Unit 315HV: Understand intermediate scientific principles for mechanical building engineering services

# Delivery guide

Unit information

This unit provides knowledge and understanding of essential scientific principles that underpin the installation, commissioning and maintenance requirements of systems and components in the mechanical building services industry. The unit also requires the learner to carry out a range of fundamental calculations relevant to mechanical building engineering services.

Learners may be introduced to this unit by asking themselves questions such as:

* What are units of measurement and how are they applied in my trade?
* What are the properties and applications of solid materials, liquids and gases?
* What is the relationship between energy, heat and power?
* How do the principles of force and pressure apply in the systems?
* What are the key mechanical and electrical principles?

Learning outcomes

1. Understand units of measurement used in the mechanical building engineering services industries
2. Understand properties of materials
3. Understand the fundamental relationship between energy, heat and power
4. Understand force and pressure
5. Understand the fundamental mechanical principles
6. Understand fundamental principles of electricity

Suggested resources

Textbook

* CIBSE *Guide K: Electricity in Buildings* (2004).   
  ISBN 978-1-9032-8726-2

Websites

* [Engineering Toolbox | Homepage](http://www.engineeringtoolbox.com/)
* [The Engineering Mindset | Homepage](http://www.theengineeringmindset.com/)
* [Explain That Stuff | Homepage](http://www.explainthatstuff.com/)

| **Learning outcomes** | **Criteria** | **Delivery guidance** |
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| 1. Understand units of measurement used in the mechanical building engineering services industries | * 1. The internationally recognised (SI) units of measurement | * Learners to understand the metric system of measurement and that it is an internationally recognised standard of measurement. * Learners to know the full range of relevant SI units including: * metre (length) m * kilogram (mass) kg * second (time) s * Kelvin (temperature) * Pascals. * Learners to be able to give examples of the applications of these measurements within industry. * Learners to be able to use tape measures to take measurements. * Learners to be able to ensure that the measurement of temperature is clear by comparing the Kelvin scale to that of degrees Celsius. * Learners to know the term ‘absolute Zero’. * Learners to be able to work between Pascals and Kilopascals and to be able to relate Bar to a height or depth of static water head. * Learners to be able to relate gauges on a working system to a physical measurement. * Learners to know how to convert Pascals to Bar. |
| * 1. The application and use of SI derived units | * Learners to be aware of the difference between derived and base units. * Learners to be able to give examples of derived units from stated base units. * Learners to know the relevant derived units including: * area (m2) * volume (m3) * litres (L) * density (kg/m3) * velocity (m/s). * Learners to be given set tasks to calculate given areas and volumes such as room volume or volume of a cistern. * Learners to know the methods used to calculate volumes and areas of unusual shapes such as cylinders. * Learners to be able to relate volumes of water to litres and to know that the density of water is stated at 4°C. * Learners to be able to identify the effect of temperature on the density of water. |
| * 1. The use of conversion tables for non-SI units | * Learners to know the term ‘imperial’ and the measurements they may come across in industry. * Learners to recognise that some tradespeople may still work in imperial measurements. * Learners to know the following measurements and to be able to show tables to represent their conversion to SI units: * feet and inches to metres and millimetres * pounds to kilograms * pounds per square inch (PSI) to Pascals * Kelvin to Celsius and Fahrenheit. * Learners to be given tasks to convert a range of measurements. |
| 1. Understand properties of materials | * 1. The relative densities of common materials | * Learners to know the densities of common gases in relation to air and common liquids and solids in relation to water. * Learners to be shown demonstrations of the densities of general building materials when in water. * Learners to be able to explain how density is measured referring back to SI Units. * Learners to know the terms ‘Relative Density’ (RD) and ‘Specific Gravity’ (SG). * Learners to know that water and air are given a value of 1.0 for comparison as follows. |
| * 1. The properties and applications of solid materials | * Learners to be familiar with a range of common materials, such as iron, Low Carbon Steel (LCS), copper, brass, plastics, fireclay, solder, ceramics and to be able to discuss their properties and uses without discussing the scientific definitions for those properties. * Learners to be able to list the properties and definitions such as: * hardness * strength (compressive, tensile) * malleability * ductility * durability * conductivity (heat and electricity) * elasticity * plasticity * corrosion resistance. * Learners to be able to attach these terms to the materials shown. * Learners to be able to give examples of the properties of these materials that are selected and used in industry. * Learners to know the difference between thermosetting and thermoplastics and to be able to give examples of each relevant to types of pipe materials. * Learners to be shown a range of plastic pipe and fittings and to discuss whether they are thermosetting or thermoplastic including: * Polyvinyl Chloride (PVC) * Acrylonitrile Butadiene Styrene (ABS) * Medium-Density Polyethylene (MDPE) * Polybutylene (PB) * Cross-linked Polyethylene. |
| * 1. The reasons why solid materials breakdown | * Learners to understand why solids breakdown and to be aware of the different types of corrosion relevant to each material. * Learners to be shown a range of corroded materials such as pipe, fittings and brackets and to know how each may have occurred. * Learners to be able to identify the causes and names of different types of corrosion including: * atmospheric corrosion * erosion corrosion * acidic corrosion * oxidisation of metals * electrolytic corrosion * dezincification. * Learners to be shown a demonstration of electrolytic corrosion by using a multi-meter attached to two different metals within an electrolyte and to know how to record the different reactions. * Learners to be shown the electromotive series table and to be able to identify the metals that react the most. * Learners to know the terms ‘anode’, ‘cathode’ and ‘electrolyte’. * Learners to know how plastics are affected by atmosphere and light including: * Ultraviolet (UV) damage to plastics * heat damage to plastics. * Learners to know the difference between erosion and corrosion and the effect of liquids and air passing over pipe and fittings creating erosion over a period of time. |
| * 1. The methods of preventing corrosion | * Learners to be able to identify protection methods used to protect metal components, such as pipes, both internally and externally. * Learners to be able to list environments and conditions where metals will corrode and to know methods to protect against them using: * inhibiters * painting * sacrificial anodes * separation from other reactive metals * wrapping with oil-based materials such as petroleum-based tape * use of phenolic blocks and isolated brackets/clips * protection and sleeving of plastic pipe and materials from direct UV externally. |
| * 1. The applications of liquids and gases | * Learners to be able to identify systems and applications where a range of liquids and gasses are used including: * water * refrigerants * anti-freeze/glycol mixes * fuel oils * lubricants/greases * steam * natural gas * Liquefied Petroleum Gas (LPG) * carbon dioxide * nitrogen. |
| * 1. The basic properties of liquids | * Learners to understand the principle behind why the properties of liquids are affected by changes to pressure and temperature. * Learners to know the boiling point of water at atmospheric temperature and the effect of raising and lowering pressure on its boiling point. * Learners to be shown how much energy is stored in water once converted to steam and the dangers attached to this caused by expansion when a change of state occurs. * Learners to know the following properties: * boiling/freezing point * change of state and molecular changes * volume and pressure increases * density at differing temperatures * steam/super-heated steam. * Learners to be shown a simple demonstration where volumes of water in matching containers change when their temperatures change. * Learners to understand how density and volume are linked to temperature change in liquids. * Learners to be aware that water is most dense at 4°C and that it expands at different rates when freezing and boiling. * Learners to know the following properties of liquids: * capillarity * acidity/alkalinity (pH value) * water hardness (soft, temporary hard, permanently hard) * the effect of hard and soft water and their relevant pH levels. |
| * 1. The basic properties of gases | * Learners to know the properties of a range of gasses including: * natural gas * LPG * Air * oxygen. * Learners to know how the changes to their properties are affected and how these properties are affected by each other including: * pressure * volume * temperature * Charles’s Law * Boyle’s Law. * Learners to know the term ‘inert’ when relevant to gasses and the types of inert gasses used within industry such as Nitrogen, Carbon Dioxide and Argon. |
| 1. Understand the fundamental relationship between energy, heat and power | * 1. The relationship between the Celsius and Kelvin temperature scales | * Learners to be aware of the Kelvin and Celsius temperature scale and to understand the relationship between them. * Learners to be given a range of temperatures to convert and to discuss the answers in class. * Learners to know how all molecular movement stops at -273°C and how, above that temperature, energy is contained in a substance despite it seeming cold to humans. This will later help underpin the difference between heat energy and temperature. |
| * 1. The principles associated with a change of state | * Learners to understand the following terms: * melting * freezing * boiling * evaporating * condensing * Learners to know at what temperatures the above terms take place at atmospheric pressure. * Learners to know and discuss how pressure affects this. |
| * 1. How the terms latent and sensible heat apply to liquids and gases | * Learners to be given simple examples to define latent and sensible heat such as a boiling pan with a thermometer. * Learners to know why the pan will not exceed 100°C. * Learners to understand where the rest of the heat energy is going, the effect of latent heat on the steam and how it is released during condensing phase. * Learners to be shown relevant graphs to represent sensible and latent heat stages. |
| * 1. The methods of heat transfer | * Learners to know the difference between heat, energy and temperature. * Learners to be able to define heat and temperature and to know how temperature is the effect of heat. * Learners to know how temperature is relative to the mass of a body and the amount of heat applied. * Learners to know that the same amount of heat applied to two different volumes of a substance (water for example) will result in different temperatures. * Learners to know how this heat energy is transferred and to be able to give examples within industry to explain the following heat transfer methods: * conduction * convection * radiation. |
| * 1. How units of energy and heat are related and derived | * Learners to know: * the specific heat capacity for water and other substances and what these numbers mean * the difference between a Joule and a Kilojoule * the term Watt which represents Power is the same as Joule but at a given rate and that the two can be easily converted. * Learners to know the following terms: * energy – Joules (J) * specific heat capacity (kJ/kg/°C) * power – Watts (W). * Learners to know that these figures relate to water at its maximum density of 4°C. * Learners to be able to give a range of linear expansion coefficients for metals and solids and discuss how they also expand due to temperature rise. * Learners to be able to calculate simple linear expansion examples in a range of materials including: * maximum density * coefficient of linear expansion. |
| * 1. Heat, energy and power calculations | * Learners to be able to carry out basic heat, energy and power calculations such as the amount of energy required to raise the temperature within a calorifier or cylinder. * Learners to be able to calculate the amount of power required to reach that temperature over a given time period. |
| 1. Understand the principles of force and pressure and their application in mechanical building engineering services | * 1. How units of force and pressure are derived from SI units | * Learners to be able to identify the relationship between force and pressure. * Learners to be able to define pressure as force divided by area and to give examples to prove this. * Learners to know about gravity and its effect on mass. * Learners to be able to define the term ‘Newton’ and to know how this is given as force. * Learners to know the term ‘velocity’ and how acceleration is used to determine a change in velocity within a time. * Learners to be able to calculate basic force and pressure problems. * Learners to be able to explain the following: * acceleration (m/s2) * force due to gravity * force – Newton (N) * pressure (N/m2) * atmospheric pressure. * Learners to know the term flow rate and the measurements used to determine flow in pipes etc. * Learners to know that 1m3 is the same as 1000L and that it weighs approximately 1000kg at 4°C. * Learners to know how the flow of water through a pipe may be reduced or increased and to be able to give examples of how this may happen within a system: * flow rate (m3/s). |
| * 1. The pressure and flow rate units of measurements | * Learners to understand a range of pressure and flow rate measurements. * Learners to be able to convert between the range where appropriate for the following units of measurement: * Bar/Millibar * Pa/kPa * Psi * Metre head * m3/s * l/s * kg/s. |
| * 1. The application of pressure and flow rate measurements | * Learners to know how pressure and flow rate measurements are applied within industry in areas such as: * flow rates at cold water and hot water system outlets * flow rates within heating circuits * standing pressure within wet systems * standing and working pressures within gas systems. |
| * 1. Simple force and pressure calculations | * Learners to be able to complete simple force and pressure calculations and to know how to convert between units. * Learners to know how to determine static head in metres and then convert to Bar. * Learners to know how pressure is measured in Pascals and the loss of pressure in Pascals due to resistance in pipe and fittings. * Learners to know that total pressure is a combination of static and dynamic pressure. * Learners to understand: * pressure head * static pressure * dynamic/velocity pressure * draught * forced draught. |
| * 1. The relationship between velocity, pressure and flow rate in systems | * Learners to know Bernoulli’s theory on moving fluids and how pressure decreases as velocity increases and vice versa. * Learners to be able to give examples, such as hosepipes and the pressure behind the outlet of the hose as a restriction is placed over it. * Learners to know the effect of a venturi and how these may be applied within industry. * Learners to be able to list the relationships between pressure, flow rate and velocity such as: * effects of increasing/reducing pressure * effects of increasing/reducing pipe size. * Learners to use the pipe sizing charts in CIBSE Guide C (2007), Section 4 (Flow of Fluids in Pipes and Ducts) to understand how the size of pipes effects flow, pressure and velocity. |
| * 1. How restrictions in the pipework affects the flow of liquids and gases | * Learners to be familiar with a range of pipe layouts and the effects of pipe restrictions on flow. * Learners to know the typical ‘equivalent lengths’ created by fittings of various size and material. * Learners to be able to give examples of pipe sizing and to demonstrate how these restrictions and fittings increase ‘equivalent length’ and include: * changes of direction * bends and tees * pipe size * pipe reductions * roughness of material surface * constrictions, such as valves. * Learners to develop an understanding of the theory of laminar and turbulent flow in pipes. * Learners to know that there is a frictional resistance created when fluid moves in a pipe and that the diameter of a pipe determines the magnitude of frictional resistance. |
| * 1. The principles of a siphon | * Learners to be shown practical demonstrations of how a siphon works and where this principle may be used. * Learners to be shown how to use a hose, WC flush and to be able to identify pressure differences in a range of examples to determine when a siphon would work. |
| 1. Understand the fundamental mechanical principles | * 1. The principles of simple machines | * Learners to be able to identify class 1, 2 and 3 levers and give examples of each class. * Learners to be given examples to explain each class such as wheelbarrows, stilsons and scissors. * Learners to be given examples of simple calculations to determine the effect of a lever and to calculate the amount of force required to balance or to lift. * Learners to be able to explain the term ‘pulley’ and how the number of pulleys within a machine affects the force required to lift an object. * Learners to know how Archimedes screws are used and their principles for lifting water. |
| * 1. The principles of basic mechanics | * Learners to be able to calculate the mechanical advantage of a range of machines. * Learners to know: * Theory of moments * action and reaction * centre of gravity * equilibrium * velocity and ratio * mechanical advantage. |
| 1. Understand fundamental principles of electricity | * 1. The basic principles of electron flow theory | * Learners to know the principles of electron flow including: * current * flow * voltage * material conductivity and resistance * direct current (DC) and alternating current (AC). * Learners to be shown how alternating current is generated and at what voltages it is distributed at. * Learners to know how current flows through a conductor and how direct current is generated chemically. * Learners to know the voltages of domestic single phase outlets, reduced voltages on site and 3 phase voltages (the in depth explanation of 3 phase power is not required at this stage but learners should have an awareness of voltage). |
| * 1. The purpose and application of simple units of electrical measurement | * Learners to know the symbols attached to the following electrical measurements and to be able to describe the effect of each on an electrical circuit: * current / Amps / I * voltage / Volts / V * resistance / Ohms / Ω * power / Watts / W. |
| * 1. Simple electrical circuits | * Learners to be able to explain how parallel and series circuits differ and the effect on power, voltage and current at points within each comparatively. * Learners to be able to explain Ohms Law and the power triangle. * Learners to be able to calculate examples of each to determine power consumption, current, voltage and resistance within a circuit. * Learners to know the purpose of over current protection devices and to be able to identify the different types including: * fuses * Miniature Circuit Breakers (MCBs) * Residual Current Device (RCDs) * MCBOs * Residual Current Circuit Breaker (RCBOs). |
| * 1. The requirements for earthing of electrical circuits | * Learners to be given examples of earthing arrangements including: * TNS * TNCS * TT. * Learners to understand why earthing is essential and the principle behind equipotential bonding. * Learners to be able to describe the procedure for temporary bonding. * Learners to be shown earth bonding clips and where they should be positioned within a mechanical system. * Learners to be able to recognise situations that may lead to electric shock due to earthing faults. |