# Unit 9: Materials, Properties and Testing

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| **Unit code** | **J/615/1483** |
| **Unit level** | **4** |
| **Credit value** | **15** |

## Introduction

The world we live in would be a very different place without the sophisticated engineering materials currently available. Many of the things we take for granted, such as telecommunications, air travel, safe and low-cost energy, or modern homes, rely on advanced materials development for their very existence. Successful engineering application and innovation is dependent upon the appropriate use of these materials, and the understanding of their properties.

This unit introduces students to the atomic structure of materials and the way it affects the properties, physical nature and performance characteristics of common manufacturing materials; how these properties are tested, and modified by various processing treatments; and problems that occur which can cause materials to fail in service.

On successful completion of this unit students will be able to explain the relationship between the atomic structure and the physical properties of materials, determine the suitability of engineering materials for use in a specified role, explore the testing techniques to determine the physical properties of an engineering material and identify the causes of in-service material failure.

## Learning Outcomes

By the end of this unit students will be able to:

1. Explain the relationship between the atomic structure and the physical properties of materials.
2. Determine the suitability of engineering materials for use in a specified role.
3. Explore the testing techniques to determine the physical properties of an engineering material.
4. Recognise and categorise the causes of in-service material failure.

## Essential Content

LO1 **Explain the relationship between the atomic structure and the physical properties of materials**

*Physical properties of materials:*

Classification and terminology of engineering materials

Material categories: metallic, ceramic, polymer and composites

Atomic structure, electrostatic covalent and ionic bonding

Crystalline structures: body-centred and face-centred cubic lattice and hexagonal close packed

Characteristics and function of ferrous, non-ferrous phase diagrams, amorphous and crystalline polymer structures

LO2 **Determine the suitability of engineering materials for use in a specified role**

*Materials used in specific roles:*

The relationship between product design and material selection

Categorising materials by their physical, mechanical, electrical and thermal properties

The effect heat treatment and mechanical processes have on material properties

How environmental factors can affect material behaviour of metallic, ceramic, polymer and composite materials

Consideration of the impact that forms of supply and cost have on material selection

LO3 **Explore the testing techniques to determine the physical properties of an engineering material**

*Testing techniques:*

Destructive and non-destructive tests used to identify material properties

The influence of test results on material selection for a given application

Most appropriate tests for the different categories of materials

Undertaking mechanical tests on each of the four material categories for data comparison and compare results against industry recognised data sources, explain reasons for any deviation found

LO4 **Recognise and categorise the causes of in-service material failure**

*Material failure:*

Reasons why engineered components fail in service

Working and environmental conditions that lead to material failure

Common mechanisms of failure for metals, polymers, ceramics and composites

Preventative measures that can be used to extend service life.

## Learning Outcomes and Assessment Criteria

| Pass | Merit | Distinction |
|---|---|---|
| **LO1** Explain the relationship between the atomic structure and the physical properties of materials | | **D1** Explain how composition and structure of materials influence the properties of the parent material across the material's range |
| **P1** Describe the crystalline structure of the body-centred cubic cell, face-centred cubic cell and hexagonal close packed cell<br>**P2** Identify the different material properties that are associated with amorphous and crystalline polymer structures | **M1** Describe physical, mechanical, electrical and thermal material properties, identifying practical applications for each property if it were to be used in an engineering context | |
| **LO2** Determine the suitability of engineering materials for use in a specified role | | **D2** Explain why the behaviour of materials is considered such an important factor when selecting a material for a given product or application |
| **P3** Provide a list of the four materials categories, including an example of a product and application for each material identified<br>**P4** Identify the specific characteristics related to the behaviour of the four categories of engineering materials | **M2** Describe, with examples, the effect heat treatment and mechanical processes have on material properties | |

| Pass | Merit | Distinction |
|---|---|---|
| **LO3** Explore the testing techniques to determine the physical properties of an engineering material | | **D3** Analyse the results of mechanical tests on each of the four material categories for data comparison and compare results against industry recognised data sources, explaining any differences found |
| **P5** Describe the six most common tests used to identify material properties<br>**P6** Describe the non-destructive testing processes – dye penetrant, magnetic particle, ultrasonic and radiography – and include an example application for each | **M3** Explain how test results influence material selection for a given application | |
| **LO4** Recognise and categorise the causes of in-service material failure | | **D4** Explain the methods that could be used for estimating product service life when a product is subject to creep and fatigue loading |
| **P7** Describe six common mechanisms of failure<br>**P8** Describe working and environmental conditions that lead to failure for a product made from material from each of the four material categories | **M4** Explain, with examples, the preventative measures that can be used to extend the service life of a given product within its working environment | |

## Recommended Resources

### Textbooks

ASHBY, M. (2005) *Materials Selection in Mechanical Design*. 3rd Ed. Elsevier.

CALLISTER, W. and RETHWISCH, D. (2009) *Fundamentals of Materials Science and Engineering: An Integrated Approach*. 4th Ed. Wiley.

### Links

This unit links to the following related units:

*Unit 1: Engineering Design*

*Unit 10: Mechanical Workshop Practices*