

20.2.0 MATERIALS TECHNOLOGY AND METALLURGY II

20.2.1 Introduction

This module unit has been designed to equip the trainee with the necessary knowledge in selection treatment and application and testing of engineering materials technology and metallurgy is the study of engineering materials and their applications in engineering field.

The study involves the composition of materials their production processes, mechanical and physical properties.

The trainee undertaking this module should have completed materials Technology I or any accepted equivalent knowledge / qualification

20.2.2 General Objectives:

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

- analyse thermal equilibrium diagrams
- understand the application of composites and ceramics in engineering
- understand powder metallurgy process
- perform destructive and non-destructive tests on engineering materials

20.2.3 Module Unit Summary and Time Allocation

MATERIALS TECHNOLOGY AND METALLURGY II

Code	Sub-Module Unit	Content	Theory Hrs	Pract Hrs	Time Hrs
20.2.01	Thermal Equilibrium Diagrams	<ul style="list-style-type: none">Types of thermal equilibrium diagramCoring and diffusionPrecipitation and solid solutionTerminologiesSimple iron/carbon diagramPhase equilibrium of two metal systems	2	2	4
20.2.02	Composites	<ul style="list-style-type: none">Typical compositesMechanical propertiesCuring and seasoning of timber	2	2	4

20.2.03	Ceramics	<ul style="list-style-type: none"> • Types of ceramic materials and properties • Methods of manufacturing ceramics • Uses of ceramics 	2	2	4
20.2.05	Powder Metallurgy	<ul style="list-style-type: none"> • Powder production • Powder metallurgy process • Applications 	4	4	8
20.2.06	Material Testing Destructive tests	<ul style="list-style-type: none"> • Destructive tests • Tensile Test • Brinell hardness • Vickers Pyramid Hardness test • Rockwell Hardness test • Shore Scleroscope • Izod Impact test • Charpy Impact test • Fatigue test • Creep test 	4	4	8
20.2.07	Non-Destructive Tests	<ul style="list-style-type: none"> • Non-Destructive Tests • Dye-penetrant • Magnetic particle • Eddy current • X-ray radiography • Gamma-ray radiography • Ultra-sonic • Macro-examination • Micro-examination 	8	8	16
Total Time			22	22	44

20.2.01	THERMAL EQUILIBRIUM DIAGRAMS	various constituents v) Label fully thermal equilibrium diagram
	Theory	
20.2.01T0	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:	vi) Identify various solutions by means of model
	a) sketch and discuss the various types of equilibrium diagrams	<i>Content</i> 20.2.01T1 Equilibrium diagrams - solid solution - eutectics
	b) describe the term 'coring'	- partial solutions 20.2.01T2 Coring and diffusion
	c) describe the term 'precipitation'	20.2.01T3 Precipitation from a solid solution
	d) distinguish terminologies	20.2.01T4 Terminologies - liquidus - solidus - solutions - eutectic phase - eutectoid phase - interstitial solid solution - substitutional solid solution - phase
	e) draw and label simplified iron/carbon thermal equilibrium diagrams	
	f) describe various solution systems	
20.2.01C	<i>Competence</i> The trainee should have the ability to: sketch various types of equilibrium diagrams	20.2.01T5 Iron/carbon equilibrium diagrams 20.2.01T6 Solution systems - copper/nickel - bismuth/cadmium - Lead tin
	i) Define Coring And Diffusion	
	ii) Explain Precipitation	Practice
	iii) Distinguish terminologies	
	iv) Plot various thermal equilibrium diagram from	20.2.01P0 <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) plot various thermal equilibrium diagrams from given constituents b) label fully thermal equilibrium diagrams c) identify various solutions by means of models 	<p>20.2.02 COMPOSITES Theory</p> <p>20.2.02T0 <i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <ul style="list-style-type: none"> a) define various composites b) explain a typical composite c) explain the properties of composites d) describe the characteristics of glass materials e) explain the processes of timber preservation
20.2.01P1	<p><i>Content</i></p> <p>Thermal equilibrium diagrams</p> <ul style="list-style-type: none"> - Tin/lead (various compositions) - Copper/nickel: Bismuth/Cadmium 	
20.2.01P2	<p>Labelling thermal equilibrium diagrams</p> <ul style="list-style-type: none"> - Solidus line - Liquidus line - Eutectic point - Eutectoid point - Phase 	20.2.02C <i>Competence</i> The trainee should have the ability to:
20.2.01P3	<p>Solid solution models</p> <ul style="list-style-type: none"> - Interstitial - Substitutional 	<ul style="list-style-type: none"> - explain various composites - list properties of composites - carry out a given test - analysis of test results - identify various composite materials
	<p><i>Suggested Learning Resources</i></p> <ul style="list-style-type: none"> - Charts - Science lab - Means of determining composition - Various metals - Heating furnace - Temperature measuring device 	<p><i>Content</i></p> <p>20.2.02T1 Definition of terms</p> <p>20.2.02T2 Typical composites</p> <p>20.2.02T3 Concrete</p> <p>20.2.02T4 Re-inforced</p> <ul style="list-style-type: none"> - concrete - fibre

	<ul style="list-style-type: none"> - re-inforced plastics - resin metal - bonded sintered powders - ceramics 	<ul style="list-style-type: none"> - Textbooks - Laboratory equipment - Industrial visits - Material laboratory
20.2.02T5	<p>Properties of composites</p> <ul style="list-style-type: none"> - mechanical - stress - strain <p>Practice</p>	<ul style="list-style-type: none"> - Composite materials - Glass - Ceramics - Re-enforced plastics - Sintered products - Tensile test equipment
20.2.02P0	<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"> a) identify different types of composites b) perform various test to determine mechanical properties of composites <p><i>Content</i></p>	<p>20.2.03 CERAMICS</p> <p>Theory</p>
20.2.02P1	<p>Identification of composites</p> <ul style="list-style-type: none"> - glass concrete - glass fibre re-enforced plastics - bonded sintered products - timber - ceramics 	<p>20.2.03T0 <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"> a) distinguish various types of ceramic materials b) explain the constituents of various ceramics c) explain the characteristics of ceramic materials d) describe the various processes of producing ceramic products e) explain the application of ceramic materials
20.2.02P2	<p>Tests</p> <ul style="list-style-type: none"> - tensile - stress - strain - compressive <p><i>Suggested Learning Resources</i></p>	<p>20.2.03C <i>Competence</i></p> <p>The trainee should have the ability to:</p>

	<ul style="list-style-type: none"> i) explain the constituents of various ceramics ii) explain the characteristics of ceramics iii) describe various processes of producing ceramic products iv) identification of ceramics v) perform various tests vi) identification of ceramic products applications vii) perform sintering operation and produce actual component viii) operate invest casting equipment 	<ul style="list-style-type: none"> ○ Carbon ○ Nitrogen
		<p>20.2.03T3 Characteristics of ceramic materials</p> <ul style="list-style-type: none"> - Heat Conduction - Electrical Conduction - Chemical Resistance - Wear Resistance - Chemical Bonds (Van-Der-Waal) - Crystalline and non-crystalline
		<p>20.2.03T4 Processes of producing ceramic products</p> <ul style="list-style-type: none"> - Compacting - Sintering - Spraying - Coating - Casting
		<p>20.2.03T5 Application of ceramics in engineering</p> <ul style="list-style-type: none"> - Refractories - Electrical (conductor/insulator) - Composites - coating
	<i>Content</i>	
20.2.03T1	Types of ceramic materials	
	<ul style="list-style-type: none"> - oxides - nitrates - carbides - silica - glass - refractories - insulators <ul style="list-style-type: none"> ○ thermal ○ electrical 	
20.2.03T2	Constituents of ceramics	
	<ul style="list-style-type: none"> - Metallic elements - Non-metals <ul style="list-style-type: none"> ○ Oxygen 	
		<p>Practice</p>
		<p>20.2.03P0 <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 types of ceramic materials b) perform tests on ceramic products

	<ul style="list-style-type: none"> c) identify the application of ceramics d) perform sintering operation and produce typical component e) operate equipment used in invest casting 		<ul style="list-style-type: none"> - Assorted ceramic materials and products - Sintering equipment - Invest casting moulding equipment
		20.2.04	POWDER METALLURGY
			Theory
	<i>Content</i>		
20.2.03P1	Identification of ceramics	20.2.04T0	<i>Specific Objectives</i>
20.2.03P2	Ceramic tests <ul style="list-style-type: none"> - impact - twist - comparison - melting temperatures - wear resistance - hardness 		By the end of the sub-module unit, the trainee should be able to:
20.2.03P3	Applications of ceramics		a) describe various methods of producing metal powders
20.2.03P4	Sintering operation <ul style="list-style-type: none"> - mixture in die - press mixture to shape - effect billets - sintering - safety 		b) describe the stages in powder metallurgy process
20.2.03P5	Investment casting <ul style="list-style-type: none"> - equipment - pattern making - mould and casting production 		c) state design consideration in powder metallurgy
		20.2.04C	d) state typical applications of powder metallurgy
			<i>Competence</i>
			The trainee should have the ability to:
			i) Produce a component using powder metallurgy process
			ii) Suggested teaching and
	<i>Suggested Learning Resources</i>		
	<ul style="list-style-type: none"> - Ceramic laboratory - Textbooks - Industrial visit 		

	learning activities		b) produce a part using powder metallurgy
	iii) Discussion		
	iv) Lecture		
	v) Demonstration		
	<i>Content</i>		<i>Content</i>
20.2.04T1	Powder production methods	20.2.04P1	Powder production
	- Mechanical pulverization	20.2.04P2	Production of part using powder metallurgy
	- Atomization		
	- Chemical reduction		<i>Suggested learning resources</i>
	- Electrolysis		- Different materials
20.2.04T2	Stages in powder metallurgy		- Ball mill
	- Powder production		- Press
	- Blending and mixing	20.2.05	- Furnace
	- Compacting	DESTRUCTIVE TESTS TENSILE TESTS	
	- Sintering		
20.2.04T3	Design considerations	20.2.05T0	<i>Specific Objectives</i>
	- Length to width ratio		By the end of the sub-module unit, the trainee should be able to:
	- Undercuts, threads, knurling		a) describe the standard tensile test specimen
	- Hole direction		b) explain how the tensile test is carried out
20.2.04T4	Typical applications		
	- Porous products		
	- Refractory parts		
	- Complex shapes		
	- Automotive parts	20.2.05C	<i>Competence</i>
	- Materials difficult to machine		The trainee should have the ability to:
			i) Prepare standard specimen for tensile test
			ii) Operate tensile testing machine
			iii) Tabulate and interpret results
			iv) Carryout tensile test in the laboratory
	Practice		
20.2.04P0	<i>Specific Objectives</i>		
	By the end of the sub-module unit, the trainee should be able to:		
	a) produce metal powder		

	v) Write laboratory report		- Percentage elongation
	vi) Care and maintain a tensile testing machine		- Percentage reduction in area
	<i>Content</i>		- Tensile strength
20.2.05T1	Standard specimen	20.2.05T4	Care and maintenance
	- Gauge length		<i>Suggested Learning Resources</i>
	- Yield stress		- Universal Tensile Testing Machine
	- Proof stress		- Machine shop to enable the preparation of specimen
	- percentage elongation		
	- percentage reduction in area		
20.2.05T2	Tensile test	20.2.06	BRINELL HARDNESS TEST
	Practice		
20.2.05P0	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:	20.2.06T0	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:
	a) prepare a tensile test specimen		a) describe how the Brinell hardness test is carried out.
	b) carry out a tensile test		b) calculate Brinell Hardness number
	c) plot and interpret results		c) care and maintain the Brinell hardness testing machine
	d) care and maintain tensile test machine		
	<i>Content</i>	20.2.06C	<i>Competence</i> The trainee should have the ability to:
20.2.05P1	Preparation of standard tensile test specimen		i) Carry out Brinell hardness test
20.2.05P2	Tensile tests		ii) Obtain Brinell hardness number for a given material
20.2.05P3	Interpretation of results		iii) Interpret results
	- Gauge length		
	- Yield stress		
	- Proof stress		

<p>20.2.06T1</p> <p>20.2.06T2</p> <p>20.2.06T3</p> <p>20.2.06P0</p> <p>20.2.06P1</p> <p>20.2.06T2</p> <p>20.2.06T3</p> <p>20.2.06T4</p>	<p><i>Content</i></p> <p>Brinell hardness test</p> <ul style="list-style-type: none"> - Hardened steel balls - Indentation - Analysis - Interpretation <p>Calculation</p> <p>Care and maintenance</p> <p>Practice</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) carry out a Brinell hardness test b) calculate Brinell hardness number c) interpret results d) care and maintain a Brinell hardness testing machine <p><i>Content</i></p> <p>Brinell tests</p> <ul style="list-style-type: none"> - Hardened steel balls - Indentation <p>Calculation</p> <p>Results analysis</p> <p>Care and maintenance</p> <p><i>Suggested Learning Resources</i></p> <ul style="list-style-type: none"> - Brinell hardness Tester - Hardened steel balls 	<p>20.2.07</p> <p>VICKER'S PYRAMID HARDNESS TEST</p> <p>Theory</p> <p>20.2.07T0</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) describe the Vickers pyramid test b) calculate vickers pyramid number <p>20.2.07C</p> <p><i>Competence</i></p> <p>The trainee should have the ability to determine the hardness of a material using the Vicker's pyramid tests</p> <p>20.2.07T1</p> <p>20.2.07T2</p> <p>Practice</p> <p>20.2.07P0</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) carry out Vicker's pyramid hardness test b) calculate Vicker's pyramid number 	<p><i>Content</i></p> <p>Vickers pyramid test</p> <ul style="list-style-type: none"> - Indentation - Analysis <p>Calculation</p> <p>Practice</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) carry out Vicker's pyramid hardness test b) calculate Vicker's pyramid number
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	c) care and maintain the Vicker's pyramid hardness test	20.2.8T1	<i>Content</i> Rockwell hardness cone
20.2.07P1	Vicker's pyramid test indenter	20.2.8T2	Calculations - Rockwell hardness number
20.2.07T2	- Indentation - Analyses Calculation		Practice
20.2.07P3	Care and maintenance	20.2.8P0	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:
	<i>Suggested Learning Resources</i> - Equip Vicker's pyramid tester - Mounting gear		a) carry out Rockwell hardness test b) calculate Rockwell hardness number c) analyse the results d) care and maintain the Rock well hardness testing machines
20.2.8	ROCKWELL HARDNESS TEST		
	Theory		
	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:		<i>Content</i>
	a) describe Rockwell hardness test	20.2.8P1	Rockwell hardness cone
	b) calculate Rockwell hardness number	20.2.8P2	Weight for indentation
		20.2.8P3	Interpretation of results
		20.2.8P4	Care and maintenance
20.2.8C	<i>Competence</i> The trainee should have the ability to:		<i>Suggested Learning Resources</i> - Equipment Rockwell hardness tester
	i) Carryout Rockwell hardness test		
	ii) Calculate Rockwell hardness number		

20.2.9	SHORE SCLEROSCOPE		c) care and maintain Shore Scleroscope machine
	Theory		
	<i>Specific Objectives</i> By the end of the sub- module unit, the trainee should be able to:	20.2.10P1	<i>Content</i> Scleroscope hardness test
	a) describe the shore scleroscope test	20.2.10P2	Interpreting results
	b) carry out shore scleroscope hardness test	20.2.10P3	Care and maintenance
			<i>Suggested Learning Resources</i> - Equipment - Diamond pointed hammer 2.36g - Scale for rebound
20.2.10C	<i>Competence</i> The trainee should have the ability to carry out shore scleroscope test		
		20.2.11	IZOD IMPACT TEST
	<i>Content</i>		Theory
20.2.9T1	Description		
	- Small diamond pointed hammer	20.2.11T0	<i>Specific Objectives</i> By the end of the sub- module unit, the trainee should be able to:
	- Standard height of fall		a) describe the Izod impact test
	- Graduated scale		b) design a specimen for Izod impact test
20.2.9T2	Scleroscope hardness test		
	Practice		
20.2.9P0	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:	20.2.11C	<i>Competence</i> The trainee should have the ability to:
	a) carry out Shore Scleroscope hardness test		i) Prepare Izod impact test specimen
	b) interpret results		ii) Carryout the Izod impact test
			iii) Interpret results
			iv) Care and maintain Izod impact testing machine

	<i>Content</i>		trainee should be able to:
20.2.11T1	Izod impact test		a) describe the
20.2.11T2	Specimen specifications		Charpy impact test
	Practice		b) prepare a specimen for the Charpy impact test
	<i>Specific Objectives</i>		c) care for and maintain the Charpy impact testing machine
	By the end of the sub module unit, the trainee should be able to:	20.2.11C	<i>Competence</i>
	a) prepare specimen for the Izod Test		The trainee should have the ability to:
	b) carry out the Izod impact test		i) prepare Charpy impact test specimen
	c) interpret results		ii) carryout Charpy impact test
	d) care and maintain the Izod impact testing machine		iii) interpret results
			iv) care for and maintain the Charpy impact testing machine
	<i>Content</i>		
20.2.11P1	Specimen specification		
20.2.11P2	Izod test (Hammer)		
20.2.11P3	Interpretation of results		
20.2.11P4	Care and maintenance		
	<i>Suggested Learning Resources</i>	20.2.12T1	<i>Content</i>
	- Specimen		Specimen specifications
	- Izod impact testing machine (pendulum type)	20.2.12T2	Mounting the specimen on the machine
		20.2.12T3	Application of the load
			Practice
20.2.12	CHARPY IMPACT TEST		<i>Specific Objectives</i>
	Theory		By the end of the sub module unit, the trainee should be able to:
20.2.12P	<i>Specific Objectives</i>		a) prepare the Charpy impact test specimen
	By the end of the sub-module unit, the		

	b) carry out the Charpy impact test	20.2.12T1	<i>Content</i> Creep phenomena
	c) interpret results	20.2.12T2	Specimen
	d) care and maintain the Charpy impact testing machine		- Loading (constant)
			- Measurement of extension at regular intervals
			- Plot the data
			- Analyse
20.2.11P1	<i>Content</i> Specimen specification		Practice
20.2.11P2	Mounting the specimen		
20.2.11P3	Application of the load	20.2.12P0	<i>Specific Objectives</i>
20.2.11P4	Interpretation of results		By the end of the sub module unit, the trainee should be able to:
20.2.11P5	Care and maintenance		a) prepare the specimen
	<i>Suggested Learning Resources</i>		b) carry out the Creep test
	- Specimens		c) analyse results
	- Impact testing machine		
20.2.12	CREEP TEST		
	Theory		
20.2.12T0	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:	20.2.12P1	<i>Content</i> Preparation of specimen
	a) describe creep phenomenon	20.2.12P2	Performance of creep test
	b) explain the procedure of specimen preparation for creep test		- Constant load
			- Plotting data
			- Analysis
			<i>Suggested Learning Resources</i>
			- Loading system
20.2.12C	<i>Competence</i> The trainee should have the ability to:	20.2.13	FATIGUE TEST
	i) Prepare specimen		Theory
	ii) Carryout tests	20.2.13P	<i>Specific Objectives</i>
	Analyze data		By the end of the sub module unit, the trainee

	should be able to:	20.2.14	NON-DESTRUCTIVE TESTS- DYE PENETRANT
	a) describe fatigue phenomena		
	b) prepare the specimen		
	c) mount the specimen		
20.2.13C	<i>Competence</i> The trainee should have the ability to prepare a specimen and carryout a fatigue tests	20.2.12T0	<i>Specific Objectives</i> By the end of the module-unit, the trainee should be able to:
	<i>Content</i>		a) describe the procedure of carrying out dye penetrant flaw detection test
20.2.13T1	Fatigue phenomena		b) explain the procedure for interpreting results for dye penetrant flaw detection test
20.2.13T2	Specimen preparation		
20.2.13T3	Mounting of specimen - Testing		
	Practice		
20.2.13P1	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:	20.2.14C	<i>Competence</i> The trainee should have the ability to:
	a) prepare specimen for fatigue test		i) Clean and prepare specimen
	b) carry out the fatigue test		ii) Immerse work in penetrant
	c) analyse the results		iii) Apply developer iv) Interpret results
	<i>Content</i>		<i>Content</i>
20.2.13P1	Preparation of specimen	20.2.14T1	Procedures for performing dye penetrant flaw detection test
20.2.13P2	Fatigue test		- Dye penetrant
20.2.13P3	Result analysis		- Developer
	<i>Suggested Learning Resources</i>	20.2.14T2	Interpretation of results
	- Fatigue testing machine		

	Practice	20.2.15T	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) describe the magnetic powder flaw detection test b) interpret results
20.2.12P0	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) clean and prepare the specimen for dye penetrant flaw detection test b) apply developer for dye penetrant flaw detection test c) interpret results for dye penetrant flaw detection test		
		20.2.15C	<i>Competence</i> The trainee should have the ability to: i) magnetize work piece ii) analyze powder distribution
			<i>Content</i>
20.2.14P1	<i>Content</i> Specimen preparation - application of dye penetrant - cleaning off excess penetrant	20.2.15T1	Magnetic powder flaw detection test - Application of magnetic powder
20.2.14P2	Dye penetrant	20.2.15T3	Analysis of powder distribution
20.2.14P3	Application of developer for dye penetrant flaw detection test		Practice
20.2.14P4	Interpretation of results for dye penetrant flaw detection test	20.2.15P	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to: a) magnetise the work piece b) apply magnetic powder c) interpret results
	<i>Suggested Learning Resources</i> - Specimen - Dye penetrant - Developer		
20.2.15	MAGNETIC PARTICLE		<i>Content</i>
	Theory	20.2.15P1	Electromagnet
		20.2.15P2	Application of magnetic powder

20.2.15P3 Interpretation of results
Analysis of powder
distribution

*Suggested Learning
Resources*

- Electromagnet
- Magnetic powder
- Ferrous specimen

20.2.16 EDDY CURRENT

Theory

20.2.16T0 *Specific Objectives*
By the end of the sub-
module unit, the
trainee should be able
to:

- describe the eddy
current flow
detection test
- care for and
maintain the eddy
current flow
detection
equipment

20.2.16C *Competence*

- The trainee should
have the ability to:-
- Use eddy current
to detect flaws
 - Interpret results
 - Care for and
maintain eddy
current flow
detection
equipment

Content

20.2.16T1 Eddy current flow
detection test

- Search coil

- Means for motion
- Galvanometer
- Means of passing
a current through the
work piece

20.2.16T2 Care and maintenance of
eddy current flow
detection test equipment

Practice

20.2.16P *Specific Objectives*
By the end of the sub-
module unit, the
trainee should be able
to:

- carry out Eddy
current flow
detection tests
- analyse results

Content

20.2.16P1 Search coil
20.2.16P2 Means for motion
20.2.16P3 Galvanometer
20.2.16P4 Means of passing a
current through the
work piece

*Suggested Learning
Resources*

- Coil
- Galvanometer
- Means of passing
current through the
work piece

20.2.17	X-RAY RADIOGRAPHY		b) carry out the X Ray radiography test c) interpret results d) observe safety
	Theory		
20.2.17T	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:		<i>Content</i>
	a) describe the X-Ray radiography flaw detection method	20.2.17P1	Preparation of X Ray room
	b) observe safety in X-Ray room	20.2.17P2	Film exposure
	c) care for and maintain the X-Ray machine	20.2.17P3	Film development and interpretation
			<i>Suggested Learning Resources</i> - X-ray tube - Film development facilities - Safety gear
20.2.17C	<i>Competence</i> The trainee should have the ability to:	20.2.18	GAMMA - RAY RADIOGRAPHY
	i) prepare x-ray room		Theory
	ii) expose and develop film		<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:
	iii) interpret film		a) describe electromagnetic radiation
	iv) observe safety		b) select appropriate gamma ray source c) observe safety
	<i>Content</i>		
20.2.17T1	X-ray tube		
20.2.17T2	Film exposure		
20.2.17T3	Film development and interpretation		
	Practice		
20.2.17P	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:	20.2.18C	<i>Competence</i> The trainee should have the ability to:
	a) prepare the X Ray room		i) Describe electromagnetic radiation

	<ul style="list-style-type: none"> ii) Select appropriate isotope iii) Set-up isotope and test stations iv) Exposure and development 		<ul style="list-style-type: none"> - Film exposure and development equipment - Safety gear
	Observe safety	20.2.19	ULTRASONIC TESTING
	<i>Content</i>		Theory
20.2.18T1	Electromagnetic radiation		<i>Specific Objectives</i>
20.2.18T2	Gamma-ray source		By the end of the sub-module unit, the trainee should be able to:
20.2.18T3	Gamma-ray test		a) describe acoustics
	- Exposure		b) describe the set-up for ultrasonic testing equipment
	- Development		c) interpret reading on Cathode Ray Tube (C.R.T)
	- Interpretation		
20.2.18T4	Safety		
	Practice		
20.2.18C	<i>Specific Objectives</i>		
	By the end of the sub-module unit, the trainee should be able to:	20.2.19C	<i>Competence</i>
	a) select appropriate Gamma ray source		The trainee should have the ability to:-
	b) perform Gamma ray test		i) use acoustics to detect internal flaws
	c) interpret result		ii) interpret results
	d) observe safety		iii) care for and maintain ultrasonic testing equipment
	<i>Content</i>		
20.2.18P1	Gamma ray source		<i>Content</i>
20.2.18P2	Gamma ray test	20.2.19T1	Ultral High Frequency (U.H.F) sound generator
	- Exposure		20.2.19T2
	- Development		Signal transmitter/receiver
	- Interpretation	24.2 19T3	Cathode Ray Oscilloscope (.C.R.T.)
20.2.18P3	Safety		
	<i>Suggested Learning Resources</i>		
	- Gamma ray equipment		

20.2.19C	<p>Practice</p> <p><i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <p>a) set up Ultrasonic testing equipment b) carry out Ultrasonic test c) interpret results d) care and maintain the Ultrasonic testing equipment</p>	<p>c) describe the process of sulphur printing</p>
20.2.19P1	<p><i>Content</i> Ultra high frequency</p>	<p>20.2.20C <i>Competence</i> The trainee should have the ability to:-</p> <p>i) Carry out visual examination ii) Interpret results</p>
20.2.19P2	<p>Signal transmitter/receiver</p>	<p><i>Content</i> 20.2.20T1 Naked eye/simple lens examination</p> <ul style="list-style-type: none"> - Fatigue failure - Slag inclusions - Blow holes - Directional properties
20.2.19P3	<p>Cathode Ray Tube</p>	<p>20.2.20T2 Grinding/polishing 20.2.20T3 Etching reagents 20.2.20T4 Accessories for sulphur printing</p>
20.2.20	<p>MACRO EXAMINATION Theory</p> <p><i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <p>a) explain the visual examination on fractured surfaces b) describe the method of preparing and etching the specimen</p>	<p>Practice</p> <p>20.2.20C <i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:</p> <p>a) carry out visual examination on fractured surfaces b) prepare and etch specimen c) carry out sulphur printing d) interpret results</p>
		<p><i>Content</i> 20.2.20P1 Naked eye/simple lens examination 20.2.20P2 Grinding/polishing</p>

20.2.20P3	Etching re- agents		metallurgical
20.2.20P4	Sulphur printing		microscope
	<i>Suggested Learning Resources</i>		<i>Content</i>
	- Simple lens	20.2.21T1	Selection of specimen
	- Grinding/polishing materials	20.2.21T2	Grinding and polishing
	- Etching reagents	20.2.21T3	Mounting of specimen
	- Silver bromide paper	20.2.21T4	Etching the specimen
		20.2.21T5	Examination of the specimen with metallurgical microscope
20.2.21	MICRO EXAMINATION		Practice
	Theory	20.2.21P	<i>Specific Objectives</i>
20.2.21T	<i>Specific Objectives</i> By the end of the module unit, the trainee should be able to:		By the end of the sub-module unit, the trainee should be able to:
	a) outline factors to be considered in specimen selection		a) carry out specimen selection
	b) describe the process of grinding and polishing		b) perform grinding and polishing
	c) describe the procedure for mounting the specimen		c) mount the specimen
			d) etch the specimen
			e) exam the specimen using microscope
			f) interpret results
			<i>Content</i>
20.2.21C	<i>Competence</i> The trainee should have the ability to:	20.2. 21P1	Selection of specimen
	i) Select specimen	20.2. 21P2	Grinding and polishing
	ii) Grind and polish specimen	20.2. 21P3	Mounting the specimen
	iii) Mount the specimen	20.2. 21P3	Etching the specimen
	iv) Etch the specimen	20.2. 21P4	Examination of specimen using metallurgical microscope
	v) Examine the specimen with	20.2. 21P5	Interpretation of results
			<i>Suggested Learning Resources</i>
			- Specimen

- Grinding and polishing equipment

- Etching reagents

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