

11.1.0 MATERIALS TECHNOLOGY

11.1.1 Introduction

This module unit is designed to equip the trainee with the knowledge, skills and competences required for the selection, treatment and application of engineering materials. It also exposes the trainee to various methods of improving the properties of metals by heat treatment methods.

11.1.2 General Objectives:

By the end of the module unit, the trainee should be able to:

- apply the acquired knowledge on various engineering materials and their applications
- describe production processes of engineering materials
- apply heat treatment processes on metal to improve their properties
- identify factors to be considered when selecting engineering materials for particular use

11.1.3 Module Unit Summary and Time Allocation

MATERIALS TECHNOLOGY

Code	Sub-Module Unit	Content	Time Hrs		
			Theo ry	Practi ce	Tot al
11.1.01	Properties of Engineering Materials	<ul style="list-style-type: none">Types of engineering materialsPhysical properties of engineering materialsMechanical properties of engineering materialsForms of supply	4	2	6
11.1.02	Structure of Materials	<ul style="list-style-type: none">Crystalline stateCrystal structuresTerminologies	2	2	4
11.1.03	Production of Iron, Steel and Cast Iron	<ul style="list-style-type: none">Types of iron oresAdditional charging materials and their effects on ironConstruction and operation principles of furnacesCare and safety	4	6	10

		precautions			
11.1.04	Cast Iron	<ul style="list-style-type: none"> • Types of cast iron and their application • Properties of cast iron • Effects of alloying elements • Defects in cast iron 	2	2	4
11.1.05	Carbon Steels	<ul style="list-style-type: none"> • Classification of plain carbon steels • Properties of plain carbon steel • Applications of plain carbon steel 	4	2	6
11.1.06	Alloy Steels	<ul style="list-style-type: none"> • Alloying elements and their effects • Classification of alloy steels • Corrosion resistant steels • Application of corrosion resistant steels • Heat resistant steels • Application of heat resistant steels 	4	2	6
11.1.07	Stainless Steel	<ul style="list-style-type: none"> • Definition of stainless steel • Production of stainless steel • Classification of stainless steel • Application of stainless steel • Weld decay 	6	2	8
11.1.08	Non-Ferrous Metals and Alloys	<ul style="list-style-type: none"> • Non-ferrous metals • Methods of producing non-ferrous metals • Properties of non-ferrous metals • Forms of supply • Non-ferrous alloys • Alloys for specific application 	4	6	10

11.1.09	Plastics, Wood and Rubber	<ul style="list-style-type: none"> • Thermoplastics and thermosetting plastics • Properties of plastics • Classification of polymer materials • Forms of supply • Adhesives/resins • Joint design effects • Structure of wood • Process of wood preservation • Elastomers • Types of rubber • Properties of rubber 	4	2	6
11.1.10	Bearing Materials	<ul style="list-style-type: none"> • Classification of bearing materials • Bearing material properties • Materials for bearing application 	2	2	4
11.1.11	Corrosion and its Prevention	<ul style="list-style-type: none"> • Mechanism of corrosion • Corrosion prevention 	2	4	6
11.1.12	Heat Treatment	<ul style="list-style-type: none"> • Heat treatment processes • Advantages and limitations of heat treatment 	4	6	10
11.1.13	Material Testing	<ul style="list-style-type: none"> • Definition of material testing • Needs for material testing • Material testing methods 	4	4	8
Total			46	42	88

11.1.01 PROPERTIES OF ENGINEERING MATERIALS

Theory

11.1.01T *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

- a) identify various types of engineering materials
- b) describe physical properties of engineering materials
- c) describe mechanical properties of engineering materials
- d) state forms of supply

11.1.01C Competence

The trainee should have the ability to:

- i) identify various types of engineering materials for a given task
- ii) determine various material properties
- iii) identify various forms of supply

Content

- 11.1.01T1 Types of engineering materials
- i) metals
 - ii) ceramics
 - iii) composites
 - iv) organics

- v) semiconductors
- 11.1.01T2 Physical properties

- i) colour
- ii) thermal conductivity
- iii) corrosion resistance

- iv) density
- v) melting point
- vi) electrical conductivity
- vii) magnetism

- 11.1.01T3 Mechanical properties

- i) tensile strength
- ii) hardness
- iii) ductility
- iv) impact strength
- v) malleability
- vi) brittleness
- vii) elasticity
- viii) plasticity
- ix) weldability

- 11.1.01T4 Forms of supply

- i) sheets,
- ii) plates
- iii) bars
- iv) tubes
- v) rolled section
- vi) granules
- vii) pellets,
- viii) powder

Practice

- 11.1.01P *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:

- a) identify various types of engineering materials
- b) determine various material properties

	c) identify various forms of supply	c) describe terminologies
	<i>Content</i>	11.1.02C Competence
11.1.01P1	Identification of types of materials <ul style="list-style-type: none"> i) ferrous ii) non-ferrous iii) composites iv) organic v) ceramics vi) semiconductors 	The trainee should have the ability to: <ul style="list-style-type: none"> i) grow crystals ii) identify crystal structures iii) illustrate various material states using computer models
11.1.01P2	Determination of various material properties <ul style="list-style-type: none"> i) colours ii) density iii) conductivity iv) hardness v) corrosion resistance 	<i>Content</i>
		11.1.02T1 Crystalline state <ul style="list-style-type: none"> i) cell and space lattice ii) grain and grain boundary iii) growth of dendrites
11.1.01P3	Identification of various forms of supply	11.1.02T2 Crystal structures <ul style="list-style-type: none"> i) simple cubic ii) body centred cubic (B.C.C) iii) face centred cubic (F.C.C) iv) hexagonal close packed (H.C.P)
	<i>Suggested Teaching/Learning Resources</i> <ul style="list-style-type: none"> - Testing machines - Specimens 	
11.1.02	STRUCTURE OF MATERIALS	11.1.02T3 Terminologies <ul style="list-style-type: none"> i) mixture ii) compound iii) alloy iv) solid solution v) liquidus vi) eutectic vii) solidus viii) eutectoid ix) thermal equilibrium diagrams
	Theory	
11.1.02T	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: <ul style="list-style-type: none"> a) explain crystalline state b) describe types of crystal structures 	

Practice		
11.1.02P	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> grow crystals identify various crystal structures illustrate various material states 	<ol style="list-style-type: none"> explain the additional charging material in a furnace and their effects on iron describe the construction and operational principles of furnaces state the care and safety precautions necessary in the operation of furnaces
	<i>Content</i>	
11.1.02P1	Crystal growing	
	<ol style="list-style-type: none"> sugar salt 	
11.1.02P2	Identification of crystal structures	
11.1.02P3	Illustration of material states	
	<ul style="list-style-type: none"> compound mixture alloy 	
	<i>Suggested Teaching/Learning Resources</i>	
	<ul style="list-style-type: none"> Simple model crystal structures Sugar Salt String 	
11.1.03	PRODUCTION OF IRON, STEEL AND CAST IRON	11.1.03C Competence
		The trainee should have the ability to:
		<ol style="list-style-type: none"> identify various iron and charging materials identify various types of furnaces produce iron, steel and cast iron observe safe working practice
		<i>Content</i>
		11.1.03T1 Types of iron ores
		11.1.03T2 Additional charging materials and their effects on iron
		11.1.03T3 Construction and operation principles of furnaces
		<ol style="list-style-type: none"> blast furnace cupola open hearth bessemer electric furnace oxygen process (kaldo)
	Theory	
11.1.03T	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> describe various types of iron ore 	

11.1.03T4 Care and safety precautions

Practice

- 11.1.03P *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) identify various types of iron ores and charging materials
 - b) identify various types of furnaces
 - c) produce iron, steel and cast iron
 - d) practice safety

Content

- 11.1.03P1 Identification of ores and charging materials
- 11.1.03P2 Identification of types of furnaces
- 11.1.03P3 Production of iron, steel and cast iron
- 11.1.03P4 Safety
 - i) personal
 - ii) equipment

Suggested Teaching/Learning Resources

- Ores and charging materials
- Different types of furnaces

11.1.04 CAST IRON

Theory

- 11.1.04T *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) name various types of cast irons and their applications
 - b) describe properties of cast iron
 - c) describe the effects of alloying elements on the properties of cast irons
 - d) state defects in cast iron casting

11.1.04C **Competence**

- The trainee should have the ability to:
- i) identify different types of cast iron
 - ii) describe grey and white cast iron
 - iii) describe properties of various cast irons
 - iv) state casting defects

Content

- 11.1.04T1 Types of cast iron and their application
- 11.1.04T2 Properties of cast iron
- 11.1.04T3 Effects of alloying elements
- 11.1.04T4 Defects in iron casting

Practice			
11.1.04P	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> identify various types of cast iron test properties of cast iron identify defects in cast iron 		<ol style="list-style-type: none"> explain properties of plain carbon steels explain the applications of plain carbon steels
		11.1.05C	Competence
			The trainee should have the ability to:
			<ol style="list-style-type: none"> state different plain carbon steels, their properties and applications identify types of plain carbon steels select suitable plain carbon steels for various applications
	<i>Content</i>		
11.1.04P1	Identification of types of cast iron		
11.1.04P2	Demonstrating tests on cast iron		
11.1.04P3	Identification of defects in cast iron		
	<i>Suggested Teaching/Learning Resources</i>		
	<ul style="list-style-type: none"> Samples of cast iron materials Mechanical testing kits 	11.1.05T1	<i>Content</i> Classification of plain carbon steels <ol style="list-style-type: none"> dead mild mild medium carbon high carbon
11.1.05	CARBON STEELS	11.1.05T2	Properties of plain carbon steel <ol style="list-style-type: none"> tensile strength ductility hardness toughness, malleability brittleness
	Theory		
11.1.05T	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> classify various types of plain carbon steels based on carbon content 	11.1.05T3	Applications of plain carbon steels <ol style="list-style-type: none"> chain rivets, structures crankshafts, hammers

vi) drills

11.1.06 ALLOY STEELS

Practice

- 11.1.05P *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- identify types of plain carbon steels
 - identify cold rolled/ drop forged items.

Content

- 11.1.05P1 Identification of types of plain carbon steels
- dead mild
 - mild
 - medium carbon
 - high carbon steel,
- 11.1.05P2 Identification of cold rolled/drop forged items

Suggested Teaching/

Learning Resources

Samples of plain carbon steels

- dead mild
- mild
- medium carbon
- high carbon

Theory

- 11.1.05T *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- state the various alloying elements and their effects
 - classify alloy steels
 - explain corrosion resistant steels
 - explain the application of corrosion resistant steels
 - describe heat resistant steels
 - explain the applications of heat resistant steels
 - explain weld decay and sigma phase

11.1.06C Competence

The trainee should have the ability to:

- identify alloying elements
- use alloy steels for suitable applications
- describe tool materials and their properties

Content

- 11.1.06T1 Alloying elements and their effects
- nickel
 - molybdenum
 - chromium
 - sulphur

	v) titanium vi) vanadium			Practice
11.1.06T2	Classification of alloy steels i) manganese steels ii) nickel steels iii) nickel chrome steels iv) nickel chrome vanadium steels v) nickel chromium, molybdenum alloys vi) chromium steels	11.1.06P	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) identify various alloying elements b) identify uses of alloy steels c) select an alloy steel for a suitable application d) identify various tool materials and their properties	
11.1.06T3	Corrosion resistant steels (stainless steels) i) nickel, chromium, molybdenum alloys ii) austenitic ferritic, martensitic steels		<i>Content</i>	
11.1.06T4	Application of corrosion resistant steels i) cutlery ii) food processing iii) chemical plant	11.1.06P1	Identification of various alloying elements	
11.1.06T5	Heat resistant steels i) molybdenum ii) tungsten, iii) vanadium	11.1.06P2	Identification of uses of alloy steels	
11.1.06T6	Application of heat resistant steels i) tools ii) dies iii) furnaces iv) turbine blades	11.1.06P3	Selection of alloys for application	
11.1.06T7	Weld decay and sigma phase	11.1.06P4	Identification of tool materials and properties	
			<i>Suggested Teaching/ Learning Resources</i> - Samples of various alloy steels	
		11.1.07	STAINLESS STEEL	
			Theory	
		11.1.07	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) Define stainless steel	

	<ul style="list-style-type: none"> b) State applications of stainless steel c) Identify classes of stainless steel d) Explain the production methods of stainless steel 	<ul style="list-style-type: none"> b) Work on stainless steel components
		<i>Content</i>
		11.1.07P1 Selection of stainless steel for specific applications
		11.1.07P2 Work on stainless steel components
11.1.07C	Competences	
	The trainee should have the ability to:	<i>Suggested Teaching/Learning Resources</i>
	<ul style="list-style-type: none"> i) Select various types of stainless steel for various applications ii) Work on components made of stainless steel 	<ul style="list-style-type: none"> - Stainless steel materials - Welded test pieces
		11.1.08 NON-FERROUS METALS AND ALLOYS
	<i>Content</i>	Theory
11.1.07T1	Definition of stainless steel	
11.1.07T2	Application of stainless steel	11.1.08T <i>Specific Objectives</i>
11.1.07T3	Classes of stainless steel	By the end of the sub-module unit, the trainee should be able to:
	<ul style="list-style-type: none"> i) Austenitic ii) Martensitic iii) Ferritic 	<ul style="list-style-type: none"> a) state non-ferrous metals b) describe methods of producing non-ferrous metals c) explain the properties of non-ferrous metals d) state forms of supply e) describe non-ferrous alloys f) state alloys for specific application
11.1.07T4	Production methods of stain steel	
	Practice	
11.1.07P	<i>Specific Objectives</i>	
	By the end of the sub-module unit, the trainee should be able to:	
	<ul style="list-style-type: none"> a) Select stainless steels for a particular application 	

11.1.08C	Competence The trainee should have the ability to: i) describe methods of producing non-ferrous metals ii) state forms of supply of non-ferrous metals iii) identify non-ferrous metals iv) perform electrolysis process v) carryout tests on materials vi) identify non-ferrous alloys vii) select alloys for specific application	11.1.08T5	iv) tubes Non ferrous alloys i) aluminium ii) wrought iron iii) cast iron iv) copper v) non-heat treatable vi) heat treatable vii) brass viii) bronze ix) cupronickel
		11.1.08T6	Alloys for specific application i) conductor ii) heat exchanger iii) aircraft fuselage and structural construction iv) thrust bearing v) cartridges and others
	<i>Content</i>		Practice
11.1.08T1	Non-ferrous metals i) copper ii) aluminium		
11.1.08T2	Methods of producing non-ferrous metals i) electrolysis of aluminium oxide ii) smelting of copper	11.1.08P	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) identify non-ferrous metals b) perform an electrolysis process c) determine various material properties d) identify non-ferrous alloys e) identify alloying elements in non-ferrous alloys f) select alloys for specific applications
11.1.08T3	Properties of non-ferrous metals i) high electrical conductivity ii) light weight iii) corrosion resistance iv) high thermal conductivity v) ductility vi) malleability		
11.1.08T4	Forms of supply i) sheets ii) bars iii) rolled sections		

- Content*
- 11.1.08P1 Identification of non-ferrous metals
 i) aluminium
 ii) copper
- 11.1.08P2 Performing electrolysis process
 i) use of copper solvents
- 11.1.08P3 Determination of properties of materials
 i) hardness
 ii) heat conductivity
 iii) corrosion resistance
 iv) magnetism and others
- 11.1.08P4 Identification of non ferrous alloys
 i) copper based
 - brasses
 - bronzes
 - cupronickels
 ii) aluminium based
 - wrought heat (treatable/non-heat treatable)
 - cast heat (treatable/non heat treatable)
- 11.1.08P5 Identification of alloying elements
- 11.1.08P6 Selection of alloys for specific applications
 i) cartridges
 ii) shell cases
 iii) heat exchangers,
 iv) fuselage

*Suggested Teaching/
Learning Resources*

- Copper oxide
- Aluminium oxide

- Various non-ferrous metals
- Various non-ferrous alloys
- furnances
- laboratory equipment

11.1.09 PLASTICS, WOOD AND RUBBER

Theory

- 11.1.09T *Specific Objectives*
 By the end of the sub-module unit, the trainee should be able to:
- a) differentiate thermoplastics from thermosetting plastics
 - b) describe properties of plastics
 - c) classify polymeric materials
 - d) state forms of supply of plastics
 - e) state types of polymeric adhesives
 - f) explain how joint design affects strength of joint
 - g) describe the structure of wood
 - h) explain the process of wood preservation
 - i) describe various elastomers
 - j) state types of rubber
 - k) describe properties of rubber.

11.1.09C Competence

The trainee should have the ability to:

- i) distinguish between thermoplastics and thermosetting plastics
- ii) test the effect of joint design on strength of joint
- iii) distinguish different types of wood
- iv) season and cure wood
- v) test plastic for various properties
- vi) identify applications for plastics
- vii) identify polymeric adhesives
- viii) distinguish different types of rubber

Content

- 11.1.09T1 Thermoplastics and thermosetting plastics
- 11.1.09T2 Properties of plastics
- 11.1.09T3 Classification of polymer materials
- i) thermo plastics
 - ii) thermosetting plastics
 - iii) elastomers
- 11.1.09T4 Forms of supply
- 11.1.09T5 Adhesives/resins
- i) araldite
 - ii) epoxies
 - iii) phenolic resins
- 11.1.09T6 Joint design effects
- i) contact surface
 - ii) tension load
 - iii) cleavage

11.1.09T7 Structure of wood

11.1.09T8 Process of wood preservation

i) seasoning

ii) curing

11.1.09T9 Elastomers

11.1.09T10 Types of rubber

i) natural

ii) styrene butadiene rubber

iii) butyl

iv) nitrile

v) ethylene propylene rubber(EPR)

vi) polysulphide

11.1.09T11 Properties of rubber

Practice

11.1.09P

Specific Objectives

By the end of the sub-module unit, the trainee should be able to:

- a) distinguish plastics by heat application
- b) test plastics for various properties
- c) identify various plastics application
- d) identify various polymeric adhesives.

Content

11.1.09P1 Distinguishing plastics

i) thermoplastics

ii) thermosetting

11.1.09P2 Testing for properties of plastics

iii) weight

iv) low melting temperature

- v) strength
 - vi) electrical conductivity
 - vii) elasticity
- 11.1.09P3 Identification of applications of plastics
- i) machine operations
 - ii) bearing materials
 - iii) car rims
 - iv) seat covers
 - v) tiles

- 11.1.09P4 Identification of polymeric adhesives
- i) araldite
 - ii) epoxies
 - iii) phenolics

*Suggested Teaching/
Learning Resources*

- Various plastics
- Wood
- Rubber materials
- Heat source

11.1.10 BEARING MATERIALS

Theory

- 11.1.10T *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) classify bearing materials
 - b) describe bearing material properties
 - c) select material for bearing application

11.1.10C Competence

The trainee should have the ability to:

- i) identify various types of bearing materials
- ii) carry out tests for bearing properties
- iii) select bearing material for a given application

Content

- 11.1.10T1 Classification of bearing materials

- i) metals
 - white metals
 - copper based
 - aluminium based
- ii) non-metals
 - graphite
 - nylon
 - polytetra floura ethylene (PTFE)

- 11.1.10T2 Bearing material properties

- i) wear resistance
- ii) shock resistance
- iii) strength
- iv) ductility
- v) corrosion resistance

- 11.1.10T3 Materials for bearing application

- i) metals
- ii) non-metals

	Practice		<i>Suggested Teaching/ Learning Resources</i>
11.1.10P	<p><i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> identify various types of bearing materials carry out tests for bearing materials properties select suitable bearing for a given application 		<p>Bearing materials</p> <ul style="list-style-type: none"> Metals Non-metals
		11.1.11	CORROSION AND ITS PREVENTION
			Theory
		11.1.11T	<p><i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <ol style="list-style-type: none"> describe mechanism of corrosion explain methods available for prevention of corrosion
	<i>Content</i>		
11.1.10P1	<p>Identification of bearing materials</p> <ol style="list-style-type: none"> metal based <ul style="list-style-type: none"> tin based lead based copper based aluminium based non-metals <ul style="list-style-type: none"> graphite nylon polytetra floura ethylene (PTFE) 	11.1.11C	<p>Competence The trainee should have the ability to:</p> <ol style="list-style-type: none"> identify types of corrosion perform corrosion preventive methods observe safety
11.1.10P2	<p>Testing of bearing materials properties</p> <ol style="list-style-type: none"> wear resistance shock resistance strength ductility corrosion 		<i>Content</i>
11.1.10P3	<p>Bearing applications</p> <ol style="list-style-type: none"> end thrust side thrust 	11.1.11T1	<p>Mechanism of corrosion</p> <ol style="list-style-type: none"> chemical attack electrolytic action with reference to electro-chemical series
		11.1.11T2	<p>Corrosion prevention</p> <ol style="list-style-type: none"> electroplating cladding spraying calourising

- v) sherardizing
- vi) chromizing
- vii) phosphating
- viii) painting
- ix) varnishing
- x) cathodic protection

Practice

- 11.1.11P *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) subject materials to corrosive environments
 - b) perform corrosion prevention exercises
 - c) observe safety precautions

Content

- 11.1.11P1 Subjecting materials to corrosive conditions
- i) acids
 - ii) salts
 - iii) air
 - iv) paints
- 11.1.11P2 Performing corrosion preventive methods
- i) painting
 - ii) spraying
 - iii) varnishing
 - iv) electroplating
 - v) carbonizing
 - vi) sheradising
 - vii) anodizing
- 11.1.11P3 Safety precautions
- i) personal
 - ii) equipment

Suggested Teaching/Learning Resources

- Laboratory equipments for testing corrosion
- Acid
- Salts
- Air
- Paints

11.1.12 HEAT TREATMENT

Theory

- 11.1.12T *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) describe various heat treatment processes
 - b) outline the advantages and limitations of heat treatment processes

11.1.12C Competence

- The trainee should have the ability to:
- i) carry out various heat treatment processes
 - ii) state advantages and limitations of heat treatment processes
 - iii) identify various carbonaceous materials
 - iv) carry out heat treatment processes
 - v) observe safety

11.1.12T1	<p><i>Content</i></p> <p>Heat treatment processes</p> <ul style="list-style-type: none"> i) annealing ii) tempering iii) normalizing iv) hardening v) surface hardening processes 	<ul style="list-style-type: none"> iv) hardening v) surface hardening <p>11.1.12P3 Performing surface hardening processes</p> <ul style="list-style-type: none"> i) case hardening ii) carbon nitriding iii) flame hardening iv) induction hardening
11.1.12T2	<p>Advantages and limitations of heat treatment</p>	<p>11.1.12P4 Observing safety when performing heat treatment</p> <ul style="list-style-type: none"> i) personal ii) equipment
Practice		
11.1.12P	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ul style="list-style-type: none"> a) identify various carbonaceous materials b) carry out and select heat treatment process c) perform service hardening treatment processes d) practice safety when performing heat treatment 	<p><i>Suggested Teaching/ Learning Resources</i></p> <ul style="list-style-type: none"> - Carbonaceous materials - Test pieces - Heating equipment
11.1.13 MATERIAL TESTING		
Theory		
11.1.13T	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p>	<p><i>Specific Objectives</i></p> <p>By the end of the sub-module unit, the trainee should be able to:</p> <ul style="list-style-type: none"> a) define the term material testing b) state needs for material testing c) explain material testing methods
11.1.12P1	<p><i>Content</i></p> <p>Identification of carbonaceous materials</p> <ul style="list-style-type: none"> i) charcoal ii) carbon/graphite iii) various salts iv) cyanide 	
11.1.12P2	<p>Carrying out heat treatment processes</p> <ul style="list-style-type: none"> i) annealing ii) normalizing iii) tempering 	<p>11.1.13C Competence</p> <p>The trainee should have the ability to:</p> <ul style="list-style-type: none"> i) identify material testing methods

	ii) perform material testing		Practice
	<i>Content</i>	11.1.12P	<i>Specific Objectives</i>
11.1.13T1	Definition of material testing		By the end of the sub-module unit, the trainee should be able to:
11.1.13T2	Needs for material testing		a) identify material testing methods
11.1.13T3	Material testing methods		b) perform material testing for different materials
	i) destructive testing		c) practice safety
	ii) non-destructive testing		
			<i>Content</i>
		11.1.12P1	Identification of stainless steels
		11.1.12P2	Material testing
		11.1.12P3	Safety
			<i>Suggested Teaching/Learning Resources</i>
			- Test pieces
			- Material testing equipments