets and improve your performance. LP3.3 Review progress and establish evidence of your achievements.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• performing four separate calculations associated with the provision of a comfortable internal environment and the prevention of condensation.	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.
Working with others Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• assessing the effect of varying standard design options on the provision of heating, ventilation, acoustics and lighting and the prevention of condensation.	WO3.1 Plan work with others. WO3.2 Seek to develop co-operation and check progress towards your agreed objectives. WO3.3 Review work with others and agree ways of improving collaborative work in the future.