

**REPUBLIC OF KENYA**

**COMPETENCY-BASED MODULAR CURRICULUM**

**FOR**

**MECHANICAL PLANT TECHNOLOGY**

**KNQF LEVEL 6**

**PROGRAMME ISCED CODE: 0715554A**

©2025

All rights reserved. No part of this Curriculum may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods without the prior written permission of …….., except in the case of brief quotations embodied in critical reviews and certain other non-commercial uses permitted by copyright law. For permission requests, write to the Council Secretary/CEO/Chief Principal at the address below:

# FOREWORD

The provision of quality education and training is fundamental to the Government’s overall strategy for social and economic development. Quality education and training contribute to the achievement of Kenya’s development blueprint and sustainable development goals.

Reforms in the education sector are necessary to achieve Kenya Vision 2030 and meet the provisions of the Constitution of Kenya 2010. The education sector had to be aligned to the Constitution, and this resulted in the formulation of the Policy Framework for Reforming Education and Training in Kenya (Sessional Paper No. 14 of 2012). A key feature of this policy is the radical change in the design and delivery of TVET training. This policy document requires that training in TVET be competency-based, curriculum development be industry-led, certification be based on demonstration of competence, and the mode of delivery allow for multiple entry and exit in TVET programmes.

These reforms demand that Industry takes a leading role in curriculum development to ensure the curriculum addresses its competence needs. It is against this background that this curriculum has been developed. For trainees to build their skills on foundational hands-on activities of the occupation, units of learning are grouped in modules. This has eliminated duplication of content and streamlined exemptions based on skills acquired as a trainee progresses in the up-skilling process, while at the same time allowing trainees to be employable in the shortest time possible through the acquisition of part qualifications.

It is my conviction that this curriculum will play a great role in developing competent human resources for the plant technology Sector’s growth and development.

**PRINCIPAL SECRETARY**

**STATE DEPARTMENT FOR TVET**

**MINISTRY OF EDUCATION**

# PREFACE

Kenya Vision 2030 aims to transform Kenya into a newly industrializing middle-income country, providing high-quality life to all its citizens by the year 2030. Kenya intends to create globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy through lifelong education and training. TVET has a responsibility to facilitate the process of inculcating knowledge, skills, and worker behaviour necessary for catapulting the nation to a globally competitive country, hence the paradigm shift to embrace Competency-Based Education and Training (CBET).

TVET Act, CAP 210A and Sessional Paper No. 1 of 2019 on Reforming Education and Training in Kenya for Sustainable Development emphasized the need to reform curriculum development, assessment, and certification. This called for a shift to CBET to address the mismatch between skills acquired through training and skills needed by industry, as well as increase the global competitiveness of the Kenyan labour force.

This curriculum has been developed in adherence to the Kenya National Qualifications Framework and CBETA standards and guidelines. The curriculum is designed and organized into Units of Learning with Learning Outcomes, suggested delivery methods, learning resources, and methods of assessing the trainee’s achievement. In addition, the units of learning have been grouped in modules to concretize the skills acquisition process and streamline upskilling.

I am grateful to all expert trainers and everyone who played a role in translating the Occupational Standards into this competency-based modular curriculum.

# ACKNOWLEDGEMENT

This curriculum has been designed for competency-based training and has independent units of learning that allow the trainee flexibility in entry and exit. In developing the curriculum, significant involvement and support were received from expert trainers, institutions and organizations.

I recognize with appreciation the role of the Mechanical Plant National Sector Skills Committee (NSSC) in ensuring that competencies required by the industry are addressed in the curriculum. I also thank all stakeholders in the plant technology sector for their valuable input and everyone who participated in developing this curriculum.

I am convinced that this curriculum will go a long way in ensuring that individuals aspiring to work in the plant technology Sector acquire competencies to perform their work more efficiently and effectively.

# TABLE OF CONTENTS

[FOREWORD 2](#_Toc197134469)

[PREFACE 3](#_Toc197134470)

[ACKNOWLEDGEMENT 4](#_Toc197134471)

[TABLE OF CONTENTS 5](#_Toc197134472)

[ABBREVIATIONS AND ACRONYMS 7](#_Toc197134473)

[KEY TO UNIT ISCED CODE 8](#_Toc197134474)

[COURSE OVERVIEW 9](#_Toc197134475)

[MODULE I 13](#_Toc197134476)

[COMMUNICATION SKILLS 14](#_Toc197134477)

[WORKSHOP TECHNOLOGY 19](#_Toc197134478)

[MECHANICAL PUMPS AND COMPRESSORS INSTALLATION 38](#_Toc197134479)

[MECHANICAL PUMPS AND COMPRESSORS MAINTENANCE 70](#_Toc197134480)

[MODULE II 93](#_Toc197134481)

[WORK ETHICS AND PRACTICES 94](#_Toc197134482)

[TECHNICAL DRAWING 100](#_Toc197134483)

[ELECTRICAL AND ELECTRONICS PRINCIPLES 106](#_Toc197134484)

[HYDRAULIC AND PNEUMATIC SYSTEMS INSTALLATION 125](#_Toc197134485)

[HYDRAULIC AND PNEUMATIC SYSTEMS MAINTENANCE 163](#_Toc197134486)

[MODULE III 192](#_Toc197134487)

[ENTREPRENEURIAL SKILLS 193](#_Toc197134488)

[APPLIED MATHEMATICS 199](#_Toc197134489)

[MATERIAL HANDLING SYSTEM INSTALLATION 206](#_Toc197134490)

[MATERIAL HANDLING SYSTEMS MAINTENANCE 240](#_Toc197134491)

[MODULE IV 280](#_Toc197134492)

[DIGITAL LITERACY 281](#_Toc197134493)

[MECHANICAL SCIENCE 300](#_Toc197134494)

[REFRIGERATION AND AIR CONDITIONING SYSTEM INSTALLATION 325](#_Toc197134495)

[REFRIGERATION AND AIR CONDITIONING SYSTEMS MAINTENANCE 331](#_Toc197134496)

[MODULE V 349](#_Toc197134497)

[ENGINEERING MATHEMATICS 350](#_Toc197134498)

[THERMODYNAMICS PRINCIPLES 357](#_Toc197134499)

[FLUID MECHANICS 368](#_Toc197134500)

[STEAM SYSTEM INSTALLATION 375](#_Toc197134501)

[MODULE VI 397](#_Toc197134502)

[ENGINEERING MECHANICS 398](#_Toc197134503)

[COMPUTER AIDED DRAWING 405](#_Toc197134504)

[BOILER AND STEAM SYSTEM MAINTENANCE 417](#_Toc197134505)

[MODULE VII 437](#_Toc197134506)

[ELECTRONICS AND CONTROL PRINCIPLES 438](#_Toc197134507)

[MECHANICAL PLANT SYSTEM DESIGN 453](#_Toc197134508)

# ABBREVIATIONS AND ACRONYMS

AC Alternating Current

CAD Computer Aided Design

CBET Competency Based Education and Training

DC Direct Current

HDMI High-Definition Multimedia Interface

I/O Input/ Output

ICT Information Communication Technology

ISO International Organization of Standardization

NEMA National Environment Management Authority.

PPE Personal Protective Equipment

ICT Information and Communication Technology

KNQF Kenya National Qualifications Framework

CPU Central Processing Unit

DVDs Digital Versatile Discs

3D Three-Dimensional

A/C Air conditioning

OSH Occupational Safety and Health

HVAC Heating, Ventilation, and Air Conditioning

PLC Programmable Logic Controller

DVI Digital Visual Interface

RAM Random Access Memory

USB Universal Serial Bus

VGA Video Graphics Array

# KEY TO UNIT ISCED CODE



# COURSE OVERVIEW

Mechanical plant technology level 6 consists of competencies that an individual must achieve to perform maintenance and installation of mechanical plant systems. It involves install pumps and compressors, maintain pump and compressors, install hydraulic and pneumatic systems, maintain hydraulic and pneumatic systems, install refrigeration and air conditioning system, maintain refrigeration and air conditioning system, install material Handling System and maintain material Handling System, mechanical plant system, install steam system, and maintain boiler and steam system.

**Summary of Units of Learning**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | | | |
| **Unit code** | **Unit name** | | **Duration**  **in**  **Hours** | **Credit factor** | |
| **MODULE I** | | | | | |
| 0031 541 01A | Communication skills | | **40** | **4.0** | |
| 0715 451 02A | Workshop Technology | | **120** | **12.0** | |
| 0715 451 03A | Mechanical pumps and compressors installation | | **120** | **12.0** | |
| 0715 451 04A | Mechanical pumps and compressors maintenance | | **120** | **12.0** | |
| **MODULE II** | | | | | |
| 0417 541 05A | Work ethics and practices | | **40** | **4.0** | |
| 0732 451 06A | Technical Drawing | | **80** | **8.0** | |
| 0713 441 07A | Electrical and Electronics Principles | | **80** | **8.0** | |
| 0715 451 08A | Hydraulic and pneumatic systems installation | | **100** | **10.0** | |
| 0715 451 09A | Hydraulic and pneumatic systems maintenance | | **120** | **12.0** | |
| **MODULE III** | | | | | |
| 0413 541 10A | Entrepreneurial skills | | **40** | **4.0** | |
| 0541 441 11 A | Applied Mathematics | | **80** | **8.0** | |
| 0715 451 12A | Material handling systems installation | | **120** | **12.0** | |
| 0715 451 13A | Material handling systems maintenance | | **120** | **12.0** | |
| **MODULE IV** | | | | | |
| 0611 541 14A | Digital literacy | | **40** | **4.0** | |
| 0715 441 15A | Mechanical Science Principles | | **80** | **8.0** | |
| 0715 451 16A | Refrigeration and air conditioning systems installation | | **120** | **12.0** | |
| 0715 451 17A | Refrigeration and air conditioning systems maintenance | | **120** | **12.0** | |
| **MODULE V** | | | | | |
| 0541 541 18A | Engineering Mathematics | | **100** | **10.0** | |
| 0715 541 19A | Thermodynamics Principles | | **90** | **9.0** | |
| 0715 541 20A | Fluid Mechanics Principles | | **90** | **9.0** | |
| 0715 551 21A | Steam system installation | | **200** | **20.0** | |
|  | **MODULE VI** | |  |  | |
| 0715 541 22A | Engineering Mechanics Principles | | **80** | **8.0** | |
| 0732 551 23A | Computer Aided Drawing | | **120** | **12.0** | |
| 0715 551 24A | Boiler and steam system maintenance | | **200** | **20.0** | |
| **MODULE VII** | | | | | |
| 0713 541 25A | Electronics and Control Principles | | **160** | **16.0** | |
| 0715 551 26A | Mechanical plant system design | | **200** | **20.0** | |
| **Sub Total** | | **2780** | | **278.0** |
| Industrial Attachment | | 480 | | 48.0 |
| **GRAND TOTAL** | | **3260** | | **326.0** |

**Entry Requirements**

An individual entering this course should have any of the following minimum requirements:

1. Kenya Certificate of Secondary Education (KCSE) or its equivalent.

**OR**

1. Equivalent qualifications as determined by TVETA.

**Trainer Requirements**

A trainer for this course shall meet the following requirements:

1. Possession of at least KNQF Level 7 in mechanical plant technology or related trade area;
2. Licensed by TVETA
3. Registered by Engineer Board of Kenya (E.B.K) or Kenya Engineering Technology Registration Board (KETRB).

**Industry Training**

An individual enrolled in this course will be required to undergo Industry training for a minimum period of 480 hours in mechanical plant sector. The industrial training may be taken after completion of all units for those pursuing the full qualification or be distributed equally in each unit for those pursuing part qualification. In the case of dual training model, industrial training shall be as guided by the dual training policy.

**Competence Assessment**

1. An individual enrolled in this course shall be assessed for competence through formative and summative assessments.
2. During formative assessment all performance criteria shall be assessed based on performance criteria weighting.
3. Number of formative assessments shall minimally be equal to the number of elements in a unit of competency.
4. During summative assessment basic and common units may be integrated in the core units or assessed as discrete units.
5. Theoretical and practical weighting for each unit of learning shall be as follows:
   1. 30:70 for the units in modules I, II, III and IV; and
   2. 40:60 for the units in modules V, VI and VII.
6. Formative and summative assessments shall be weighted at 60% and 40% respectively in the overall unit of learning score.
7. For a candidate to be declared competent in a unit of competency, the candidate must meet the following conditions:
8. Obtained at least 40% in theory assessment in formative and summative assessments.
9. Obtained at least 60% in practical assessment in formative and summative assessment where applicable.
10. Obtained at least 50% in the weighted results between formative assessment and summative assessment where the former constitutes 60% and the latter 40% of the overall score.
11. Assessment performance rating for each unit of competency shall be as follows:

|  |  |
| --- | --- |
| **MARKS** | **COMPETENCE RATING** |
| 80 -100 | Attained Mastery |
| 65 - 79 | Proficient |
| 50 - 64 | Competent |
| 49 and below | Not Yet Competent |
| Y | Assessment Malpractice/irregularities |

1. Assessment for Recognition of Prior Learning (RPL) may lead to award of part and/or full qualification.

**Certification**

A candidate will be awarded a Certificate of Competency upon demonstration of competence in a core Unit of Competency. To be awarded **Kenya National TVET Certificate** in Mechanical Plant Technology Level 6 the candidate must demonstrate competence in all the Units of Competency as given in the qualification pack. A Statement of Attainment certificate may be awarded upon demonstration of competence in a certifiable element within a unit.

The certificates will be awarded by the…………..

# MODULE I

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| 0031 541 01A | Communication skills | 40 | 4.0 |
| 0715 451 02A | Workshop Technology | 120 | 12.0 |
| 0715 451 03A | Mechanical pumps and compressors installation | 120 | 12.0 |
| 0715 451 04A | Mechanical pumps and compressors maintenance | 120 | 12.0 |

## **COMMUNICATION SKILLS**

**ISCED UNIT CODE:** 0031 441 01A

**Duration of Unit**: 40 Hours

**Relationship with Occupational Standards**

This unit addresses the Unit of Competency: Apply Communication Skills

**Unit Description**

This unit covers the competencies required to apply communication skills. It involves applying communication channels, written, non-verbal, oral, and group communication skills.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO.** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Apply communication channels. | **10** |
|  | Apply written communication skills. | **12** |
|  | Apply non-verbal skills. | **4** |
|  | Apply oral communication skills. | **4** |
|  | Apply group communication skills. | **10** |
|  | **TOTAL** | **40** |

**Learning Outcomes, Content, and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply communication channels. | * 1. Communication process   2. Principles of effective communication   3. Channels/medium/modes of communication   4. Factors to consider when selecting a channel of communication   5. Barriers to effective communication   6. Flow/patterns of communication   7. Sources of information   8. Organizational policies | * Oral questions * Written assessment * Observation * Portfolio of Evidence * Practical assessment * Third party report |
| 1. Apply written communication skills. | * 1. Types of written communication   2. Elements of communication   3. Organization requirements for written communication | * Oral assessment * Written assessment * Observation * Portfolio of Evidence * Practical assessment * Third party report |
| 1. Apply non-verbal skills. | * 1. Utilize body language and gestures   2. Apply body posture   3. Apply workplace dressing code | * Oral assessment * Written assessment * Observation * Portfolio of Evidence * Practical assessment * Third party report |
| 1. Apply oral communication skills. | * 1. Types of oral communication pathways   2. Effective questioning techniques   3. Workplace etiquette   4. Active listening | * Oral assessment * Written assessment * Observation * Portfolio of Evidence * Practical assessment * Third party report |
| 1. Apply group communication skills. | * 1. Establishing rapport      1. Facilitating resolution of issues      2. Developing action plans      3. Group organization techniques      4. Turn-taking techniques      5. Conflict resolution techniques      6. Team-work | * Oral assessment * Written assessment * Observation * Portfolio of Evidence * Practical assessment |

**Suggested Methods of Instruction**

* Discussion
* Roleplaying
* Simulation
* Direct instruction
* Demonstration
* Field trips

**Recommended Resources for 30 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive texts books on Communication Skills | 30 pcs | 1:1 |
|  | Mobile Phones | Smartphone for use by trainees | 30 pcs | 1:1 |
|  | Internet connection | Internet connection to aid communication between trainees |  |  |
|  | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
|  | Templates | Templates for creating various documents e.g. CV, Cover Letter, minutes, reports etc. | 30 | 1:1 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
|  | Lecture/Theory Room  /Learning Resource  Area\* | Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m) | 1 | 1:30 |
|  | Computer Laboratory | Equipped with at least 30 functional computers with internet connectivity and the following software:   * + - Windows/ Linux/ Macintosh Operating System     - Microsoft Office Software     - Google Workspace Account     - Antivirus Software | 30 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
|  | Printing Papers | A4 and A3 Printing papers suitable for the task | Enough |  |
|  | Flashcards | For carrying out various activities by trainees | Enough |  |
|  | Flipcharts | Sufficient for group work activities and displaying | Enough |  |
|  | Whiteboard Marker Pens | Dry-erase markers for trainers use. Assorted colours | Enough |  |

## **WORKSHOP TECHNOLOGY**

**UNIT CODE:** 0715 441 02A

**Duration of Unit:** 120 Hours

**Relationship with Occupational Standards:**

This unit addresses the unit of competency: Apply workshop technology principles

**Unit description**

This unit describes the competencies required by a technician in order to apply workshop practice in their work. It includes applying workshop safety, material science principles and workshop tools and equipment, carryout metal joining processes. It also includes performing material preservation and housekeeping.

**Summary of Learning Outcome**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcome** | **DURATION (HOURS)** |
|  | Apply workshop safety | **10** |
|  | Apply material science principles | **30** |
|  | Apply workshop tools and equipment | **30** |
|  | Perform material preservation | **20** |
|  | Carry out metal joining processes | **20** |
|  | Perform housekeeping | **10** |
|  | **TOTAL** | **120** |

**Learning Outcomes, Content and suggested assessment methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** | |
| --- | --- | --- | --- |
| 1. Apply workshop safety | * 1. Workshop safety      1. Workshop safety definition      2. Types and uses of PPE’s   2. Emergency responses steps      1. Common emergencies         1. Fire         2. Chemical spills         3. Injuries   3. Fire safety      1. Fire extinguishers types and uses      2. Flammable materials identification      3. Fire prevention   4. Safe handling and disposal of chemicals and materials      1. Chemical hazard identification      2. Safe handling procedure      3. Storage and labelling of chemicals      4. Chemical disposal procedures      5. Emergency response for chemical exposure   5. Identifying and marking hazardous zones      1. Common hazardous zones         1. Flammable zones         2. High traffic zones         3. Electrical hazard zones         4. Chemical storage areas   6. Work area organization and maintenance      1. Setting up      2. Proper storage and labelling of tools and equipment   7. Workplace hazards      1. Physical hazards         1. Noises         2. Vibration         3. Heat         4. Sharp object      2. Chemical hazards         1. Fuels         2. Oils         3. Cleaning agents      3. Electric hazards         1. Live wires         2. Batteries         3. Electrical systems   8. Workshop accidents, causes and prevention      1. Near Accident      2. Trivial Accident      3. Minor Accident      4. Serious Accident      5. Fatal Accident: | * Written tests. * Practical * Project * Portfolio of evidence * Third party report |
| 1. Apply material science principles | * 1. Material science principles      1. Definition      2. Importance of material science in engineering   2. Engineering materials Classification and characteristics      1. Metals      2. Polymers      3. Ceramics   3. Properties of engineering materials      1. Mechanical properties         1. Strength         2. Hardness         3. Toughness         4. Malleability         5. Ductility         6. Rigidity      2. Thermal properties         1. Specific heat         2. Thermal expansion      3. Chemical properties         1. Corrosion resistance      4. Electrical properties         1. Electrical conductivity         2. Insulation properties   4. Material selection for engineering materials      1. Factors to consider   5. Material handling safety      1. Handling metals and alloys      2. Chemical and fuels      3. Safety measures for plastics and composites      4. Electrical safety and conductive materials | * Practical * Project * Portfolio of evidence * Third party report * Written tests. |
| 1. Apply workshop tools and equipment | * 1. Tools and equipment safety and maintenance practices      1. Inspection      2. Safe handling techniques   2. Technical drawing interpretation      1. Purpose of assembly drawing      2. Bill of quantity      3. Assembly instructions   3. Workshop tools and equipment uses and maintenance      1. Measuring tools         1. Tape measure         2. Steel rule         3. Callipers         4. Micrometre gauge         5. Protractor         6. Spirit level         7. Dial indicator         8. Torque wrench      2. Marking out tools         1. Scriber         2. Marking gauge         3. Combination square      3. Cutting tools         1. Hacksaw         2. Chisel         3. Files         4. Scissors      4. Fitting tools         1. Wrenches         2. Sockets         3. Pliers         4. Hammers         5. Punch         6. Tap and die      5. Forging tools         1. Anvil         2. Hammers         3. Tongs         4. Swage block      6. Sheet metal tools         1. Shears         2. Tin snips         3. Rivet gun         4. Vise      7. Workshop machine         1. Grinding machine         2. Arc welding machine         3. Gas welding machine         4. Drilling machine | * Written tests * Practical * Project * Portfolio of evidence * Third party report |
| 1. Perform material preservation | * 1. Observation of safety      1. Safety gears      2. Machine operation manuals   2. Metal joining methods      1. Welding         1. Arc welding         2. Gas welding      2. Riveting      3. Fastening   3. Material preparation      1. Measuring      2. Marking out   4. Process of metal finishing      1. Grinding      2. Filing      3. Polishing | * Practical * Project * Portfolio of evidence * Third party report * Written tests. |
| 1. Carry out metal joining processes | * 1. Material preservation      1. Definition of material preservation      2. Importance of material preservation      3. Storage techniques      4. Material preservation safety measures   2. Common preservation methods      1. Protective coatings      2. Chemical treatments      3. Controlled storage conditions      4. Proper handling techniques      5. Cleaning and maintenance   3. Material preservation procedure      1. Work requirements assessment      2. Selection of appropriate preservation method | * Practical * Project * Portfolio of evidence * Third party report * Written tests. |
| 1. Perform housekeeping | * 1. Workshop layout      1. Types of workshop layout         1. Fixed layout         2. Process layout         3. Line layout         4. Operation layout         5. Combination/group layout      2. Safety signs      3. Emergency exits   2. Management inventory      1. Types of inventories      2. Record keeping      3. Job card preparation   3. Maintenance schedules      1. Goals of maintenance schedule         1. Reactive         2. Equipment failure         3. Maintenance backlog      2. Types of maintenance         1. Preventive maintenance         2. Corrective maintenance         3. Condition based maintenance         4. Predictive maintenance         5. Break down maintenance   4. Housekeeping      1. Definition      2. Importance of housekeeping   5. Housekeeping activities and their importance      1. Tool and equipment organization      2. Work area cleanliness      3. Safe handling and disposal of hazardous materials      4. Inspection and maintenance of equipment      5. Personal protective equipment management      6. Air and ventilation maintenance      7. Incident prevention and reporting   6. Housekeeping tools and equipment      1. Uses and maintenance         1. Brooms and brushes         2. Dustpans and squeegees         3. Vacuum cleaners         4. Mops and mop buckets         5. Waste bins and recycling containers   7. Housekeeping materials      1. Cleaning cloths and rags      2. Cleaning agents and solvents      3. Lubricants      4. Gloves and PPE’s      5. Disposable bags and liners   8. Workshop waste sorting and disposal      1. Types of waste         1. General waste         2. Hazardous waste         3. Recyclable waste         4. Organic waste         5. e-waste      2. Waste sorting procedure         1. Designated bins for different types of waste         2. Sorting by material         3. Pre-sorting hazardous waste      3. Hazardous waste disposal         1. Chemical waste         2. Used oil and solvents         3. Paints and finishes | * Practical * Project * Portfolio of evidence * Third party report * Written tests. |

**Suggested Delivery Methods**

* Demonstration by trainer
* Discussions
* Practical
* Exercises
* Industrials visits
* Simulation

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |
|  | Textbooks | Comprehensive textbooks on Manual Metal Arc Welding (MMAW) | 25 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area and welding booths approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Welding helmets | Protecting the eyes while providing a clear view of the weld. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Raw materials | Steel and aluminum  Plates   * 4mm thickness. * 6 mm thickness.   Pipes   * 4 mm thickness * 6 mm thickness |  |  |
|  | Arc welding electrodes | Electrodes used in Arc welding | 20 packets |  |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment | Enough |  |
|  | Cleaning detergents | General degreasers | 10 liters |  |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** |
| **Measuring tools** | | | | |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Collet | Hold the tungsten electrode in place | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** |
|  | Arc welding machine |  | 5 | 1:5 |
|  | Gas welding machine |  | 5 | 1:5 |
|  | Firefighting equipment | for ensuring safety in workshops where fire hazards are present, such as sparks | 3 |  |
|  | Welding gun | Feeds the filler wire into the weld pool | 5 | 1:5 |
|  | Drilling machine |  |  |  |
| **F** | **Reference Materials** |
| 1 | Working drawings |  |  |  |
| 2 | Operation sheets/ templates |  |  |  |
| 3 | Welding Procedure Specifications (WPS) |  | 25 pcs | 1:1 |
| 4 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 6 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **MECHANICAL PUMPS AND COMPRESSORS INSTALLATION**

**UNIT CODE:** 0715 551 03A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: mechanical pumps and compressors installation

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train pump and compressors installation. The learning outcomes shall enable the learner to prepare for installation of pumps and compressors, mount pumps and compressor system, assemble pump and compressor system and test and commission pumps and compressor system.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for installation of pumps and compressors | **30** |
|  | Mount pump and compressor system | **30** |
|  | Assemble pump and compressor system | **30** |
|  | Test and commission pump and compressor system | **30** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare for installation of pumps and compressors | * 1. Introduction to Pump and Compressor Installation      1. Overview of Pumps and Compressors         1. Functions of pumps and compressors in industrial applications.         2. Types of pumps (centrifugal, positive displacement) and compressors (reciprocating, rotary).         3. Role of pumps and compressors in fluid systems and air systems.      2. Importance of Proper Installation         1. Understanding the impact of proper installation on system performance and efficiency.         2. Common issues arising from improper installation (vibration, leaks, efficiency loss).      3. Key Considerations for Installation         1. Site preparation, alignment, and mounting.         2. Verification of system specifications and components.   2. Adhering to Safety Procedures According to OSH Act, 2007      1. Overview of OSH Act, 2007         1. Key safety requirements for machinery installation under the OSH Act.         2. Employer and employee obligations in maintaining workplace safety during installation.      2. Safety Procedures During Installation         1. Lockout/tag out (LOTO) procedures.         2. Correct handling of tools and materials.         3. Use of personal protective equipment (PPE): gloves, helmets, eye protection, hearing protection, and safety boots.         4. Preventing electrical hazards and ensuring proper grounding.         5. Lifting and handling heavy equipment safely (using cranes, hoists, or manual lifting techniques).      3. Common Installation Hazards         1. Moving parts, electrical hazards, and pressurized systems.         2. Falls, slips, and trips during installation.         3. Properly securing tools and materials to avoid accidents.   3. Site Conditions and Installation Requirements Assessment      1. Installation requirements * Site assessment * Regulatory approvals * NEMA * NCA * Safety regulations and standards * System design * Structural support * Electrical and power requirements * Automation and control systems * Equipment installation * Integration with existing system * Material flow consideration * Accessibility and maintenance * Training and documentation * Emergency procedures   + 1. Site Preparation for Installation        1. Evaluating the physical space for installation: location, accessibility, and foundation.        2. Ensuring proper ventilation, drainage, and electrical supply.        3. Site-specific safety considerations (space constraints, high-temperature environments, etc.).     2. Understanding Manufacturer’s Specifications        1. Reviewing the manufacturer's installation manual and specifications.        2. Identifying the specific requirements for pump and compressor mounting, piping, and electrical connections.        3. Understanding environmental considerations such as ambient temperature, humidity, and the presence of corrosive substances.     3. Verification of Installation Conditions        1. Measuring floor space and ensuring the area can accommodate equipment dimensions.        2. Checking alignment and foundation requirements.        3. Ensuring that required utilities (electricity, water, compressed air) are accessible.   1. Verifying Pump and Compressor Specifications According to Design Requirements      1. Key Specifications to Verify         1. Pump and compressor capacity (flow rate, pressure, power consumption).         2. Electrical and mechanical specifications (motor size, voltage, horsepower).         3. Material selection for components (corrosion resistance, durability).         4. Alignment and tolerance requirements for pumps and compressors.      2. Comparing Manufacturer’s Specifications to Design Requirements         1. Ensuring the equipment meets the required performance standards and operational conditions.         2. Identifying discrepancies and ensuring corrective actions (e.g., choosing the correct motor size, pump head, or compressor capacity).      3. Safety Features and Compliance         1. Verifying that safety components (pressure relief valves, seals, guards) are in place and functioning.         2. Ensuring compliance with local and international safety standards.   2. Selecting and Assembling Tools, Equipment, and Materials for Installation      1. Essential Tools and Equipment for Installation         1. Common tools: wrenches, torque wrenches, alignment tools, lifting equipment, safety gear.         2. Power tools: drills, grinders, and saws.         3. Specific installation aids for pumps/compressors: mounting plates, brackets, alignment instruments.      2. Material Selection         1. Seals, gaskets, and fasteners: Selecting materials that are compatible with the pump/compressor and system fluids.         2. Piping, hoses, and tubing: Ensuring proper materials for fluid handling systems.         3. Electrical wiring and connections: Ensuring proper insulation and correct gauge for power connections.      3. Assembly and Organization         1. Organizing tools and materials according to the installation plan.         2. Verifying all necessary components are available before starting the installation process.         3. Managing the transportation and handling of heavy or large components. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Mount pump and compressor system | * 1. Introduction to Mounting of Pumps and Compressors      1. Overview of Pumps and Compressors         1. Understanding the function of pumps and compressors in fluid and air systems.         2. Types of pumps (centrifugal, positive displacement) and compressors (reciprocating, rotary).         3. Differences in installation procedures based on pump/compressor type.      2. Importance of Correct Mounting         1. The role of proper mounting in ensuring efficient operation, minimizing wear, and reducing the risk of equipment failure.         2. Common issues that arise from improper mounting (misalignment, vibration, reduced efficiency).   2. Safety Procedures in Mounting Pumps and Compressors (OSH Act, 2007)      1. Overview of the OSH Act, 2007         1. Key safety regulations regarding machinery installation and mounting.         2. Roles and responsibilities of employees and employers.         3. Specific safety requirements for mounting pumps and compressors.      2. Safety Procedures During Pump and Compressor Mounting         1. Lockout/Tag out (LOTO) procedures to prevent accidental startup during mounting.         2. Safe handling of heavy equipment: Lifting techniques, hoisting, and rigging safety.         3. Proper use of Personal Protective Equipment (PPE): helmets, gloves, eye protection, hearing protection, and steel-toed boots.         4. Electrical safety: grounding and isolation.         5. Awareness of hazards such as moving parts, high pressure, and heavy equipment.   3. Mounting the Compressor System as per Manufacturer’s Specifications      1. Compressor System Components         1. Overview of the compressor system and its key components (motor, compressor unit, pressure relief valves, etc.).         2. Understanding mounting requirements for various types of compressors (reciprocating, rotary screw, centrifugal).      2. Mounting Process for Compressors         1. Verifying the compressor system specifications against the manufacturer’s manual.         2. Preparing the installation site: Ensuring correct positioning, foundation, and space requirements.         3. Securing the compressor: Proper alignment and bolting to the foundation or mounting frame.         4. Installing compressor accessories (filters, valves, and pressure gauges) as per the job requirements.      3. Key Considerations         1. Ensuring proper alignment with the motor and other connected components.         2. Handling and securing refrigerant lines and other accessories.         3. Checking for vibration and noise levels after installation.   4. Mounting the Pump System as per Manufacturer’s Specifications      1. Pump System Components         1. Understanding the components of a pump system (motor, pump body, inlet/outlet ports, and valves).         2. Types of pumps (centrifugal, positive displacement) and mounting requirements for each type.      2. Mounting Process for Pumps         1. Verifying the pump specifications against the manufacturer’s installation manual.         2. Preparing the installation area: Ensuring correct foundation, positioning, and clearance.         3. Aligning and mounting the pump system to prevent misalignment or excessive vibrations.         4. Properly sealing the pump inlet/outlet ports and connecting pipes.      3. Key Considerations         1. Ensuring the pump is level and aligned with the motor.         2. Addressing any special requirements for foundation support.         3. Checking for vibration and ensuring that the pump operates within the designed parameters.   5. Mounting Compressor Accessories in Designated Locations      1. Compressor Accessories Overview         1. Common accessories include * Pressure relief valves * Air filters * Oil separators * Regulators * Air filters * Pressure regulators * Lubricators * Air hoses * Couplers and fittings * Air tanks/receiver tanks * Moisture/oil separators * After cooler * Driers   + - 1. The importance of correct installation and positioning to ensure safe and efficient compressor operation.     1. Mounting Accessories        1. Verifying the specifications for each accessory against the manufacturer’s manual.        2. Identifying the proper locations for mounting based on the system layout.        3. Ensuring all accessories are securely mounted and easily accessible for maintenance.     2. Key Considerations        1. Proper routing of piping and hoses to avoid interference with other equipment.        2. Ensuring that valves and gauges are easy to read and operate.        3. Checking for proper sealing and leak-proof installation.   1. Mounting Pump Accessories in Designated Locations      1. Pump Accessories Overview         1. Types of pump accessories: suction and discharge valves, pressure relief valves, strainer filters, flow meters.         2. Their role in ensuring efficient pump operation and preventing damage.      2. Mounting Accessories         1. Verifying the accessories' specifications and installation requirements.         2. Properly locating and mounting each accessory in line with job specifications.         3. Ensuring that each accessory is securely fastened, leak-proof, and properly aligned.      3. Key Considerations         1. Ensuring correct orientation and placement of valves and gauges for easy access.         2. Proper connection to pipes and electrical components (where applicable).         3. Checking for leaks and proper sealing.   2. Housekeeping      1. Housekeeping During Installation         1. Keeping tools and materials organized during the installation process to minimize hazards.         2. Proper disposal of waste materials such as packaging, metal shavings, and discarded parts.         3. Maintaining cleanliness around mounting areas to prevent accidents and improve accessibility.      2. Post-Mounting Inspection         1. Conducting final inspections to ensure that all components (pumps, compressors, and accessories) are securely mounted and properly aligned.         2. Verifying that all bolts, nuts, and fasteners are tightened to the correct torque specifications.         3. Ensuring that all piping, electrical connections, and safety devices are correctly installed. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Assemble pump and compressor system | * 1. Safety Procedures According to OSH Act, 2007      1. Overview of the OSH Act, 2007         1. Key safety regulations for machinery assembly and maintenance.         2. Worker rights and employer responsibilities in a work environment.         3. Identifying hazards associated with pump and compressor assembly.      2. Safety Procedures for Assembly         1. Lockout/Tag out (LOTO) protocols for power isolation during assembly.         2. Safe handling of heavy components (e.g., pumps, motors).         3. Proper use of Personal Protective Equipment (PPE): gloves, helmets, eye protection, hearing protection, and steel-toed boots.         4. Awareness of electrical and mechanical hazards during assembly.         5. Working in confined spaces and adhering to ventilation requirements.         6. Fire safety and emergency procedures.   2. Fitting Pump and Compressor Components According to Manufacturer’s Specifications      1. Overview of Manufacturer’s Specifications         1. Understanding the importance of adhering to the specifications provided in the manual.         2. Common components: impellers, motors, housings, seals, shafts, and bearings.         3. How to read and interpret manufacturer’s assembly drawings and specifications.      2. Component Fitting Process         1. Fitting motor to pump/compressor assembly.         2. Proper installation of seals and bearings to prevent leakage and reduce friction.         3. Ensuring alignment of shafts and coupling to avoid operational issues.   3. Fitting Pump and Compressor Piping According to Job Specifications      1. Overview of Piping Requirements         1. Understanding job-specific piping configurations and flow requirements.         2. Pipe materials and selection: PVC, steel, copper, etc.         3. Pipe sizes, bends, and lengths as per system design.      2. Piping Installation         1. Connecting suction and discharge pipes to pumps and compressors.         2. Ensuring proper pipe alignment, support, and securing.         3. Installing valves, strainers, and check valves where necessary.         4. Checking pipework for any leaks and ensuring proper sealing with gaskets and seals.   4. Electrical Connections to Compressor and Pump Systems      1. Overview of Electrical Connection         1. Understanding pump and compressor motor electrical requirements (voltage, current, power ratings).         2. Identifying the electrical components: motor terminals, starters, overload protection, wiring, and grounding.      2. Electrical Connection Process         1. Wiring the motor to the control panel.         2. Ensuring proper grounding and earthling of electrical components.         3. Connecting and testing electrical power supply.         4. Verifying electrical connections according to manufacturer’s guidelines.   5. Checking Assembly Layout According to Installation Manual      1. Importance of Layout Checks         1. Preventing common assembly mistakes.         2. Verifying alignment of pump, compressor, and accessories.         3. Ensuring that all components are in place and properly connected.      2. Assembly Layout Review         1. Reviewing the installation manual and comparing the actual setup to ensure compliance with design specifications.         2. Checking pipe connections, electrical setup, component placement, and overall system configuration.   6. Housekeeping      1. Housekeeping Standards         1. Keeping the assembly area free from tools, materials, and debris.         2. Ensuring that all equipment is properly stored and labeled.         3. Proper disposal of waste materials and used parts.      2. Final Checks Before Commissioning         1. Inspecting the pump/compressor assembly for proper fitting, alignment, and secure connections.         2. Testing the system for leaks, vibrations, and noise.         3. Verifying that all components (electrical and mechanical) are functioning properly. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission pump and compressor system | 1. Safety Procedures According to OSH Act, 2007    * 1. Overview of the OSH Act, 2007         1. Key safety regulations for operating machinery and conducting commissioning activities.         2. Worker rights and responsibilities in relation to safety.         3. Common hazards associated with pump and compressor systems (electrical, mechanical, noise, vibration).      2. Safety Procedures         1. Lockout/Tag out (LOTO) procedures for pump and compressor systems.         2. Proper PPE requirements for testing and commissioning.         3. Ensuring electrical isolation and ensuring the system is safe to operate.         4. Monitoring for hazardous emissions (e.g., carbon monoxide in compressors).         5. Using appropriate fire safety measures when testing systems. 2. Running Pumps and Checking for Abnormalities (Per Job Specifications)    * 1. Pump Running Procedures         1. Steps to start the pump system as per manufacturer and job specifications.         2. Verifying power supply, pump alignment, and proper connections.         3. Monitoring pump startup to ensure smooth operation.      2. Checking for Abnormalities         1. Common abnormalities to look for during the initial run (leaks, vibrations, noise, pressure, flow rate).         2. Using tools like pressure gauges, flow meters, and temperature sensors.         3. Visual inspection for leaks or unusual wear.         4. Adjusting settings (e.g., speed, pressure, flow) to meet design specifications. 3. Running Compressor Systems and Checking for Abnormalities (Per Job Specifications)    * 1. Compressor Running Procedures         1. Steps to safely start the compressor system.         2. Verifying power supply and connections.         3. Ensuring correct startup sequence as per manufacturer specifications.      2. Checking for Abnormalities         1. Identifying signs of abnormal operation (noise, temperature, pressure, vibration).         2. Using diagnostic tools: pressure gauges, temperature sensors, and vibration meters.         3. Troubleshooting abnormal compressor behavior during the initial run 4. Pump System Troubleshooting According to Manufacturer’s Specifications    * 1. Common Pump System Faults         1. Inadequate flow, low pressure, excessive vibrations, cavitation.         2. Identifying potential causes: worn components, airlocks, incorrect alignment.      2. Troubleshooting Process         1. Step-by-step guide to troubleshooting pumps: isolation, inspection, and diagnosis.         2. Using manufacturer’s troubleshooting charts and guidelines.         3. Techniques for identifying mechanical and electrical issues.         4. Replacing faulty components and recalibrating settings as needed. 5. Compressor System Troubleshooting According to Manufacturer’s Specifications    * 1. Common Compressor System Faults         1. Loss of pressure, overheating, oil contamination, noisy operation.         2. Identifying the root cause of common issues: leaks, motor failure, valve malfunctions.      2. Troubleshooting Process         1. Step-by-step approach to diagnosing compressor faults using manufacturer’s manuals.         2. Checking critical components: valves, seals, pistons, cooling system, electrical connections.         3. Using diagnostic tools (pressure gauges, thermometers, and vibration meters).         4. Repairing and replacing damaged components, recalibrating settings, and testing. 6. Fixing Pump and Compressor System Faults According to Manufacturer’s Specifications    * 1. Fault Identification and Fixing         1. How to perform repairs based on manufacturer specifications for both pumps and compressors.         2. Replacing worn components, correcting alignment issues, fixing leaks, recalibrating systems.         3. Addressing electrical, mechanical, and operational faults. 7. Training Pump and Compressor System End-Users (As Per Manufacturer’s Specifications)    * 1. End-User Training Topics         1. Proper system operation, routine checks, and preventive maintenance procedures.         2. Key operational parameters to monitor (pressure, flow, temperature).         3. Identifying early warning signs of system issues and how to report them.         4. Preventive maintenance routines to prolong equipment lifespan.         5. Safety protocols for system operation and emergency situations.      2. Training Methods         1. Preparing training materials (manuals, videos, handouts).         2. Demonstrating operational procedures and safety protocols.         3. Providing a Q&A session for users to clarify doubts.    1. Housekeeping       1. Waste segregation       2. Bench cleaning       3. Keeping workplace neat and orderly       4. Consumables and inventory       5. Tool rack       6. Tool box    2. Preparing Testing and Commissioning Reports       1. Reporting Guidelines          1. What to include in a test and commissioning report (test results, abnormalities, troubleshooting actions, corrective measures).          2. Proper documentation procedures: consistency, clarity, and accuracy.          3. Importance of submitting timely and complete reports for record-keeping and future reference. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Pump Installation, Operation, and Maintenance" by American Petroleum Institute (API) | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Lifting trolley | 1 ton | 1 | 1:25 |
|  | Hoist | 1 ton | 1 | 1:25 |
|  | Lifting rock | 1 ton | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 5 | 1:5 |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Installation manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **MECHANICAL PUMPS AND COMPRESSORS MAINTENANCE**

**UNIT CODE:** 0715 451 04A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

**This unit addresses the unit of competency**: Mechanical pumps and compressors maintenance

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, contents, assessment methods, method of delivery and resources required to train mechanical pumps and compressors maintenance. The learning shall enable the learner to prepare for pump and compressor maintenance, conduct preventive maintenance of pump and compressor system, conduct corrective maintenance of pump and compressor system and test and commission pumps and compressor system.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to:

|  |  |  |
| --- | --- | --- |
| **S/No.** | **Learning Outcomes** | **Duration (Hours)** |
|  | Prepare for pump and compressor maintenance | **30** |
|  | Conduct Preventive maintenance of pump and compressor system | **20** |
|  | Conduct corrective maintenance of pump and compressor system | **40** |
|  | Test and commission pumps and compressor system | **30** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested assessment methods** |
| * + - 1. Prepare for pump and compressor maintenance | * 1. Introduction to Pumps and Compressor Systems Maintenance      1. Overview of Pumps and Compressor Systems         1. Types of pumps and compressors (centrifugal, positive displacement, reciprocating, rotary).         2. Key components of pumps and compressors (impellers, valves, pistons, bearings).         3. Purpose and importance of maintenance.         4. Preventive vs. corrective maintenance.         5. Functionality and applications in various industries (HVAC, water treatment, manufacturing).      2. Role of Proper Maintenance         1. How maintenance improves system reliability and lifespan.         2. Reducing downtime and unexpected failures through proper maintenance.         3. Importance of adhering to manufacturer specifications.         4. Definition and importance of preventive maintenance.         5. Key differences between preventive and corrective maintenance.         6. Benefits of preventive maintenance (reduced downtime, increased system efficiency, cost savings).   2. Safety Procedures According to the OSH Act, 2007      1. Understanding the OSH Act, 2007         1. Key provisions of the OSH Act relevant to pump and compressor maintenance.         2. Employer and employee responsibilities.         3. Common hazards in pump and compressor maintenance (mechanical, electrical, noise, and chemical hazards).      2. Safety Procedures for Maintenance         1. Lockout/Tag out (LOTO) procedures.         2. Safe handling of tools and equipment.         3. Personal Protective Equipment (PPE) requirements (gloves, eye protection, hearing protection, etc.).         4. Proper ventilation and noise control.         5. Emergency response procedures for accidents or system failures.   3. Assessing Pump and Compressor Maintenance Requirements      1. Understanding Manufacturer’s Specifications         1. How to access and interpret manufacturer manuals and maintenance guides.         2. Common maintenance requirements for pumps and compressors (lubrication, air filters, belts, seals, pressure testing).         3. How to assess system performance based on specifications (flow rates, pressure, and motor operation).      2. Assessing System Condition         1. How to visually inspect pumps and compressors for wear and tear, leaks, vibration, and noise.         2. Using diagnostic tools (pressure gauges, temperature sensors, and vibration meters) to assess system performance.         3. Identifying early signs of failure: leakage, unusual sounds, overheating, and low efficiency.         4. Regular checks and monitoring requirements.   4. Developing Maintenance Schedules Based on Manufacturer’s Specifications      1. The Importance of a Maintenance Schedule         1. Preventive maintenance schedules and their role in ensuring reliable operation.         2. Frequency of maintenance tasks (e.g., daily, weekly, monthly, annual).         3. Managing resources and ensuring system downtime is minimized.      2. Key Elements of a Maintenance Schedule         1. Identifying key tasks for each type of pump and compressor (e.g., changing filters, checking belts, lubricating moving parts).         2. Identifying intervals for each task according to manufacturer recommendations.         3. Establishing a timeline for tasks: short-term and long-term schedules.         4. Documenting and tracking completed maintenance activities.      3. Creating and Managing the Maintenance Schedule         1. Tools and software for scheduling maintenance activities.         2. Coordinating maintenance with operational schedules.         3. Ensuring proper communication and documentation between maintenance and operational teams.   5. Selection of Tools, Equipment, and Materials for Maintenance      1. Selecting Maintenance Tools         1. Types of tools required for pump and compressor system maintenance: hand tools, diagnostic tools, and special tools (e.g., torque wrenches, vibration analyzers, and pressure gauges).         2. Proper tool maintenance and calibration.         3. Safety checks for tools to ensure proper functioning.      2. Choosing the Right Equipment         1. Equipment for lifting and handling heavy pump and compressor components (e.g., hoists, cranes, lifting straps).         2. Using diagnostic and testing equipment as per manufacturer specifications.         3. Tools for cleaning, lubrication, and pressure testing.      3. Selecting Materials for Maintenance         1. Common materials used for maintenance: seals, gaskets, lubricants, O-rings, filters, belts.         2. Ensuring materials meet manufacturer standards and are compatible with the system.         3. Storage and handling of materials. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| * + - 1. Conduct Preventive maintenance of pump and compressor system | * 1. Adhering to Safety Procedures as per the OSH Act, 2007      1. Overview of the OSH Act, 2007         1. Key provisions of the OSH Act relevant to pump and compressor maintenance.         2. Employer and employee responsibilities under the OSH Act.         3. Workplace safety practices and regulations.      2. Risk Assessment and Hazard Identification         1. Common hazards in pump and compressor maintenance (mechanical, electrical, noise, chemical).         2. How to assess potential risks and implement preventive measures.         3. Personal Protective Equipment (PPE) requirements (e.g., gloves, goggles, ear protection).      3. Safety Procedures for Pump and Compressor Maintenance         1. Lockout/Tag out (LOTO) procedures for isolating equipment.         2. Proper handling and storage of maintenance tools and materials.         3. Safe handling of fluids (e.g., lubricants, coolants, compressed air).         4. Emergency response and first-aid procedures.   2. Identifying Preventive Maintenance Activities for Pumps and Compressors      1. Common Preventive Maintenance Activities for Pumps         1. Inspection of pump components (impellers, seals, bearings, casing).         2. Lubrication of moving parts (bearings, shafts).         3. Cleaning of filters and strainers.         4. Checking for leaks and pressure anomalies.         5. Alignment checks and adjustments.      2. Common Preventive Maintenance Activities for Compressors         1. Inspection of air filters and air intake systems.         2. Lubrication of moving parts (valves, pistons, cylinders).         3. Pressure testing and leak detection.         4. Checking for overheating and abnormal vibrations.         5. Ensuring proper system ventilation and cooling.      3. Diagnostic Tools and Techniques         1. Using vibration analysis, pressure gauges, thermometers, and other diagnostic tools to assess system health.         2. Identifying early signs of system deterioration (unusual noise, temperature spikes, oil contamination).   3. Developing a Preventive Maintenance Schedule      1. Understanding Maintenance Schedules: The importance of timely and effective preventive maintenance.      2. Frequency of Maintenance: How to set schedules based on operating hours, service conditions, and manufacturer recommendations.      3. Tools for Scheduling: Software tools and systems for tracking maintenance activities (e.g., Computerized Maintenance Management System - CMMS).      4. Factors Influencing Maintenance Frequency: Operational loads, environment, age of equipment, and manufacturer recommendations.      5. Creating a Maintenance Calendar: Developing a comprehensive calendar that includes inspection, lubrication, and component replacement activities.   4. Performing Preventive Maintenance Activities as Per Manufacturer’s Specifications      1. Maintenance Procedures         1. Detailed steps for various preventive maintenance tasks (lubrication, filter changes, system cleaning, and alignment).      2. Tools and Equipment         1. Identifying the right tools and equipment for maintenance tasks (e.g., torque wrenches, gauges, and lubrication systems).      3. Performing Checks and Replacements         1. Step-by-step guide to inspecting and replacing critical components (bearings, seals, belts).      4. Troubleshooting         1. Identifying common issues like leaks, vibrations, and excessive noise, and following troubleshooting steps as per manufacturer specifications.      5. Documentation         1. Recording maintenance actions, parts replaced, and any issues encountered during the task.   5. Housekeeping      1. Importance of Housekeeping         1. Reducing hazards, ensuring efficiency, and preventing equipment damage.      2. Workplace Procedures         1. Adhering to procedures for cleaning, organizing, and storing tools, equipment, and materials.      3. Waste Management         1. Safe disposal of oils, lubricants, and other hazardous materials.      4. Tool Organization         1. Ensuring tools and materials are cleaned and stored properly after maintenance work.      5. Preventing Contamination         1. Maintaining a clean environment to avoid contamination of pumps and compressors. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| * + - 1. Conduct corrective maintenance of pump and compressor system | * 1. Safety Procedures in Maintenance      1. Understanding the OSH Act, 2007         1. Purpose and scope         2. Employer and employee responsibilities         3. Ensuring a safe working environment      2. Personal Protective Equipment (PPE)         1. Types of PPE for pump and compressor maintenance         2. Correct usage and maintenance of PPE      3. Lockout/Tag out Procedures (LOTO)         1. Ensuring machines are safely shut down before maintenance         2. Proper use of lockout and tag out devices         3. Verifying equipment is de-energized      4. Electrical and Mechanical Safety         1. Handling electrical equipment safely         2. Isolation of energy sources (e.g., gas, water)         3. Preventing mechanical hazards (e.g., rotating parts)      5. Emergency Procedures         1. First-aid and emergency response in case of accidents         2. Reporting and documenting incidents   2. Troubleshooting of Pump and Compressor Systems      1. Common Problems in Pumps and Compressors         1. Pump failures (e.g., leakage, cavitation, overloading)         2. Compressor issues (e.g., low pressure, excessive noise, overheating)      2. Reading and Interpreting Manufacturer Manuals         1. Understanding troubleshooting guides         2. Identifying warning signs and symptoms         3. Using diagnostic tools (e.g., pressure gauges, vibration sensors)      3. Systematic Troubleshooting Approach         1. Step-by-step procedures for fault diagnosis         2. Using flow charts and diagnostic checklists         3. Identifying root causes of failures      4. Tools and Techniques         1. Using multimeters, pressure testers, and vibration analyzers         2. Using manufacturer-specific diagnostic software (if applicable)   3. Rectifying Faulty Components      1. Identifying Faulty Components         1. Common failure points in pumps (e.g., seals, impellers, bearings)         2. Common failure points in compressors (e.g., pistons, valves, gaskets)      2. Corrective Maintenance Techniques         1. Dismantling and reassembling pump and compressor units         2. Replacement of defective parts (gaskets, valves, seals)         3. Lubrication and alignment procedures         4. Calibration and adjustments according to manufacturer guidelines      3. Use of Manufacturer Specifications         1. Referencing specific part numbers, tolerances, and dimensions         2. Correct installation methods         3. Testing and validation of new parts      4. Quality Assurance in Repairs         1. Ensuring repairs meet manufacturer standards         2. Testing the functionality of repaired systems         3. Documentation of repairs made   4. Housekeeping      1. Workplace Housekeeping Standards         1. The importance of a clean and organized workspace         2. Tools and materials storage         3. Disposal of waste materials (e.g., used parts, lubricants)      2. Safe Handling of Equipment         1. Correct placement of tools and machinery         2. Reducing risks of trips, falls, and injuries      3. Preventative Measures         1. Routine cleaning and inspection         2. Ensuring no obstruction of ventilation or emergency exits         3. Handling hazardous substances in accordance with safety protocols      4. Post-Maintenance Procedures         1. Returning tools and equipment to designated storage         2. Cleaning up workstations after maintenance         3. Ensuring the maintenance area is safe for further operations | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 4. Test and commission pumps and compressor system | * 1. Safety Procedures (OSH Act, 2007)      1. Understanding the OSH Act, 2007         1. Purpose, scope, and key responsibilities         2. Rights and duties of employers and employees      2. Personal Protective Equipment (PPE)         1. Types of PPE required during commissioning         2. Correct usage of safety equipment (e.g., gloves, goggles, ear protection)      3. Lockout/Tag out (LOTO) Procedures         1. Lockout and tag out techniques to isolate energy sources before commissioning         2. Safety measures for electrical and mechanical hazards during the commissioning phase      4. Hazardous Environments         1. Dealing with high-pressure systems, flammable materials, and electrical systems         2. Ventilation, proper handling of compressed air, and fluid systems      5. Emergency Procedures         1. Emergency response protocols for accidents or system failures         2. First-aid, reporting incidents, and following emergency action plans   2. Running and Testing of Pumps and Compressors      1. Pre-commissioning Checks         1. Verifying installation quality and alignment         2. Checking mechanical and electrical connections         3. Ensuring proper lubrication and fluid levels      2. System Start-Up Procedures         1. Step-by-step guide for initial startup         2. Monitoring system parameters (e.g., pressure, flow rate, temperature)         3. Identifying and troubleshooting any system abnormalities      3. Operational Testing         1. Running the system under normal operating conditions         2. Checking for vibrations, noise, leakage, or overheating         3. Performing load tests and capacity checks      4. Checking for Abnormalities         1. Identifying abnormal noises, vibrations, leaks, and electrical issues         2. Using diagnostic tools to measure performance (e.g., vibration analysis, thermography)         3. Assessing the performance of pumps and compressors against manufacturer specifications   3. End User Training According to Manufacturer Specifications      1. User Manuals and Manufacturer Specifications         1. Overview of key operating and maintenance instructions         2. How to interpret technical specifications for optimal use      2. Operator Training         1. Basic operation principles of pumps and compressors         2. Safe start-up and shut-down procedures         3. Routine monitoring and adjustments (e.g., pressure, temperature, and flow rate)      3. Maintenance Training         1. Preventive maintenance tasks and schedules         2. Common troubleshooting and diagnostic techniques         3. Identifying signs of wear or failure and responding appropriately      4. Safety and Emergency Procedures         1. Operating the system safely to prevent injury         2. What to do in case of system malfunctions or emergencies      5. Hands-on Training         1. Practical demonstrations on pump and compressor operation         2. Allowing end-users to operate the system under supervision   4. Housekeeping      1. Importance of Housekeeping in Commissioning         1. Maintaining a clean and organized environment during testing and commissioning         2. Reducing hazards and improving work efficiency      2. Workplace Cleanliness and Organization         1. Proper storage of tools, materials, and equipment         2. Regular cleaning of the testing area and equipment         3. Labeling and organizing parts, hoses, and cables      3. Waste Disposal         1. Proper disposal of used parts, packaging, and hazardous waste         2. Environmental considerations for fluid spills, oils, and lubricants      4. Post-Testing Clean-Up         1. Clearing the site of testing equipment and tools         2. Restoring workspaces to their original condition         3. Ensuring no hazards remain once testing is complete   5. Documentation and Handover      1. Importance of Documentation         1. Ensuring all commissioning activities are documented for future reference         2. Types of documentation: test reports, inspection records, system performance logs      2. Final Commissioning Report         1. Key components of the report: system parameters, test results, and any issues encountered         2. Sign-off procedures from relevant parties (e.g., client, supervisor, engineer)      3. Manufacturer’s Documentation and Compliance         1. Ensuring all tests and inspections are conducted per the manufacturer’s specifications         2. Providing end-users with manuals and maintenance schedules      4. Handover Procedures         1. Official handover of the pump or compressor system to the end-user or client         2. Demonstrating system operation and providing training materials         3. Ensuring all maintenance and operational documentation is provided to the end-user | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Pump Handbook" by Igor J. Karassik, Joseph P. Messina, Paul Cooper, and Charles M. Heald | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Lifting trolley | 1 ton | 1 | 1:25 |
|  | Hoist | 1 ton | 1 | 1:25 |
|  | Lifting rock | 1 ton | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 5 | 1:5 |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Maintenance manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE II

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| 0417 541 05A | Work ethics and practices | 40 | 4.0 |
| 0732 451 06A | Technical Drawing | 80 | 8.0 |
| 0713 441 07A | Electrical and Electronics Principles | 80 | 8.0 |
| 0715 451 08A | Hydraulic and pneumatic systems installation | 100 | 10.0 |
| 0715 451 09A | Hydraulic and pneumatic systems maintenance | 120 | 12.0 |

## **WORK ETHICS AND PRACTICES**

**ISCED UNIT CODE:** 0417 441 05A

**Duration of Unit:** 40 Hours

**Relationship with Occupational Standards**

This unit addresses the Unit of Competency: Apply work ethics and practices.

**Unit Description**

This unit covers competencies required to demonstrate employability skills. It involves the ability to: conduct self-management, promote ethical work practices and values, promote teamwork, manage workplace conflicts, maintain professional and personal development, apply problem-solving, and promote customer care.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Apply self-management skills | **10** |
|  | Promote ethical practices and values | **4** |
|  | Promote Teamwork | **10** |
|  | Maintain professional and personal development | **10** |
|  | Apply Problem-solving skills | **4** |
|  | Promote Customer care | **2** |
|  | **TOTAL** | **40** |

**Learning Outcomes, Content, and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply self-management skills | * 1. Self-awareness   2. Formulating personal vision, mission, and goals   3. Healthy lifestyle practices   4. Strategies for overcoming work challenges   5. Emotional intelligence   6. Coping with Work Stress.   7. Assertiveness versus aggressiveness and passiveness      1. Developing and maintaining high self-esteem      2. Developing and maintaining positive self-image      3. Time management      4. Setting performance targets      5. Monitoring and evaluating performance targets | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote ethical work practices and values | * 1. Integrity   2. Core Values, ethics and beliefs   3. Patriotism   4. Professionalism   5. Organizational codes of conduct   6. Industry policies and procedures | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote Teamwork | * 1. Types of teams   2. Team building      1. Individual responsibilities in a team      2. Determination of team roles and objectives      3. Team parameters and relationships      4. Benefits of teamwork      5. Qualities of a team player      6. Leading a team      7. Team performance and evaluation   3. Conflicts and conflict resolution   4. Gender and diversity mainstreaming   5. Developing Healthy workplace relationships   6. Adaptability and flexibility   7. Coaching and mentoring skills | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Maintain professional and personal development | * 1. Personal vs professional development and growth   2. Avenues for professional growth   3. Recognizing career advancement   4. Training and career opportunities      1. Assessing training needs      2. Mobilizing training resources   5. Licenses and certifications for professional growth and development   6. Pursuing personal and organizational goals   7. Managing work priorities and commitments   8. Dynamism and on-the-job learning | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Apply Problem-solving skills | * 1. Causes of problems   2. Methods of solving problems   3. Problem-solving process   4. Decision making   5. Creative thinking and critical thinking process in development of innovative and practical solutions | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote Customer Care | * 1. Identifying customer needs   2. Qualities of good customer service   3. Customer feedback methods   4. Resolving customer concerns   5. Customer outreach programs   6. Customer retention | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |

**Suggested Methods of Instruction**

* Instructor lead facilitation of theory using active learning strategies.
* Demonstrations
* Simulation/Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive texts books on Work Ethics and Practices | 30 pcs | 1:1 |
|  | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Media Resources | This include but are not limited to:   * Video Clips * Audio Clips * TV Sets * Radio Sets |  |  |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
|  | Lecture/Theory Room  /Learning Resource  Area\* | Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m) | 1 | 1:30 |
|  | Computer Laboratory | Equipped with at least 30 functional computers with internet connectivity and the following software:   * + - Windows/ Linux/ Macintosh Operating System     - Microsoft Office Software     - Google Workspace Account     - Antivirus Software | 30 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
|  | Printing Papers | A4 and A3 Printing papers suitable for the task | Enough |  |
|  | Flashcards | For carrying out various activities by trainees | Enough |  |
|  | Charts | Sufficient for group work activities and displaying | Enough |  |
|  | Whiteboard Marker Pens | Dry-erase markers for trainers use. Assorted colours | Enough |  |

## **TECHNICAL DRAWING**

**UNIT CODE:** 0732 441 06A

**Duration of Unit:** 80 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply technical drawing

**Unit Description**

This unit covers the competences required to apply technical drawings. It involves using technical drawing tools, equipment and materials, producing plane geometry drawings, orthographic drawings of components, solid geometry drawings, isometric drawings and assembly drawings.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Use and maintain drawing equipment and materials | **10** |
|  | Produce plane geometry drawings | 10 |
|  | Produce orthographic drawings of components | **20** |
|  | Produce solid geometry drawings | **10** |
|  | Produce Isometric drawings | **20** |
|  | Produce assembly drawings | **10** |
|  | **TOTAL** | **80** |

**Learning Outcomes, Content and Suggested Assessment Methods:**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| * + - 1. Use and maintain drawing equipment and materials | * 1. Drawing equipment      1. T square      2. Set squares      3. Protractor      4. Engineering drawing set      5. Drawing board      6. Ruler   2. Drawing materials      1. Drawing papers      2. Masking tape      3. Drawing Board Clips      4. Clutch pencils      5. Eraser      6. Pencil Sharpener      7. Emery board or fine sandpaper   3. Use and maintenance of drawing equipment | * Practical Tests * Written tests |
| * + - 1. Produce plane geometry drawings | * 1. Types of lines in drawings      1. Border lines      2. Construction lines      3. Hidden detail lines      4. Chain lines      5. Centre lines      6. Cutting plane lines      7. Hatching line   2. Construction of angles      1. Acute angles      2. Right angles      3. Reflex angles      4. Obtuse angles   3. Bisection of angles      1. Acute angles      2. Right angles      3. Reflex angles      4. Obtuse angles   4. Measurement of angles      1. Use of a protractor   5. Construction of plane geometric forms      1. Triangles      2. Quadrilaterals      3. Polygons      4. Circles and tangents   6. Construction of scales      1. Plain scales      2. Diagonal scale      3. Representative Fraction Scale      4. Proportional Scale      5. Reducing and enlargement scales | * Practical tests * Written Tests |
| 1. Produce orthographic drawings of components | * 1. Orthographic drawings      1. First angle projection      2. Third angle projection   2. Sectional views   3. Dimensioning of orthographic drawings      1. Linear Dimensions      2. Radial Dimensions      3. Diametral Dimensions      4. Angular Dimensions      5. Baseline Dimensions      6. Ordinate Dimensions      7. Notes | * Practical tests * Written Tests |
| 1. Produce solid geometry drawings | * 1. Sketches and drawings of patterns      1. Cylinders      2. Prisms      3. pyramids   2. Solids drawings      1. Prisms      2. Cones      3. Cylinders   3. Development and interpenetrations of solids      1. Cylinder to cylinder      2. Cylinder to prisms      3. Cylinder to cone      4. Cylinder to pyramid   4. Different symbols and abbreviations      1. Machining Symbols      2. Standard Abbreviations   5. Auxiliary views and true shapes of truncated solids      1. Truncated cylinder      2. Truncated prism      3. Truncated pyramid | * Practical tests * Written Tests |
| 1. Produce pictorial drawings | * 1. Isometric sketches and drawings of components   2. Isometric curves and circles   3. Oblique sketches of components      1. Cabinet Oblique Drawings      2. Cavalier Oblique Drawings   4. Oblique Curves and Circles | * Practical tests * Written Tests |
| 1. Produce assembly drawings | * 1. Orthographic views of assembly drawings      1. First angle projection      2. Third angle projection   2. Sectional views   3. Hatching on assembly drawings   4. Parts list | * Practical tests * Written Tests |

**Suggested Methods of Delivery**

* Projects
* Demonstration by trainer
* Practice by the trainee
* Discussions

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive texts books on Technical Drawing | 25 pcs | 1:1 |
|  | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:25 |
|  | Working drawings | Working drawings giving a detailed overview of the task at hand |  |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
|  | Drawing Room  /Learning Resource  Area\* | Spacious, equipped with a projector and drawing tables for 25 trainees, approximately 45 sqm (5 m x 9 m) | 1 | 1:25 |
| **C** | **Consumable Materials** |  |  |  |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream | 1:25 |
|  | Drawing Pencils | For drawing   * HB * 2H/3H * 2B | Enough |  |
|  | Eraser | Dustless eraser for pencil stains | 30 |  |
|  | Masking Tape | For attaching the drawing paper to the drawing board | Enough |  |
| **D** | **Tools and Equipment** |  |  |  |
|  | Drawing Instruments | They include:   * T-squares * 30-60 degree set squares * 45 degree set square * Protractor * Compass set | 25 sets | 1:1 |
|  | Pencil Sharpener | For creating sharp pencil tips | 25 pcs | 1:1 |
|  | Drawing Tables | For drawing | 25 pcs | 1:1 |
| **E** | **Reference Materials** |  |  |  |
|  | Welding /blueprint /drawing Standards | Reference on industry standards (e.g., BS/ANSI/AWS etc.) | 5 pcs | 1:5 |
|  | Multimedia Learning Modules | Videos and tutorials | 25 pcs | 1:1 |

## **ELECTRICAL AND ELECTRONICS PRINCIPLES**

**UNIT CODE:** 0713 441 07A

**Unit Duration:** 80 Hours

**Relationship with Occupational Standards**

This unit addresses the unit of competency: Apply Electrical and electronics principles.

**Unit Duration:** 80 Hours

**Unit Description**

This unit describes the competences required in order to apply electrical and electronics principles. It involves applying basic concepts of electrical quantities, cells and batteries, magnetism and electromagnetism, basic electrical machines and electronics principles.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/No.** | **Learning Outcomes** | **Duration (Hours)** |
|  | Apply basic concepts of electrical quantities | 10 |
|  | Apply DC and AC circuits | 10 |
|  | Apply the concept of cells and batteries | 10 |
|  | Apply magnetism and electromagnetism | 10 |
|  | Apply basic electrical machines | 20 |
|  | Apply electronics components | 20 |
| TOTAL | | 80 |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply basic concepts of electrical quantities | * 1. Basic SI Units      1. Overview of SI Units         1. Power (Watts, W)         2. Current (Amperes, A)         3. Resistance (Ohms, Ω)         4. Voltage (Volts, V)   2. Conductors and Insulators      1. Identification and Characteristics         1. Metals vs. non-metals         2. Applications in electrical circuits   3. Electrical Quantities      1. Charge, Force, Work, and Power      2. Definitions and units      3. Calculations involving Electrical quantities   4. Ohm’s Law      1. Understanding Ohm's Law      2. Practical applications and calculations   5. Basic Electrical and Electronic Measurements      1. Measurement Techniques      2. Use of Multimeters, oscilloscopes, and ammeters      3. Measurement accuracy and calibration | * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |
| 1. Apply DC and AC circuits | * 1. Introduction to Electrical Circuits      1. Introduction to electricity:      2. Voltage, current, and power.      3. Overview of DC and AC circuits.      4. Basic circuit elements: Resistors, capacitors, and inductors.   2. DC Circuit Analysis      1. Series and parallel circuits.      2. Voltage and current division principles.      3. Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL).      4. Analysis of complex circuits using KVL and KCL.      5. Hands-on lab: Building and testing DC circuits.   3. AC circuits analysis      1. Introduction to AC: Sinusoidal waveforms, frequency, and period.      2. RMS values, peak values, and average values.      3. AC voltage and current sources.      4. Phasor representation of AC quantities.      5. Impedance and admittance.      6. Series and parallel AC circuits.      7. Resonance in RLC circuits.      8. Practical analysis of AC circuits using phasors.      9. Power in AC Circuits         1. Power factor and power factor correction.         2. Real, reactive, and apparent power.         3. AC power calculations for single-phase and three-phase circuits.         4. Energy consumption and efficiency.         5. Applications of AC power in household and industrial settings.   4. Practical Activity:      1. Connection in series and Parallel Simulation | * Oral questioning * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |
| 1. Apply the concept of cells and batteries | * 1. Introduction to Cells and Batteries   2. Overview of energy storage and electrochemical cells.   3. Basic concepts: Voltage, current, capacity, and energy density.   4. Internal resistance of cells and electromotive force, e.m.f.   5. Electrochemical principles: Redox reactions and electrode potentials.   6. Components of a cell: Anode, cathode, electrolyte, and separator.   7. Types of cells: Primary vs. secondary cells (non-rechargeable vs. rechargeable).   8. Primary Cells (Non-Rechargeable)      1. Zinc-Carbon Cells: Construction, chemistry, and applications.      2. Alkaline Cells: Advantages over zinc-carbon, usage, and performance characteristics.      3. Comparison of common primary cells (e.g., lithium primary cells).      4. Performance limitations and efficiency of primary cells.      5. Environmental impact and disposal considerations for non-rechargeable batteries.      6. Hands-on lab: Testing the performance of different primary cells.   9. Secondary Cells (Rechargeable)      1. Lead-Acid Batteries: Chemistry, construction, and applications (e.g., automotive).      2. Nickel-Cadmium (NiCd) and Nickel-Metal Hydride (NiMH): Differences, pros, and cons.      3. Charging and discharging cycles of rechargeable cells.      4. Lithium-Ion Batteries: Working principles, construction, and applications.      5. Advantages of lithium-ion technology over older battery types.      6. Safety considerations: Overcharging, thermal runaway, and battery management systems.      7. Emerging Technologies: Solid-state batteries, lithium-sulphur, and other advancements.      8. Energy density and power density considerations in modern applications.      9. Batteries maintenance      10. Hands-on lab: Disassembling and examining a rechargeable battery.   10. Battery Performance and Characteristics       1. Battery capacity: Ampere-hour (Ah) ratings and energy content.       2. Factors affecting battery life: Temperature, charge/discharge rates, and cycling.       3. Internal resistance and its effect on performance.       4. Battery efficiency and energy losses.       5. State of charge (SOC) and depth of discharge (DOD).       6. Battery degradation and aging mechanisms.       7. Measuring battery parameters (voltage, current, capacity).       8. Testing techniques for battery health and performance.       9. Hands-on lab: Performance testing of different battery types.   11. Applications of Batteries       1. Batteries in consumer electronics (e.g., smartphones, laptops).       2. Automotive applications: Starting, lighting, and ignition (SLI) batteries.       3. Electric vehicles (EVs) and hybrid electric vehicles (HEVs): Battery requirements and challenges.       4. Industrial and grid storage applications.       5. Renewable energy integration: Solar and wind energy storage solutions.       6. Specialized applications: Medical devices, aerospace, and military.       7. Case studies on battery failure and safety incidents.       8. Discussion on regulations and standards for battery use.   12. Environmental Impact and Recycling       1. Environmental impact of battery production and disposal.       2. Strategies for reducing the ecological footprint of battery technologies.       3. Recycling processes for different types of batteries.       4. Government policies and regulations regarding battery disposal.       5. Advances in battery recycling technologies.   13. Hands-on lab: Exploring the recycling process and evaluating eco-friendly battery alternatives. | * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |
| 1. Apply magnetism and electromagnetism | * 1. Magnetic Circuits and Devices      1. Introduction to magnetic circuits.      2. Magnetic flux, magnetic field density, magnetic field strength, Reluctance, magnetomotive force (MMF), and magnetic flux.      3. Calculations involving magnetic circuits      4. Analogies between electric and magnetic circuits.      5. Magnetic materials in electrical devices (soft and hard magnetic materials).   2. Electromagnetic Induction      1. Faraday’s Law of electromagnetic induction.      2. Lenz's Law: Direction of induced EMF.      3. Practical applications: Electric generators and transformers.      4. Induced EMF in different configurations (moving conductors, changing magnetic fields).      5. Self-induction and mutual induction.      6. Transformers: Working principles, construction, and applications.      7. Step up and step-down transformers      8. Power losses in transformers.      9. Calculations involving transformers      10. Energy stored in magnetic fields. | * Oral questioning * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |
| 1. Apply basic electrical machines | * 1. DC Machines      1. DC machine construction and types (motors and generators).      2. Working principle of DC generators and back EMF.      3. Types of DC generators: Series, shunt, and compound.      4. Working principle of DC motors.      5. Types of DC motors: Series, shunt, and compound.      6. Speed-torque characteristics of DC motors.      7. Performance analysis and efficiency of DC machines.      8. Starting methods for DC motors.      9. Hands-on lab: Testing and operating a DC motor/generator.   2. Induction Motors (AC Machines)      1. Introduction to induction motors: Construction and working principles.      2. Types of induction motors: Squirrel cage and wound rotor.      3. Rotating magnetic fields and slip in induction motors.      4. Equivalent circuit model of an induction motor.      5. Torque-speed characteristics.      6. Methods of starting and speed control.      7. Performance analysis of induction motors.      8. Losses and efficiency considerations.   3. Hands-on lab: Testing and operating an induction motor. | * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |
| 1. Apply electronics components | * 1. Introduction to Electronic Components      1. Overview of electronics: What are electronic components?      2. Classification of components: Passive, active, and electromechanical.      3. Introduction to circuit symbols and schematic diagrams.      4. Basic electrical quantities and units (voltage, current, resistance).      5. Understanding datasheets and component specifications.      6. Overview of testing and measurement tools (multimeters, oscilloscopes).   2. Passive Components      1. Resistors: Types, color codes, power ratings, and applications.      2. Capacitors: Types (ceramic, electrolytic, film), capacitance value, and working voltage.      3. Charging and discharging of capacitors in DC circuits.      4. Applications of capacitors in filtering, timing, and energy storage.      5. Inductors: Types, inductance value, and applications.      6. Inductor behavior in DC and AC circuits.      7. Introduction to filters: RC, RL, and RLC circuits.   3. Semiconductor Devices      1. Diodes: Introduction to PN junctions, characteristics, and types (LEDs, Zener diodes, Schottky diodes).      2. Applications of diodes in rectification, voltage regulation, and signal clipping.      3. Transistors: Types (BJT and MOSFET), characteristics, and configurations.      4. Basic transistor circuits: Switches and amplifiers.      5. Hands-on lab: Building and testing simple diode and transistor circuits.      6. Special semiconductor devices: Thyristors, TRIACs, and optoelectronic devices.      7. Characteristics and applications in switching and control.   4. Integrated Circuits (ICs)      1. Overview of integrated circuits: Analog vs. digital ICs.      2. Operational amplifiers (Op-Amps): Characteristics and basic configurations.      3. Applications of Op-Amps in signal processing.      4. Timers and oscillators: 555 timer IC and its applications.      5. Voltage regulators: Linear and switching regulators.      6. Introduction to data converters (ADC and DAC).      7. Digital ICs: Logic gates and flip-flops.      8. Applications of digital ICs in basic logic circuits.      9. Hands-on lab: Building circuits using Op-Amps, timers, and logic gates.   5. Electromechanical and Specialized Components      1. Relays: Types, operation, and applications in switching.      2. Switches and connectors: Types and usage in electronic circuits.      3. Transformers: Basic operation, step-up/step-down functions, and isolation.      4. Displays: LED, LCD, and seven-segment displays.      5. Circuit Design and Practical Applications      6. Basic circuit design principles: Bread boarding, PCB layout, and soldering.      7. Introduction to circuit simulation tools (e.g., Multisim, LTSpice).      8. Testing and troubleshooting techniques.      9. Real-world applications of electronic components.      10. Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits.      11. Hands-on lab: Final project assembly and testing. | * Portfolio of evidence * Practical test * Third party report * Written tests * Project work |

**Suggested Methods of Instruction**

* Demonstration by trainer
* Practice by the trainee
* Field trips
* Discussions

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
| 1 | Textbooks | Comprehensive texts on electrical and control principle. | 5 pcs | 1:5 |
| 2 | Charts | Visual aids covering electrical theories and safety protocols | 10 pcs | 1:2.5 |
| 3 | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
| 1 | Lecture/Theory Room | Equipped with projectors and seating for 25 trainees, ~60 sqm | 1 | 1:25 |
| 2 | Workshop | Hands-on training area with workbenches, tools, and safety equipment, ~80 sqm | 1 | 1:25 |
| 3 | Computer Laboratory | Equipped with testing setups for electrical experiments, ~50 sqm.  Equipped with computers installed with Circuit simulation software. | 25 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
| 1 | Electrical Wires | Assorted sizes and color-coded (e.g., 1.5mm², 2.5mm², 4mm²) | 5 rolls | 1:5 |
| 2 | Insulation Tapes | For securing connections and insulation, assorted colors | 25 pcs | 1:1 |
| 3 | Breadboard | For prototyping and testing circuits | 5 pcs | 1:5 |
| 4 | Sensors | Assorted types (temperature, pressure, proximity) | 10 pcs | 1:2.5 |
| 5 | Signal generators | For generating AC signals | 5pcs | 1:5 |
| 6 | Transducers | Assorted | 10 pcs | 1:3 |
| 7 | Electronic components | Resistors, transistors, capacitors, relays, transformers. Integrated IC, OPAM. | 100pcs | 4:25 |
|  |  |  |  |  |
| **D** | **Tools and Equipment** |  |  |  |
| 1 | Screwdrivers | Assorted sets for various applications | 2 sets | 1:12.5 |
| 2 | Side Cutters | For cutting wires and cables | 4 pcs | 1:6.25 |
| 3 | Pliers | For gripping and bending wires | 3 pcs | 1:8.33 |
| 4 | Stripping Knives | For stripping insulation from wires | 4 pcs | 1:6.25 |
| 5 | Computers | Equipped with electrical and electronics simulation software | 5 pcs | 1:5 |
| 6 | Multimeters | For measuring voltage, current, and resistance | 5 pcs | 1:5 |
| 7 | Clamp Meters | For measuring current flow in circuits | 5 pcs | 1:5 |
| 8 | Oscilloscope | For observing waveforms and signals | 1 | 1:25 |
| 9 | Voltmeter | For measuring voltage | 1 | 1:25 |
| 10 | Ammeter | For measuring current | 1 | 1:25 |
| 11 | Signal Generator | For generating electrical signals for testing | 1 | 1:25 |
| 12 | Soldering gun | For soldering | 10 | 1:3 |
| 13 | Soldering wire | For making joints in electrical circuits | 10 | 1:3 |
| 14 | PLC | For program practice | 5 | 1:5 |
| 15 | Cells and batteries | For learning | 5 | 1:5 |
|  |  |  |  |  |
| **E** | **PPE (Personal Protective Equipment)** |  |  |  |
| 1 | PPE Sets | Includes helmets, gloves, safety goggles, shoes, and harnesses | 25 sets | 1:1 |
| 2 | Safety Signs and Barriers | For simulating safety zones and hazards | 10 sets | 1:2.5 |
| 3 | Earthing Test Kits | For ground testing and demonstrating earthing procedures | 5 pcs | 1:5 |
| 4 | Electrical Test Benches | For hands-on testing of functionality and circuit design | 5 pcs | 1:5 |
|  |  |  |  |  |
| **F** | **Reference Materials** |  |  |  |
| 1 | Industrial Automation Manuals | Covering principles and practices in automation | 25 pcs | 1:1 |
| 2 | Electrical Standards | Reference on industry standards (e.g., IEEE Guidelines) | 5 pcs | 1:5 |
| 3 | Technical Handbooks | On motors, drives, and wiring systems | 25 pcs | 1:1 |
| 4 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 5 | Multimedia Learning Modules | Digital licenses for videos and tutorials | 25 pcs | 1:1 |
| 6 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **HYDRAULIC AND PNEUMATIC SYSTEMS INSTALLATION**

**UNIT CODE:** 0715 451 08A

**Duration of Unit:** 100 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency**:** Hydraulic and pneumatic systems installation

**UNIT DESCRIPTION:**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train hydraulic and pneumatic systems installation. The learning outcomes require the learner to prepare for hydraulic and pneumatic system installation, install hydraulic system, install pneumatic system and test and commission hydraulic and pneumatic system.

**Summary of learning outcomes**

By the end of this unit of learning, the trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for hydraulic and pneumatic systems installation | **30** |
|  | Install hydraulic system | **20** |
|  | Install Pneumatic system | **20** |
|  | Test and commission Hydraulic and Pneumatic system | **30** |
|  | **TOTAL** | **100** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **learning outcome** | **Content** | **Suggested Assessment Methods** |
| * + - 1. Prepare for hydraulic and pneumatic systems installation | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic and pneumatic system installation.      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site         2. Correct use of tools and equipment   2. Site conditions and installation requirement      1. Site conditions         1. Temperature         2. Structure support         3. Topography         4. Humidity         5. Ventilation      2. Site survey         1. Importance of site survey         2. Procedure for site survey            1. Site inspection            2. Verify access points            3. Determine the location      3. Civil works         1. Definition of civil works         2. Reasons for carrying out civil works         3. Civil work activities            1. Measuring            2. Marking out            3. Excavation            4. Levelling            5. Site clearance      4. Site confirmation         1. Checking of dimensions         2. Checking of access points   Confirmation   * + 1. Factors to consider during site inspection        1. Availability of utilities           1. Water           2. Electricity           3. Road network           4. Environmental impact assessment   1. Hydraulic and pneumatic system specifications      1. Introduction to hydraulic and pneumatic system         1. Definitions and principles of hydraulic and pneumatic systems      2. Components of hydraulic system         1. Reservoirs         2. Pumps         3. Valves         4. Actuators         5. Hoses and connectors         6. Filters         7. Accumulators      3. Components of pneumatic system         1. Compressors         2. Air preparation units         3. Valves         4. Actuators         5. Pipes and fittings         6. Silencers and mufflers      4. Hydraulic system design requirements         1. System pressure         2. Flow rate         3. Fluid type and compatibility         4. Components         5. Temperature range         6. Safety features         7. Reservoir specifications         8. System efficiency      5. Pneumatic system design requirements         1. System pressure         2. Air quality         3. Flow rate         4. Components         5. Temperature range         6. Noise levels   2. Tools, equipment and materials      + 1. Installation tools and equipment           1. Hand tools * Assorted spanners * Crimping tools * Assorted pliers * Allen keys   + - * 1. Measuring and marking out tools         2. Cutting tools         3. Lifting equipment * Chain block   + - * 1. Measuring equipment       1. Working space –offices, stores       2. Technical drawings/machinery installation manuals       3. Maintenance requirements:          1. Grease          2. Hydraulic oil | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Install hydraulic system | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic and pneumatic system installation.      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site      6. Correct use of tools and equipment   2. Installation manuals interpretation      1. Introduction to Installation Manuals      2. Purpose of Installation Manuals * Provide detailed instructions for correctly installing equipment or systems. * Ensure safety, optimal performance, and compliance with standards. * Offer troubleshooting, maintenance, and operational guidelines.   + 1. Types of Installation Manuals * Equipment manuals (e.g., machines, HVAC systems, pumps, valves) * System manuals (e.g., pneumatic or hydraulic systems) * Electrical installation manuals (e.g., wiring diagrams, control panels)   + 1. Structure of Installation Manuals * Table of contents and overview * Safety instructions and warnings * Tools and materials required * Step-by-step installation instructions * Post-installation checks and maintenance information * Troubleshooting guides and FAQs   + 1. Interpreting Installation Manuals        1. Reading Installation Instructions * Decoding diagrams, illustrations, and charts * Understanding technical terms and abbreviations * Identifying common symbols in wiring diagrams, system layouts, and mechanical drawings   + - 1. Following Step-by-Step Instructions * Breaking down complex installation procedures into manageable tasks * Ensuring correct sequence of operations (e.g., assembling components before connecting power) * Double-checking measurements, orientations, and connections   + - 1. Checking for Compatibility * Verifying that components match the installation requirements and specifications * Identifying and addressing any discrepancies or missing parts * Ensuring correct system integration (e.g., electrical, hydraulic, pneumatic connections)   1. Hydraulic system components mounting      1. Pre-mounting Preparation * Reviewing the installation manual thoroughly before starting * Verifying all required tools and materials are available * Conducting site inspections for proper placement and setup * Ensuring safety protocols are in place   + 1. Step-by-Step mounting * Following the manual to assemble and install components * Ensuring each step is performed according to the manual to prevent errors * Using measuring tools and test equipment to verify correct installation   + 1. Post-mounting Checks * Ensuring the system or equipment functions as expected * Conducting performance tests and verifying the system meets manufacturer specifications * Inspecting all connections for security and proper fit * Reviewing calibration requirements (e.g., pressure, temperature, voltage calibration)   1. Hydraulic system pipes and hoses connection      1. Hydraulic System Components * Pipes and Tubing: Typically used for fixed connections and higher-pressure applications. * Hoses: Flexible, often used to connect moving parts or areas that require flexibility. * Fittings and Couplings: Provide the connection between pipes, hoses, and components like pumps, valves, and actuators. * Adapters and Flanges: Used for transitioning between different types or sizes of connections.   + 1. Hydraulic Fluids and Pressure * Hydraulic systems use fluids to transmit power. Understanding the type of fluid used (e.g., mineral oil, water-based) is crucial for selecting compatible materials for pipes and hoses. * The system operates under high pressures; thus, components need to handle the pressure limits specified by the manufacturer.   + 1. Reviewingthe Manufacturer's Manual * Carefully study the hydraulic system manual for pipe and hose specifications, including recommended pipe material, diameter, pressure rating, and compatibility with hydraulic fluid. * Pipe Material: Manufacturer specifications may recommend certain materials like steel, stainless steel, or copper, based on pressure, temperature, and fluid type. * Pressure Ratings: Ensure that the selected pipes and hoses are rated for the system’s operating pressure. * Hose Material: Verify the correct material for hoses (e.g., rubber, thermoplastic, metal) based on the temperature, pressure, and fluid compatibility. * Fittings and Connections: Ensure the correct fittings, such as flare, compression, or threaded fittings, are used according to the system design.   + 1. Sizing and Length of Pipes and Hoses * Ensure pipes and hoses are sized to meet the system’s flow and pressure requirements. Too small a diameter may cause pressure drops, while too large can result in inefficient flow. * Calculate the appropriate length to prevent slack, bending, or undue tension that could cause wear.   1. Step-by-Step Process for Connecting Pipes and Hoses      1. Preparing for Installation * Check Components: Verify that all pipes, hoses, fittings, and tools are available and compatible with the system’s specifications. * Cleanliness: Ensure all components are clean, especially the inside of the pipes, hoses, and fittings. Use clean clothes or flushing techniques to remove debris, dirt, or oil. * Safety Measures: Wear appropriate personal protective equipment (PPE) like gloves, goggles, and hearing protection. Also, ensure the system is depressurized before beginning the installation.   + 1. Installing Pipes and Tubing * Measure and Cut Pipes: Cut pipes to the required length using pipe cutters or saws, ensuring clean edges to avoid burrs that could damage seals. * Deburring and Cleaning: After cutting, remove any burrs or rough edges, then clean the cut ends to prevent contamination. * Threading and Fitting: For threaded connections, ensure that threads are clean and correctly aligned. Apply appropriate thread sealant (if required by the manufacturer) to prevent leaks. * Bending: If pipes need to be bent, use a pipe bender to ensure the bends are smooth and gradual to avoid damage. * Installation of Fittings: Attach fittings securely to both the pipe and the component (e.g., pump, valve). Tighten to the manufacturer’s torque specifications to ensure a leak-free connection.   + 1. Connecting Hoses * Measure and Cut Hoses: Select hoses that match the required length, ensuring they do not sag or stretch under pressure. Cut hoses using proper hose cutters to avoid fraying or damaging the material. * Install Hose Fittings: Attach the appropriate fittings to the ends of the hoses. Depending on the system, these may be threaded, crimped, or push-on fittings. Follow the manufacturer’s recommendations for securing and tightening the fittings. * Positioning Hoses: Install hoses without sharp bends or kinks. Ensure the hoses are positioned to avoid abrasion, excessive stretching, or contact with high-heat surfaces. * Clamping and Securing Hoses: Use hose clamps or brackets to secure hoses, ensuring they remain in place and are protected from external damage.   1. Pressure Testing and Inspection      1. Pressure Testing * After installation, it’s essential to pressure-test the system to verify that all connections are secure and free of leaks. * Gradual Pressurization: Slowly bring the system up to operating pressure, monitoring for any drops or leaks. * Leak Detection: Use soapy water or an ultrasonic leak detector to identify any potential leaks around fittings or connections. * Torque Check: Recheck the tightness of all fittings and connections, ensuring they are within the manufacturer’s torque specifications.   + 1. Inspection and Final Checks * Inspect all hose and pipe connections for proper alignment and security. * Ensure that hoses are not subject to excessive tension, heat, or abrasion, which could lead to premature failure. * Verify that all components, including filters, valves, and actuators, are properly connected and functioning.   1. Hydraulic components assembly      1. Hydraulic system components         1. Hydraulic pump         2. Actuators         3. valves         4. Reservoir         5. Hydraulic Hoses         6. Filters         7. Accumulator         8. Motor         9. Hydraulic fluid      2. Troubleshooting Installation Issues      3. Common Installation Problems * Misalignment of components * Incorrect wiring or connections * Incompatible parts or accessories * System errors or performance issues   + 1. Troubleshooting Using the Manual * Referencing the troubleshooting section of the manual * Using diagnostic steps to identify faults * Analyzing system behavior based on manufacturer specifications and performance guidelines   + 1. Corrective Actions * Adjusting components to meet specification limits * Replacing faulty or incompatible parts * Re-running tests and verifying proper operation after troubleshooting   + 1. Housekeeping        1. Waste disposal method        2. Recycling Reusing and Reducing methods        3. Resource management        4. Pollution control        5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Install Pneumatic system | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic and pneumatic system installation.      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site      6. Correct use of tools and equipment   2. Installation manuals interpretation      1. Introduction to Installation Manuals      2. Purpose of Installation Manuals * Provide detailed instructions for correctly installing equipment or systems. * Ensure safety, optimal performance, and compliance with standards. * Offer troubleshooting, maintenance, and operational guidelines.   + 1. Types of Installation Manuals * Equipment manuals (e.g., machines, HVAC systems, pumps, valves) * System manuals (e.g., pneumatic or hydraulic systems) * Electrical installation manuals (e.g., wiring diagrams, control panels)   + 1. Structure of Installation Manuals * Table of contents and overview * Safety instructions and warnings * Tools and materials required * Step-by-step installation instructions * Post-installation checks and maintenance information * Troubleshooting guides and FAQs   + 1. Interpreting Installation Manuals        1. Reading Installation Instructions * Decoding diagrams, illustrations, and charts * Understanding technical terms and abbreviations * Identifying common symbols in wiring diagrams, system layouts, and mechanical drawings   + - 1. Following Step-by-Step Instructions * Breaking down complex installation procedures into manageable tasks * Ensuring correct sequence of operations (e.g., assembling components before connecting power) * Double-checking measurements, orientations, and connections   + - 1. Checking for Compatibility * Verifying that components match the installation requirements and specifications * Identifying and addressing any discrepancies or missing parts * Ensuring correct system integration (e.g., electrical, pneumatic connections)   1. Pneumatic system components mounting      1. Pre-mounting Preparation * Reviewing the installation manual thoroughly before starting * Verifying all required tools and materials are available * Conducting site inspections for proper placement and setup * Ensuring safety protocols are in place   + 1. Step-by-Step mounting * Following the manual to assemble and install components * Ensuring each step is performed according to the manual to prevent errors * Using measuring tools and test equipment to verify correct installation   + 1. Post-mounting Checks * Ensuring the system or equipment functions as expected * Conducting performance tests and verifying the system meets manufacturer specifications * Inspecting all connections for security and proper fit * Reviewing calibration requirements (e.g., pressure, temperature, voltage calibration)   1. Pneumatic system pipes and hoses connection      1. Pneumatic System Components * Pipes and Tubing: Typically used for fixed connections and higher-pressure applications. * Hoses: Flexible, often used to connect moving parts or areas that require flexibility. * Fittings and Couplings: Provide the connection between pipes, hoses, and components like pumps, valves, and actuators. * Adapters and Flanges: Used for transitioning between different types or sizes of connections.   + 1. Reviewingthe Manufacturer's Manual * Carefully study the pneumatic manual for pipe and hose specifications, including recommended pipe material, diameter, pressure rating, and compatibility with pneumatic system. * Pipe Material: Manufacturer specifications may recommend certain materials like steel, stainless steel, or copper, based on pressure, temperature, and fluid type. * Pressure Ratings: Ensure that the selected pipes and hoses are rated for the system’s operating pressure. * Hose Material: Verify the correct material for hoses (e.g., rubber, thermoplastic, metal) based on the temperature, pressure, and fluid compatibility. * Fittings and Connections: Ensure the correct fittings, such as flare, compression, or threaded fittings, are used according to the system design.   + 1. Sizing and Length of Pipes and Hoses * Ensure pipes and hoses are sized to meet the system’s flow and pressure requirements. Too small a diameter may cause pressure drops, while too large can result in inefficient flow. * Calculate the appropriate length to prevent slack, bending, or undue tension that could cause wear.   1. Step-by-Step Process for Connecting Pipes and Hoses      1. Preparing for Installation * Check Components: Verify that all pipes, hoses, fittings, and tools are available and compatible with the system’s specifications. * Cleanliness: Ensure all components are clean, especially the inside of the pipes, hoses, and fittings. Use clean clothes or flushing techniques to remove debris, dirt, or oil. * Safety Measures: Wear appropriate personal protective equipment (PPE) like gloves, goggles, and hearing protection. Also, ensure the system is depressurized before beginning the installation.   + 1. Installing Pipes and Tubing * Measure and Cut Pipes: Cut pipes to the required length using pipe cutters or saws, ensuring clean edges to avoid burrs that could damage seals. * Deburring and Cleaning: After cutting, remove any burrs or rough edges, then clean the cut ends to prevent contamination. * Threading and Fitting: For threaded connections, ensure that threads are clean and correctly aligned. Apply appropriate thread sealant (if required by the manufacturer) to prevent leaks. * Bending: If pipes need to be bent, use a pipe bender to ensure the bends are smooth and gradual to avoid damage. * Installation of Fittings: Attach fittings securely to both the pipe and the component (e.g., compressor, valve). Tighten to the manufacturer’s torque specifications to ensure a leak-free connection.   + 1. Connecting Hoses * Measure and Cut Hoses: Select hoses that match the required length, ensuring they do not sag or stretch under pressure. Cut hoses using proper hose cutters to avoid fraying or damaging the material. * Install Hose Fittings: Attach the appropriate fittings to the ends of the hoses. Depending on the system, these may be threaded, crimped, or push-on fittings. Follow the manufacturer’s recommendations for securing and tightening the fittings. * Positioning Hoses: Install hoses without sharp bends or kinks. Ensure the hoses are positioned to avoid abrasion, excessive stretching, or contact with high-heat surfaces. * Clamping and Securing Hoses: Use hose clamps or brackets to secure hoses, ensuring they remain in place and are protected from external damage.   1. Pressure Testing and Inspection      1. Pressure Testing * After installation, it’s essential to pressure-test the system to verify that all connections are secure and free of leaks. * Gradual Pressurization: Slowly bring the system up to operating pressure, monitoring for any drops or leaks. * Leak Detection: Use soapy water or an ultrasonic leak detector to identify any potential leaks around fittings or connections. * Torque Check: Recheck the tightness of all fittings and connections, ensuring they are within the manufacturer’s torque specifications.   + 1. Inspection and Final Checks * Inspect all hose and pipe connections for proper alignment and security. * Ensure that hoses are not subject to excessive tension, heat, or abrasion, which could lead to premature failure. * Verify that all components, including filters, valves, and actuators, are properly connected and functioning.   1. Pneumatic components assembly      1. Pneumatic system components         1. Compressors         2. Actuators         3. valves         4. Air Reservoir         5. Air Hoses         6. Filters, Regulators and Lubricator         7. Accumulator         8. Motor         9. Compressed Air      2. Troubleshooting Installation Issues      3. Common Installation Problems * Misalignment of components * Incorrect wiring or connections * Incompatible parts or accessories * System errors or performance issues   + 1. Troubleshooting Using the Manual * Referencing the troubleshooting section of the manual * Using diagnostic steps to identify faults * Analyzing system behavior based on manufacturer specifications and performance guidelines   + 1. Corrective Actions * Adjusting components to meet specification limits * Replacing faulty or incompatible parts * Re-running tests and verifying proper operation after troubleshooting   1. Housekeeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission Hydraulic and Pneumatic system | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic and pneumatic system installation.      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site      6. Correct use of tools and equipment   2. Assembly layout checks      1. System component arrangement         1. Check placement of components         2. Clearance and accessibility         3. Alignment and mounting      2. Piping and tubing layout         1. Pipe support and clamps         2. Connection and tightness         3. Check pipe routing      3. Pressure relief and safety measures         1. Pressure relief valves         2. Safety equipment      4. Electrical and control system integration         1. Control panel location         2. Wiring and connections      5. Pressure and flow test         1. Pressure test points         2. Flow test set up         3. System pressure checks      6. Leakage check         1. Air and fluid leakage         2. Leakage and fittings      7. System functionality testing         1. Actuator movement         2. Valve operation         3. Flow regulation   3. Troubleshooting hydraulic and pneumatic system      1. Troubleshooting Steps         1. Identify the Symptom * Hydraulic System: Common symptoms include a drop in pressure, slow or erratic movement, or overheating. * Pneumatic System: Symptoms might include loss of pressure, noisy operation, or erratic actuator movements.   + - 1. Visual Inspection * Leaks: Inspect hoses, valves, and seals for leaks in both systems. * Physical Damage: Check for damage to cylinders, pipes, and hoses. * Cleanliness: Ensure that the system is free from dirt or contamination.   + - 1. Check for Blockages * Hydraulic System: Inspect the filters, valves, and hydraulic lines for blockages or restrictions. * Pneumatic System: Check for blockages in air filters, regulators, and airlines.   + 1. Specific Hydraulic System Troubleshooting        1. Low Pressure or No Pressure * Check Fluid Level: Ensure the hydraulic reservoir is filled with the proper fluid. * Inspect the Pump: Check for pump wear or failure; ensure its operating properly. * Check the Pressure Relief Valve: Ensure the valve is set to the correct pressure and not stuck open.   + - 1. Slow or Erratic Cylinder Movement * Check for Air in the System: Bleed air from the system. * Check Valves: Ensure that control valves are functioning properly and not stuck. * Inspect Cylinders: Check if the cylinder seals are worn out or leaking.   + - 1. Overheating * Check Fluid Level and Quality: Low fluid or contaminated fluid can cause overheating. * Check Heat Exchanger: Ensure the cooling system is working effectively.   + - 1. Contamination * Check Filters: Ensure that all filters (intake, return, and pressure) are clean. * Inspect the Fluid: Replace fluid if it’s contaminated with water or debris.   + 1. Specific Pneumatic System Troubleshooting        1. Low Air Pressure * Check the Compressor: Ensure its providing adequate air pressure. * Inspect Air Filters: Clogged air filters can reduce airflow, leading to pressure loss. * Check for Leaks: Inspect all air lines and connections for leaks.   + - 1. Erratic or No Actuator Movement * Check the Solenoid Valves: Ensure they’re activating correctly and not stuck. * Check the Air Supply: Ensure that the system is receiving sufficient air from the compressor.   + - 1. Noisy Operation * Inspect the Compressor: Excessive noise can indicate mechanical issues within the compressor. * Check Valves: Worn or malfunctioning valves can cause excessive noise.   + - 1. Condensation in the Air Lines * Check the Air Dryer: Ensure the air dryer is functioning properly to remove moisture. * Check the Drain Valve: Ensure the drain valve is open to remove accumulated water.   + 1. Common Tools for Troubleshooting * Pressure Gauge: To check pressure levels at various points in the system. * Flow Meter: To check for flow rates and detect any restrictions. * Leak Detection Spray: To find leaks in the system. * Multimeter: To check electrical components, especially in solenoid valves. * Thermometer: To check if the system is overheating.   + 1. Commissioning procedures        1. Initial power start up        2. System calibration        3. System monitoring        4. Final checks     2. Documentation and handover        1. Record test results        2. Compliance with standards        3. User manuals        4. Training        5. System hand-off   1. Housekeeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

Suggested Methods of Delivery

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

Chain block

Greasing gun

Pressure gauges

RECOMMENDED RESOURCES FOR 25 TRAINEES

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Hydraulics and Pneumatics: A Technician's and Engineer's Guide" by Andrew Parr | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | Hydraulic fluids | Multipurpose heavy duty | 20litres | 1:25 |
|  | Cleaning detergents | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
| **Measuring tools** | | | | |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Compressor | Portable compressor 25 liters | 5 | 1:5 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Installation manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **HYDRAULIC AND PNEUMATIC SYSTEMS MAINTENANCE**

**UNIT CODE:** 0715 451 09A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Hydraulic and Pneumatic Systems Maintenance

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train hydraulic and pneumatic system maintenance. The learning outcome shall enable the learner to conduct preventive maintenance on hydraulic system, conduct corrective maintenance on hydraulic system, conduct preventive maintenance on pneumatic system, conduct corrective maintenance on pneumatic systems and test and commission hydraulic and pneumatic system.

**Summary of learning outcomes**

By the end of this unit of learning, trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Conduct Preventive Maintenance on hydraulic system | **20** |
|  | Conduct Corrective Maintenance on hydraulic system | 30 |
|  | Conduct Preventive Maintenance on pneumatic system | **20** |
|  | Conduct Corrective Maintenance on pneumatic system | **30** |
|  | Test and commission hydraulic and pneumatic system | **20** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct Preventive Maintenance on hydraulic system | * 1. Workshop safety      1. Definition of preventive maintenance      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic system      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site         2. Correct use of tools and equipment * Hydraulic gadget * Screw drivers * Adjustable spanner * Allen keys   1. Hydraulic system      1. Definition of terms      2. Hydraulic Symbols      3. Components and their functions         1. Actuators         2. Valves         3. Hydraulic pump         4. Reservoirs         5. Filters         6. Pressure gauges      4. Inspection         1. Definition of inspection         2. Objectives of inspection         3. Types of inspections            1. Routine            2. Periodic            3. On-ground            4. Pre-operational            5. Major         4. Inspection tools            1. Basic visual tools            2. Precision measuring tools            3. Vibration analysis tools         5. Advantages of hydraulic system inspection         6. Inspection Checks            1. Inspection for malfunction            2. Inspect machine operating parameters against manufacturer manual            3. Carry out routine checks   Unusual sound  Unusual temperature  Misalignment   * 1. Preventive maintenance      1. Types of preventive maintenance         1. Daily         2. Weekly         3. Fortnightly         4. Monthly         5. Quarterly         6. Semi-annually         7. Annually      2. Selection of tools and equipment for preventive maintenance in hydraulic system      3. Use of selected tools and equipment      4. Switching off hydraulic systems         1. Safety precautions when switching off system         2. Procedure for switching off hydraulic system components            1. Electrical systems            2. Mechanical systems            3. Software operated systems            4. Checking for functionality of hydraulic system components      5. Components to be checked         1. Gauges         2. Valves         3. Regulators         4. Sensors         5. Actuators         6. Hydraulic pump         7. Reservoirs         8. Filters      6. Preventive maintenance activities         1. Lubrication         2. Cleaning         3. Inspection         4. Adjustment         5. Tightening         6. Replacement of worn-out components.   2. Testing hydraulic system      1. Workshop safety      2. Types of tests         1. Pressure test         2. Operational test         3. Leak test         4. Flow test         5. Temperature test      3. Testing tools and equipment         1. Types of testing tools         2. Use of various testing equipment      4. Checking for fluid leakages in hydraulic systems.         + 1. Causes of leakages in hydraulic systems   3. Maintenance checklist      + 1. Definition of checklist        2. Importance of checklist        3. Preparation of checklist        4. Filing of checklist        5. Maintenance log   4. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning   5. Hydraulic systems maintenance activities and finding documentation      1. Type of maintenance documentation         1. Work orders         2. Inspection checklist         3. Service logs         4. Equipment manuals         5. Maintenance schedules         6. Failure reports         7. Spare parts inventory | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct Corrective Maintenance on hydraulic system | * 1. Workshop safety      1. Definition of preventive maintenance      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic system      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES   2. Troubleshooting      1. Definition of terms         1. Troubleshooting         2. Corrective maintenance      2. Safety precaution during troubleshooting      3. Troubleshooting techniques         1. Testing electrical components         2. Testing mechanical faulty components         3. Visual inspection      4. Hydraulic system faults         1. Failure of pressure vessels         2. Insufficient oil in the tank         3. Valve failures         4. Failure of hydraulic pumps         5. Corrosion         6. Faulty seals         7. Failure of electrical control system         8. Failure of electrical supply         9. Faulty and loose component         10. Leaks   3. Hydraulic system faulty components identification      1. Components of hydraulic system         1. Gauges         2. Valves         3. Regulators         4. Sensors         5. Actuators         6. Hydraulic pump         7. Reservoirs         8. Filter      2. Common faults in hydraulic components         1. Pumps: Cavitation, excessive noise, and low pressure.         2. Valves: Sticking, leakage, and failure to open/close.         3. Actuators: Slow or erratic movement, internal leaks.         4. Hoses and Fittings: Cracks, bulges, and connection issues.         5. Filters: Clogging and contamination.      3. Tools, equipment and spares         1. Identify and obtain spare parts         2. Selecting maintenance tools and equipment         3. Uses of tools and equipment * Pipe wrench * Combination wrench * Assorted spanners   1. Hydraulic system faults rectification procedure      1. Hydraulic system repair procedure         1. Isolate the equipment         2. Disassemble the equipment         3. Replace faulty components         4. Assemble component      2. Rectification methods for hydraulic components         1. Pumps: * Replacing worn-out gears, seals, or bearings. * Refitting or recalibrating pump components.   + - 1. Valves: * Cleaning or replacing clogged or damaged valves. * Testing and adjusting pressure relief valves.   + - 1. Actuators: * Replacing seals or pistons. * Repairing or replacing cylinder rods.   + - 1. Hoses and Fittings: * Replacing damaged hoses with manufacturer-approved alternatives. * Ensuring proper sealing and torque on fittings.   + - 1. Filters: * Replacing clogged filters. * Cleaning filter housing as specified.   1. Test the functionality of the serviced components      1. Leakages      2. Pressure test      3. Flow rate test      4. Temperature test      5. Pressure gauges      6. Sensors      7. Flow indicators      8. Pressure switches   2. Documentation      1. Check list      2. Maintenance log | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct Preventive Maintenance on pneumatic system | * 1. Workshop safety      1. Types of workshop hazard      2. Hazards and control measures associated with pneumatic system      3. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES         6. Work site safety demarcation barriers.         7. Methods of demarcating a work site         8. Correct use of tools and equipment      4. Tools         1. Basic hand tools         2. Diagnostic tools         3. Inspection tools         4. Power tools         5. Calibration tools      5. Equipment         1. Lifting equipment            + Pallet jack            + Hoist            + Chain block         2. Lubrication equipment            + Grease gun            + Test equipment      6. Materials         1. Consumables            + Lubricants            + Filters            + O-rings and seals            + Caskets            + Filter elements            + Sealants and adhesives      7. Cleaning agents      8. Use of pneumatic tools and equipment      9. Care and Maintenance   2. Pneumatic system      1. Definition of Pneumatic system      2. Pneumatic system Symbols      3. Components and their functions         + - Actuators           - Valves           - Compressor           - Reservoirs           - Filters           - Pressure gauges   3. Inspection      1. Definition of inspection      2. Objectives of inspection      3. Types of inspections         + - Routine           - Periodic           - On-ground           - Pre-operational           - Major      4. Inspection tools         + - Basic visual tools           - Precision measuring tools           - Vibration analysis tools      5. Advantages of pneumatic system inspection      6. Inspection Checks         + - Inspection for malfunction           - Inspect machine operating parameters against manufacturer manual           - Carry out routine checks           - Unusual sound           - Unusual temperature           - Misalignment   4. Pneumatic system equipment isolation      1. Working principle of pneumatic system      2. Definition of isolation      3. Procedure for isolation         + - Notify the user/authority           - Obtain permit to work           - Disconnect electrical power           - Lockout/Tag out the machine   5. Interpretation of pneumatic system maintenance manuals      1. Types of manuals         + - pneumatic system manuals           - Occupational safety manuals           - Installation manuals           - Operation manuals           - Maintenance manuals   6. Preventive maintenance activities      1. Lubrication      2. Cleaning      3. Inspection      4. Adjustment      5. Tightening      6. Replacement of worn-out components.      7. Use of selected tools and equipment   7. Pneumatic system fluid replenishing   8. Pneumatic test      1. Switching off pneumatic systems         1. Safety precautions when carrying out test         2. Procedure for switching off pneumatic system components            + Electrical systems            + Mechanical systems            + Software operated systems         3. Checking for functionality of pneumatic system components      2. Components to be checked         1. Gauges         2. Valves         3. Regulators         4. Sensors         5. Actuators         6. Compressor         7. Reservoirs         8. Filters         9. Air compressor/pressurized tanks         10. Intercoolers         11. Regulators         12. Filters         13. Lubricator         14. Pneumatic fitting         15. Pneumatic cylinders   9. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning   10. Maintenance activities documentation       1. Maintenance checklist          1. Definition of checklist          2. Importance of checklist          3. Preparation of checklist          4. Filing of checklist       2. Maintenance log | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct Corrective Maintenance on pneumatic system | * 1. Safe work practices and procedures for workshop.      1. Types of workshop hazard      2. Hazards and control measures associated with pneumatic system      3. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      4. Work site safety demarcation barriers.         1. Methods of demarcating a work site      5. Correct use of tools and equipment   2. Troubleshooting      1. Definition of terms         1. Troubleshooting         2. Corrective maintenance      2. Safety precaution during troubleshooting      3. Troubleshooting techniques         1. Testing electrical components         2. Testing mechanical faulty components         3. Visual inspection      4. Pneumatic system faults         1. Failure of pressure vessels         2. Insufficient air in the tank         3. Valve failures         4. Failure of compressors         5. Corrosion         6. Faulty seals         7. Failure of electrical control system         8. Failure of electrical supply         9. Faulty and loose component         10. Leaks   3. Pneumatic system faulty components identification      1. Components of pneumatic system         1. Actuators         2. Valves         3. Compressor         4. Reservoirs         5. Filters         6. Pressure gauges      2. Inspection         1. Definition of inspection         2. Objectives of inspection         3. Types of inspections            + Routine            + Periodic            + On-ground            + Pre-operational            + Major         4. Inspection tools            + Basic visual tools            + Precision measuring tools            + Vibration analysis tools         5. Advantages of pneumatic system inspection         6. Inspection Checks            + Inspection for malfunction            + Inspect machine operating parameters against manufacturer manual            + Carry out routine checks            + Unusual sound            + Unusual temperature            + Misalignment      3. Common faults in pneumatic system         1. Air leaks         2. Contaminated air         3. Pressure loss         4. Overheating         5. Moisture in the system         6. Faulty actuators         7. Valve malfunction         8. Compressor issues         9. Excessive noise   4. Pneumatic system faulty components rectification      1. Air leaks * Symptoms: Hissing sound, pressure drop, reduced efficiency. * Causes: Damaged seals, loose fittings, or worn tubing. * Rectification:   + Locate the leak using soapy water or an ultrasonic leak detector.   + Tighten connections or replace faulty components.     1. Pressure Drops * Symptoms: Insufficient force or inconsistent operation. * Causes: Obstructed air supply, leaks, or undersized piping. * Rectification:   + Check for blockages in filters or lines.   + Ensure proper pipe sizing and replace worn-out components.     1. Actuator Malfunction * Symptoms: Slow or erratic movement, failure to extend/retract. * Causes: Contamination, worn seals, or improper alignment. * Rectification:   + Inspect and clean the actuator.   + Replace seals or repair damaged components.     1. Valve Issues * Symptoms: Stuck or non-responsive valves. * Causes: Contamination, wear, or incorrect installation. * Rectification:   + Disassemble and clean the valve.   + Replace worn parts or recalibrate the valve.     1. Contamination in Air Supply * Symptoms: Reduced system performance or clogged components. * Causes: Dirt, oil, or water in the compressed air. * Rectification:   + Install or service filters, dryers, and lubricators.   + Perform regular maintenance on air preparation units.     1. Noise and Vibrations * Symptoms: Excessive noise or vibration during operation. * Causes: Loose fittings, misaligned components, or resonance. * Rectification:   + Tighten fittings and secure components.   + Add vibration dampers or adjust alignment.   1. Pneumatic system replenishing      1. Air preparation in pneumatic system         1. Filtration         2. Drying         3. Lubrication      2. Manufacturers specifications         1. Air quality standards         2. Pressure requirements         3. Lubrication      3. Replenishing Procedures         1. Depressurizethe System      + Shut off the air supply and relieve system pressure to ensure safety.        1. Inspect the Air Preparation Unit      + Filter * Check and replace if clogged or damaged.   + - Regulator * Adjust to the specified pressure range.   + - Lubricator * Refill with the recommended oil if necessary.   + - 1. Test the Air Source     - Ensure the compressor is functioning correctly and producing clean, dry air.     - Check for any signs of contamination or excessive moisture.       1. Install or Service Air Treatment Devices     - Add or service filters, dryers, and separators to match the manufacturer's air quality requirements.       1. Monitor Air Flow and Pressure     - Verify that the flow rate and pressure align with system needs. Use gauges and flow meters for precise measurements.   1. Pneumatic system test      1. Leak test      2. Pressure test      3. Performance test      4. Flow test      5. System cycling test      6. Functional test      7. Safety test   2. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission hydraulic and pneumatic system | * 1. Testing safety procedures      1. Types of workshop hazard      2. Hazards and control measures associated with pneumatic system      3. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs   2. Testing equipment selection      1. Hydraulic and pneumatic fundamentals * Principles of fluid power * Differences between hydraulic and pneumatic systems * Applications in industries (e.g., manufacturing, transportation, robotics)   + 1. System Components * Hydraulic: Pumps, reservoirs, cylinders, valves, hoses, and fittings * Pneumatic: Compressors, actuators, air preparation units (filters, regulators, lubricators), valves, and tubing   + 1. Operating Principles * Pressure, flow, and force relationships * Fluid dynamics in hydraulic systems * Air compression and expansion in pneumatic systems   1. Testing Basics      1. Purpose of Testing * Ensure safety and compliance with standards * Diagnose faults and optimize performance * Preventive maintenance and reliability assurance   1. Types of Tests * Leakage testing * Pressure testing * Flow testing * Component performance testing * System cycling and durability testing   1. Tools and Equipment for Testing      1. Measurement Tools * Pressure gauges * Flow meters * Leak detectors (ultrasonic or liquid-based) * Multimeters for electro-hydraulic/pneumatic systems   + 1. Testing Kits * Hydraulic testing kits with pressure adapters * Pneumatic testing kits with airflow monitoring devices   + 1. Safety Equipment * PPE (e.g., gloves, safety glasses, hearing protection) * Lockout/tag out kits   1. Testing Procedures      1. Leakage Testing * Detecting and locating leaks in hydraulic and pneumatic systems * Using soapy water, ultrasonic detectors, or dye-based methods   + 1. Pressure Testing * Evaluating pressure stability and verifying pressure ratings * Using pressure gauges to identify anomalies   + 1. Flow Testing * Measuring flow rates and identifying blockages * Calibrating flow meters for accuracy   + 1. Performance Testing * Assessing actuator speed, force, and cycle times * Testing valve response and functionality   + 1. System Durability and Cycling Tests * Running systems through continuous operation cycles * Identifying wear, overheating, or fatigue   1. Housekeeping      1. Importance of housekeeping      2. Pre testing housekeeping         1. Workspace preparation         2. Inspection of equipment         3. Fluid and air quality      3. Testing housekeeping         1. Management of tools and equipment         2. Handling spills and leaks         3. Cabling and tubing      4. Post testing housekeeping         1. Cleaning equipment and workspace         2. Storage of tools and consumables         3. Waste disposal | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

Suggested Methods of Delivery

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Air compressor
* Intercoolers
* Actuators
* Valves
* Hydraulic pump
* Reservoirs
* Filters

RECOMMENDED RESOURCES FOR 25 TRAINEES

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Hydraulics and Pneumatics: A Technician's and Engineer's Guide" by Andrew Parr | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | Hydraulic fluids | Multipurpose heavy duty | 20litres | 1:25 |
|  | Cleaning detergents | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
| **Measuring tools** | | | | |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Compressor | Portable compressor 25 liters | 5 | 1:5 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Maintenance manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE III

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| 0413 541 10A | Entrepreneurial skills | 40 | 4.0 |
| 0541 441 11 A | Mathematics | 80 | 8.0 |
| 0715 451 12A | Material handling systems installation | 120 | 12.0 |
| 0715 451 13A | Material handling systems maintenance | 120 | 12.0 |

## **ENTREPRENEURIAL SKILLS**

**ISCED UNIT CODE:** 0413 441 10A

**Duration of unit: 40** Hours

**Relationship with occupational standards**

This unit addresses the unit of competency: Apply Entrepreneurial skills.

**Unit Description:**

This unit covers the competencies required to demonstrate an understanding of entrepreneurship. It involves demonstrating an understanding of financial literacy, applying entrepreneurial concepts identifying entrepreneurship opportunities, applying business legal aspects, and developing business innovative strategies and business plans.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Apply financial literacy | 6 |
|  | Apply the entrepreneurial concept | 4 |
|  | Identify entrepreneurship opportunities | 6 |
|  | Apply business legal aspects | 6 |
|  | Innovate Business Strategies | 6 |
|  | Develop business plan | 12 |
|  | **TOTAL** | **40** |

**Learning Outcomes, Content and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply the entrepreneurial concept | * 1. Personal finance management   2. Balancing between needs and wants   3. Budget Preparation   4. Saving management   5. Factors to consider when deciding where to save   6. Debt management   7. Factors to consider before taking a loan   8. Investment decisions   9. Types of investments   10. Factors to consider when investing money   11. Insurance services   12. insurance products available in the market   13. Insurable risks | * Observation * Project * Written assessment * Oral assessment * Third party report * Interviews |
| 1. Apply the entrepreneurial concept | * 1. Difference between Entrepreneurs and Business persons   2. Types of entrepreneurs   3. Ways of becoming an entrepreneur   4. Characteristics of Entrepreneurs   5. salaried employment and self-employment   6. Requirements for entry into self-employment   7. Roles of an Entrepreneur in an enterprise   8. Contributions of Entrepreneurship | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Identify entrepreneurship opportunities | * 1. Sources of business ideas   2. Factors to consider when evaluating business opportunity   3. Business life cycle | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Apply business legal aspects | * 1. Forms of business ownership   2. Business registration and licensing processing   3. Types of contracts and agreements   4. Employment laws   5. Taxation laws | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Innovate Business Strategies | * 1. Creativity in business   2. Innovative business strategies   3. Entrepreneurial Linkages   4. ICT in business growth and development | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Develop business plan | * 1. Business description   2. Marketing plan   3. Organizational/Management   4. plan   5. Production/operation plan   6. Financial plan   7. Executive summary   8. Business plan presentation   9. Business idea incubation | * Observation * Written assessment * Project * Oral assessment * Third party report |

**Suggested Methods of Instruction**

* Direct instruction with active learning strategies
* Project (Business plan)
* Case studies
* Field trips
* Group Discussions
* Demonstration
* Question and answer
* Problem solving
* Experiential
* Team training
* Guest speakers

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive texts books on Entrepreneurial Skills | 30 pcs | 1:1 |
|  | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Media Resources | These include but are not limited to:   * Video Clips * Audio Clips * TV Sets * Radio Sets * Newspapers * Business Journals * Case studies |  |  |
|  | Templates | Templates for creating various documents e.g. business plan, invoices etc. | 30 | 1:1 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
|  | Lecture/Theory Room  /Learning Resource  Area\* | Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m) | 1 | 1:30 |
|  | Computer Laboratory | Equipped with at least 15 functional computers with internet connectivity and the following software:   * + - Windows/ Linux/ Macintosh Operating System     - Microsoft Office Software     - Google Workspace Account     - Antivirus Software | 1 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
|  | Writing Materials | Writing materials for note taking | Enough |  |
|  | Flashcards | For carrying out various activities by trainees | Enough |  |
|  | Charts | Sufficient for group work activities and displaying | Enough |  |
|  | Whiteboard Marker Pens | Dry-erase markers for trainers use. Assorted colours | Enough |  |

## **APPLIED MATHEMATICS**

**Unit Code: 0541 441 11A**

**Relationship with Occupational Standards**

This unit addresses the Unit of Competency: Apply Mathematics

**Unit Duration: 80 Hours**

**Unit Description**

This unit describes the competences required in order to Apply trigonometric functions, carrying out mensuration, Apply statistics and probability

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/No.** | **Learning Outcomes** | **Duration (Hours)** |
|  | Apply algebra | 20 |
|  | Apply trigonometric functions | 20 |
|  | Carry out mensuration | 20 |
|  | Apply statistics and probability | 20 |
| TOTAL | | 80 |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| * + - 1. Apply algebra | * 1. Indices      1. Power zero      2. Negative powers      3. Fractional powers      4. Laws of indices         1. Addition         2. Subtraction         3. Division         4. Multiplication   2. BODMAS   3. Roots      1. Square roots      2. Cube roots      3. nth roots   4. Logarithms      1. Laws of Logarithms         1. Product Law         2. Quotient Law         3. Power Law   5. Use of scientific calculator      1. Power ON/OFF      2. Mode         1. Degree         2. Radian         3. Gradient         4. SD      3. Clear      4. Save      5. Shift   6. Simultaneous equations   (up to 3 equations)   * + 1. Elimination     2. Substitution     3. Reduction     4. Graphical   1. Quadratic equations      1. Factorization      2. Quadratic formula      3. Completing the square      4. Graphical | * Written tests |
| * + - 1. Apply trigonometric functions | * 1. Angles      1. Acute      2. Obtuse      3. Reflex      4. Right angle   2. Triangles      1. Isosceles      2. Equilateral      3. Right angled      4. Scalene   3. Trigonometric Ratios      1. Sine      2. Cosine      3. Tangent      4. Cosecant      5. Secant      6. Cotangent   4. Trigonometric Identities      1. Proof of identities      2. Pythagorean identities   5. Solve trigonometric equations   6. Hyperbolic functions      1. Sinh x      2. Cosh x      3. Cosech x      4. Tanh x      5. Sech x | * Written tests |
| 1. Carry out mensuration | * 1. Units and symbols of measurement      1. Mass      2. Distance      3. Speed      4. Temperature      5. Time   2. Imperial and metric units      1. Conversions   3. Perimeter      1. Regular shapes   4. Area      1. Regular shapes   5. Volume      1. Regular shapes | * Written tests |
| 1. Apply statistics and probability | * 1. Data presentation      1. Continuous variables         1. Histogram         2. Line      2. Discrete variable         1. Bar graph         2. Pie graph      3. Grouped data         1. Histogram         2. Bar         3. Cumulative frequency         4. ogive      4. Ungrouped data         1. Line         2. Cumulative frequency   2. Measures of central tendency      1. Mean         1. Grouped data         2. Ungrouped data      2. Mode         1. Grouped data         2. Ungrouped data      3. Medium         1. Grouped data         2. Ungrouped data   3. Measures of dispersion      1. Standard deviation         1. Grouped data         2. Ungrouped data      2. Variance         1. Grouped data         2. Ungrouped data   4. Probability      1. With replacement      2. Without replacement   5. Probability distribution functions      1. Binomial distribution      2. Poisson distribution   6. Normal distribution | * Written tests |

**Suggested Delivery Methods**

* Demonstration
* Group discussions
* Exercises
* Online materials
* Direct instructions
* Simulation

**Recommended Resources for 30 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Comprehensive textbooks on Engineering Mathematics | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |
| **D** | **Tools and Equipment** | | | |
|  | Set of Mathematical instruments | For constructions and measurements | 30 | 1:1 |
|  | Scientific Calculator | For Calculations | 30 | 1:1 |
|  | Firefighting extinguishers | Water, carbon dioxide and chemical powder fire extinguishers for fire fighting | 1 | 1:30 |
| **E** | **Reference Materials** | | | |
|  | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:30 |
|  | Standard Mathematical Tables | For reference on formulae, identities, laws and principles | 30 | 1:1 |

## **MATERIAL HANDLING SYSTEM INSTALLATION**

**UNIT CODE:** 0715 551 12A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

**This unit addresses the unit of Competency**: Material handling system installation

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train material handling installation. The learning outcomes shall enable the learner to prepare for installation of material handling system, assemble material handling system parts and test and commission material handling system.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for installation of material handling system | **40** |
|  | Assemble material handling System parts. | **50** |
|  | Test and Commission material handling system | **30** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | C**ontent** | **Suggested Assessment Methods** |
| 1. Prepare for installation of material handling system | * 1. Introduction to material handling systems      1. Overview of material handling systems         1. Types of material handling systems * conveyors, hoists, cranes, lifts, automated systems, Fork lift, Reach stacker, lifting trolley, lifting chain, Chain block, Lifting rock, Topper, Pallets   + - 1. Functions and importance in manufacturing, warehousing, and logistics       2. Components of a material handling system: mechanical parts, electrical systems, control systems     1. Installation preparation        1. Key steps in preparing for the installation of a material handling system        2. Understanding site requirements, equipment specifications, and safety protocols   1. Safety procedures      1. OSH Act, 2007 overview         1. Legal requirements and guidelines for workplace safety during material handling system installation         2. Hazard identification and risk assessment for installation activities         3. Safe working practices for handling heavy equipment, electrical connections, and moving machinery parts      2. PPE and safety equipment         1. Identifying and using the correct Personal Protective Equipment (PPE) for different installation tasks (gloves, helmets, steel-toe boots, etc.)         2. Safety procedures for lifting, rigging, and positioning heavy equipment         3. Using fall protection and working at height protocols when installing overhead systems      3. Site safety checklists         1. Creating a checklist for safety measures to be followed before, during, and after installation      4. Work site safety demarcation barriers.         1. Methods of demarcating a work site         2. Correct use of tools and equipment      5. Engineering safety Hierarchy of controls         1. Physical hazard elimination         2. Hazard substitution         3. Engineering design/controls         4. Administrative controls         5. Safety signs and symbols   + Trainings/drills   + Toolbox talks     - 1. Personal Protective Equipment (PPEs)   + Hand gloves   + Overall/Dustcoat   + Helmet/Head gear   + Safety boots   + Goggles   + Ear muffs   + Face shield   1. Site conditions and installation requirement      1. Site assessment process         1. Evaluating the site for environmental factors (temperature, humidity, and cleanliness) that could affect installation         2. Checking for structural integrity of floors, ceilings, and walls (for overhead or floor-based systems)         3. Assessing electrical, water, and other infrastructure connections based on system needs         4. Ensuring that adequate space for machinery components and safety clearance is available      2. Installation requirements         1. Site assessment         2. Regulatory approvals         3. NEMA         4. NCA         5. Safety regulations and standards         6. System design         7. Structural support         8. Electrical and power requirements         9. Automation and control systems         10. Equipment installation         11. Integration with existing system         12. Material flow consideration         13. Accessibility and maintenance         14. Training and documentation         15. Emergency procedures         16. Quality assurance and testing      3. Site conditions         1. Temperature         2. Structure support         3. Topography         4. Humidity         5. Ventilation      4. Site survey         1. Importance of site survey         2. Procedure for site survey         3. Site inspection         4. Verify access points         5. Determine the location      5. Civil works         1. Definition of civil works         2. Reasons for carrying out civil works         3. Civil work activities * Measuring * Marking out * Excavation * Levelling * Site clearance   + 1. Site confirmation        1. Checking of dimensions        2. Checking of access points        3. Confirmation     2. Factors to consider during site inspection        1. Availability of utilities * Water * Electricity * Road network * Environmental impact assessment   + 1. Installation requirements        1. Reviewing manufacturer’s installation requirements (power, space, weight, etc.)        2. Identifying any necessary modifications to the site or environment before installation        3. Ensuring the site meets all health, safety, and regulatory standards required for system installation   1. Material handling machinery component specifications verification.      1. Reviewing component specifications         1. Detailed examination of material handling components: motors, drives, pulleys, conveyors, and control panels         2. Checking part numbers, weight limits, electrical ratings, and other design requirements      2. Ensuring compatibility         1. Ensuring that all components are compatible with the installation site and the overall system design         2. Verifying the dimensions, power requirements, and load-bearing capacities of components         3. Cross-referencing design drawings and manufacturer’s manuals for accuracy      3. Quality control         1. Inspecting all received components for damage or defects         2. Ensuring that all parts are delivered and available before starting installation to avoid delays      4. Material handling components         1. Conveyors component specifications * Belt Type and Material   + Material: Rubber, PVC, steel, or fabric, depending on the type of load to be handled.   + Width: Typically varies from 200 mm to 2000 mm depending on the materials being conveyed.   + Length: Defined by the installation area.   + Speed: Range from 0.1 m/s to 3 m/s, depending on application needs.   + Load Capacity: Can range from 500 kg to several tons, depending on the application and belt type. * Motor   + Type: Electric motors with specific power ratings (HP or kW).   + Power rating: Typically ranges from 0.5 HP to 100 HP depending on the belt width and load.   + Torque: Rated according to the type of load and speed requirements.   + Voltage: 220V, 380V, or 415V, with frequency specifications (50Hz or 60Hz). * Pulley Specifications   + Material: Steel, cast iron, or aluminum.   + Diameter: Varies depending on the conveyor size; usually between 150 mm and 1000 mm.   + Design: Smooth or with a lagging surface (grooved or crowned) to ensure proper traction. * Idlers   + Material: Steel or aluminum.   + Type: Troughing, return, and impact idlers.   + Design: Designed for minimum friction and long-lasting wear. * Bearings   + Type: Deep groove ball bearings or roller bearings, depending on load type.   + Material: Steel or stainless steel, depending on environmental conditions (corrosive environments may require stainless steel).   + Load Rating: To be designed to support the load from the conveyor belt.     - 1. Cranes component specifications * Structure   + Material: Steel (usually carbon steel or stainless steel for high corrosion resistance).   + Design: Box girder, single girder, double girder, or cantilever structure.   + Load Capacity: Typically ranges from 1 ton to several hundred tons, depending on application. * Hoists   + Type: Electric, pneumatic, or hydraulic.   + Lift Speed: Typically, between 2 to 10 meters per minute.   + Lift Height: Customizable, based on site requirements.   + Load Capacity: Can range from 500 kg to 100 tons.   + Motor Power: Depends on crane load capacity and hoisting speed (ranges from 0.5 kW to over 100 kW). * Trolley and Rails   + Material: Steel, with specific strength and corrosion resistance specifications.   + Design: Typically designed for easy movement along a track, with ball bearings or roller bearings.   + Track Gauge: Typically standardized, e.g., 1435 mm for most industrial applications. * Control Systems   + Types: Pendant-controlled, radio-controlled, or programmable logic controllers (PLC).   + Safety Features: Overload limit switches, emergency stops, and anti-sway controls.     - 1. Hoists(for lifting and lowering loads), component specifications * Motor   + Type: Electric or pneumatic (based on power source).   + Power Rating: Range from 0.5 kW to 30 kW depending on lifting capacity.   + Voltage: 110V, 220V, or 380V depending on location.   + Duty Cycle: Usually rated for 25%, 50%, or 100% depending on operational requirements. * Lift Capacity   + Range: Commonly between 500 kg and 50 tons, depending on the application (manual hoists typically have smaller capacity). * Lifting Speed   + Typical Range: 2 to 10 meters per minute, depending on hoist type and motor specifications. * Drum and Rope   + Material: Steel ropes or synthetic ropes, with specifications based on weight and lifting frequency.   + Capacity: Should match the required load limit, and rope durability is critical to the longevity of the hoist. * Brakes and Safety Devices   + Type: Mechanical or electromagnetic brakes.   + Safety Devices: Overload limiters, emergency stop switches, and load sensors.     - 1. Forklifts and material handling trucks component specifications * Lift Capacity   + Range: Typically, 1 to 10 tons depending on the design of the forklift. * Fork Length and Width   + Length: Common lengths range from 900 mm to 1800 mm.   + Width: Adjustable, depending on the load size and forklift design. * Motor and Engine   + Type: Electric, diesel, or LPG-powered.   + Power Rating: Electric forklifts range from 3 kW to 10 kW, while combustion engines are rated higher depending on lift capacity. * Mast   + Material: Steel with high tensile strength.   + Lifting Height: From 3 meters to over 10 meters depending on application. * Tires   + Type: Pneumatic or solid rubber tires.   + Load Rating: Specific to forklift capacity and operation conditions (e.g., outdoor vs. indoor use).     - 1. Automated storage and retrieval systems (ASRS) component specifications * Racking System   + Material: Steel (high-grade galvanized or coated for corrosion resistance).   + Load Capacity: Typically designed for palletized storage, with load capacity up to 2 tons per pallet. * Automated Guided Vehicles (AGVs)   + Power Supply: Electric or hybrid systems, often with onboard charging for continuous operation.   + Load Capacity: From small bins (100 kg) to large loads (up to several tons).   + Navigation: Laser guidance, magnetic strips, or visual systems. * Control Systems   + Automation Software: PLCs and computer systems to control the movement and sorting of materials.   + Interface: Touchscreens, barcode/RFID readers for identification.     - 1. Palletizers and depalletizers component specifications * Structureand Frame   + Material: Stainless steel or carbon steel with corrosion-resistant coatings.   + Load Capacity: Varies depending on pallet weight (ranges from 200 kg to 1500 kg or more). * Gripper Arms   + Material: Steel, with rubber or polymer grips for safe handling of materials.   + Design: Adjustable to handle different package sizes. * Conveyor Integration   + Belt or Roller Conveyor: Conveyors that integrate with palletizers to automatically move materials into and out of storage areas.     - 1. Electric and pneumatic drives component specifications * Motor Power   + Electric Motors: Range from 0.5 kW to 100 kW or more depending on the machinery.   + Pneumatic Motors: Varies, with torque output tailored for the load being handled. * Control Systems   + Frequency Drives: Used to regulate motor speed based on material handling needs.   + Torque Limiting Devices: To prevent damage to components and overloading.     - 1. Safety features component specifications * Limit Switches   + To prevent overtravel or dangerous motion of material handling equipment. * Emergency Stops   + Positioned strategically to halt operations in case of an emergency. * Sensors and Monitoring   + Load sensors, proximity sensors, and fault detection systems that alert operators to potential issues.   1. Selecting and assembling tools, equipment, and materials for installation      1. Tool and equipment selection         1. Identifying tools and machinery required for various tasks in the installation (e.g., wrenches, drills, cranes, forklifts) * Types of tools   + Hand tools   + Assorted spanners   + Hammer   + Pliers   + Pipe wrench   + Screw drivers   + Allen keys   + Power tools   + Grinders   + Drill   + Power saws     - 1. Safety requirements for handling tools and machinery       2. Power tools versus hand tools: selecting based on installation needs     1. Material selection        1. Ensuring all necessary materials are available: bolts, fasteners, lubricants, cables, etc.        2. Managing inventory and verifying that all components are accounted for        3. Considering site-specific requirements like environmental protection or compliance with fire safety standards        4. Types of material handling material * Hydraulic oil * Conveyors * Oil seals * Bearings * Chains * Grease * Oil filters * Air filters * Cleaning detergents   + 1. Assembly of equipment        1. Assembling rigging, hoisting equipment, and scaffolding required for heavy lifting during installation        2. Pre-installation assembly checks for alignment, parts compatibility, and function        3. Types of material handling equipment * Fork lift * Cranes * Reach stacker * Lifting trolley * Hoist * Lifting chain * Chain block * Lifting rock * Topper * Conveyor’s system * Pallets   1. Housekeeping      1. Importance of housekeeping         1. Keeping the installation site safe by minimizing clutter, ensuring pathways are clear, and reducing the risk of accidents         2. Preventing contamination of machinery and equipment, ensuring that they are not exposed to dirt or moisture before installation      2. Housekeeping procedures         1. Properly storing tools and materials to avoid damage or loss         2. Regular cleaning of work areas to maintain a safe and efficient environment         3. Waste disposal and recycling procedures for packaging materials and scrap      3. Workplace Cleanliness During Installation         1. Ensuring that the site remains tidy and organized during installation to reduce hazards      4. Housekeeping activities         1. Waste segregation         2. Bench cleaning         3. Keeping workplace neat and orderly         4. Consumables and inventory         5. Tool rack         6. Tool box | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 2. Assemble material handling System parts. | * 1. Adhering to safety procedures (OSH Act, 2007)      1. OSH Act, 2007 overview         1. Legal requirements and guidelines for workplace safety during the assembly of material handling systems         2. Identifying potential hazards (e.g., electrical, mechanical, lifting operations)         3. Risk assessment and mitigation strategies for assembly tasks         4. The importance of safe working practices during equipment handling and installation      2. Safety equipment and PPE         1. Proper selection and use of PPE (Personal Protective Equipment) including gloves, helmets, goggles, hearing protection, and steel-toe boots         2. Safety procedures for lifting heavy components and working with tools and machinery         3. Lockout/tag out procedures for electrical or mechanical systems      3. Emergency Procedures         1. First aid basics, emergency shutdown procedures, and reporting incidents   2. Assembling material handling system components      1. Component Review and Specification         1. Overview of key components (motors, drives, conveyors, pulleys, hoists, lifts)         2. Reading and interpreting manufacturer’s manuals, assembly drawings, and component specifications         3. Importance of verifying the correct components before starting the assembly      2. Step-by-step assembly process         1. Mechanical assembly * Securing frames, supports, and structures * Attaching motors, pulleys, and belts to the mainframe * Assembling conveyor systems, hoist systems, and load-bearing components   + - 1. Electrical assembly: * Wiring and connecting electrical components (motors, sensors, control panels) * Installing safety devices like limit switches and emergency stop buttons * Verifying connections for electrical systems (voltage, current ratings, grounding)   + 1. Tools and Equipment for Assembly        1. Overview of tools used in assembly (hand tools, power tools, lifting equipment)        2. Ensuring the correct tools are used for each task to prevent damage and ensure safety   1. Mounting material handling system according to job requirements      1. Mounting system components * Proper mounting techniques for different systems (conveyors, cranes, hoists, lifts) * Ensuring structural integrity and alignment during installation * Adjusting for load distribution and minimizing stress on mounted components * Installing support brackets, rails, and foundations   + 1. Site Conditions and Requirements * Mounting considerations based on site conditions (floor strength, ceiling height, available space) * Understanding load capacities and clearance requirements for various systems * Ensuring that all systems are installed at the correct height and orientation   + 1. Adjustments and Fine-tuning * Making adjustments to accommodate real-time conditions and operational efficiency * Testing for alignment and proper function before system start-up   1. Housekeeping      1. Importance of housekeeping * Maintaining a safe, clean, and efficient workspace during the assembly of material handling systems * Reducing the risk of accidents and injuries by keeping the area organized and free of obstacles   + 1. Housekeeping procedures * Storing tools, equipment, and materials correctly to avoid damage or loss * Regular cleaning of work areas to prevent dirt or debris from interfering with assembly tasks * Managing waste disposal and recycling of packaging materials, scrap, and damaged components   + 1. Organizing workspaces * Setting up assembly areas for easy access to tools and components * Implementing a “5S” system (Sort, set in order, Shine, Standardize, Sustain) for a tidy workspace | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 3. Test and Commission material handling system | * 1. Introduction to test and commission of material handling systems      1. Overview of test and commissioning process         1. The importance of testing and commissioning in ensuring system functionality and safety.         2. Key phases of commissioning: preparation, functional testing, troubleshooting, fault correction, user training, and documentation.         3. Introduction to manufacturer’s specifications and job requirements for commissioning material handling systems.      2. Goals of Commissioning         1. Ensure the system operates efficiently and meets safety and operational standards.         2. Identify and resolve any performance issues or faults.         3. Provide users with the knowledge to operate and maintain the system safely.   2. Adhering to safety procedures (OSH Act, 2007)      1. Overview of OSH Act, 2007 and Workplace Safety         1. Understanding the legal framework for workplace safety.         2. Identifying potential hazards during testing and commissioning of material handling systems (e.g., electrical hazards, mechanical risks, lifting operations).         3. Personal Protective Equipment (PPE): Appropriate selection and use during testing and commissioning.      2. Safety Protocols During Testing and Commissioning         1. Lockout/tag out (LOTO) procedures for electrical and mechanical systems.         2. Conducting risk assessments before starting testing activities.         3. Ensuring that safety barriers and emergency shutdown systems are in place.      3. Emergency Procedures         1. Steps to take in the event of an emergency, including first aid and fire safety.         2. Importance of reporting and investigating incidents during commissioning.   3. Conducting material handling system functional testing      1. Types of functional tests         1. Electrical testing: verifying power supply, wiring, and electrical components.         2. Mechanical testing: ensuring correct alignment, load handling, and movement of components (e.g., conveyors, hoists).         3. Operational tests: running the system under normal and peak load conditions to assess performance.      2. Functional testing procedures         1. Step-by-step process for functional testing, including pre-test preparation, test execution, and post-test evaluation.         2. Ensuring that all system components are tested as per design requirements and specifications.         3. Troubleshooting issues that arise during testing (e.g., misalignment, improper load distribution, electrical faults).   4. Troubleshooting and fault correction      1. Common issues in material handling systems         1. Mechanical issues: Gearbox, bearing issues, material jams and blockages, belt misalignment, tearing, slipping, motor failures, pulley damage, and bearing wear.         2. Electrical issues: faulty wiring, sensor malfunctions, control panel failures, and overload issues.         3. Operational issues: load jamming, system errors, incorrect component installation.      2. Troubleshooting process         1. Identifying symptoms and root causes of faults.         2. Using diagnostic tools (e.g., multimeters, visual inspections, software diagnostics) to identify faults.         3. Collaborating with the manufacturer’s specifications and technical support for troubleshooting.      3. Fault Correction Procedures         1. Repairing or replacing damaged components according to manufacturer’s instructions.         2. Calibration of sensors, limit switches, and other automated systems.         3. Re-running tests after repairs to ensure correct functionality.   5. End user training      1. Training requirements         1. Identifying the skills and knowledge required for safe and efficient operation of the material handling system.         2. Manufacturer’s specifications for training content and methods (manuals, videos, on-site training).      2. Training techniques         1. How to deliver effective training: interactive demonstrations, hands-on practice, and Q&A sessions.         2. Ensuring operators understand system controls, emergency procedures, and regular maintenance tasks.         3. Providing operators with troubleshooting guidance and reporting protocols.      3. Evaluating user competency         1. Assessing operator understanding through practical tests or quizzes.         2. Providing documentation for ongoing reference.   6. Documentation and handing over the system      1. Documentation requirements         1. Creating a commissioning report: system testing results, fault corrections, and adjustments made.         2. As-built drawings and system schematics.         3. Manufacturer’s, operation, and service manuals and warranty information for the end user.         4. Maintenance schedule and recommended procedures.      2. Handing over process         1. Final inspection of the system to ensure all installation, testing, and training requirements are met.         2. Formal handover to the end user, ensuring they are satisfied with the system and have all necessary documentation.         3. Obtaining feedback from the client for continuous improvement.   7. Housekeeping      1. Waste segregation      2. Bench cleaning      3. Keeping workplace neat and orderly      4. Consumables and inventory      5. Tool rack      6. Tool box | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Fork lift
* Cranes
* Reach stacker
* Lifting trolley
* Hoist
* Lifting chain
* Chain block
* Lifting rock
* Topper
* Conveyor’s system
* Pallets

**RECOMMNDED RESOURCES**

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Material Handling Handbook" by Joseph A. Schilling | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Lifting trolley | 1 ton | 1 | 1:25 |
|  | Hoist | 1 ton | 1 | 1:25 |
|  | Lifting rock | 1 ton | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 5 | 1:5 |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Installation manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **MATERIAL HANDLING SYSTEMS MAINTENANCE**

**UNIT CODE:** 0715 551 13A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

**This unit addresses the unit of Competency:** Material handling systems maintenance

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train material handling maintenance. The learning outcomes shall enable the learner to prepare for material handling system maintenance, conduct material handling system planned maintenance, troubleshooting material handling equipment faults, carry out material handling systems preventive maintenance, conduct material handling system breakdown maintenance and test and commission material handling system.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for material handling system maintenance | **20** |
|  | Conduct material handling system planned maintenance | **20** |
|  | Trouble shoot material handling equipment faults | **20** |
|  | Carry out material handling systems preventive maintenance | **20** |
|  | Conduct material handling system breakdown maintenance. | **20** |
|  | Test and commission material handling system. | **20** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare for material handling system maintenance | * 1. Adhering to Safety Procedures (OSH Act, 2007)      1. Overview of OSH Act, 2007         1. The legal framework for workplace safety, focusing on material handling systems maintenance.         2. Identifying potential hazards in maintenance activities: electrical risks, mechanical hazards, falling objects, and lifting operations.      2. Safety Protocols for Maintenance         1. Lockout/Tag out (LOTO) procedures for safely deactivating systems during maintenance.         2. The importance of Personal Protective Equipment (PPE) during maintenance tasks: gloves, safety goggles, helmets, steel-toed boots, and hearing protection.         3. Assessing the risks before initiating maintenance activities and ensuring proper signage and barricades to secure the work area.      3. Emergency Procedures         1. Actions to take in case of an emergency: first aid, evacuation procedures, and reporting safety incidents.         2. Understanding emergency stop systems and isolation points in material handling systems.      4. Engineering safety Hierarchy of controls         1. Physical hazard elimination         2. Hazard substitution         3. Engineering design/controls         4. Administrative controls * Safety signs and symbols * Trainings/drills * Toolbox talks   + - 1. Personal Protective Equipment (PPEs) * Hand gloves * Overall/Dustcoat * Helmet/Head gear * Safety boots * Goggles * Ear muffs   1. Material handling system maintenance schedule      1. Understanding manufacturer’s maintenance requirements         1. Reviewing the maintenance manuals and specifications provided by manufacturers for different material handling systems.         2. The importance of adhering to manufacturer guidelines for scheduled maintenance to ensure warranty compliance and optimal system performance.      2. Creating a maintenance schedule         1. Understanding the frequency of different maintenance tasks (e.g., daily, weekly, monthly, yearly).         2. Identifying preventive maintenance activities (e.g., lubrication, inspections, adjustments) and corrective maintenance tasks (e.g., part replacements, troubleshooting).         3. Setting realistic time frames for each task to minimize system downtime and ensure regular checks.      3. Documentation of the maintenance schedule         1. Using a maintenance management system (software) or manual methods to document and track the maintenance schedule.         2. Communicating the schedule with maintenance personnel to ensure proper resource allocation.   2. Material handling system maintenance checklist      1. Importance of a maintenance checklist         1. The role of a checklist in ensuring that all aspects of the material handling system are thoroughly inspected and serviced during maintenance.         2. Helping to prevent missed tasks and ensuring all components are checked for wear and functionality.      2. Creating a maintenance checklist         1. Reviewing the key components that need to be inspected during maintenance: motors, drives, control systems, structural components, belts, and sensors.         2. Ensuring the checklist covers both routine maintenance (e.g., lubrication, cleaning) and major checks (e.g., motor performance, load-bearing components).         3. Incorporating safety checks into the checklist (e.g., ensuring lockout/tag out is properly performed).      3. Customizing the checklist for different systems         1. Adjusting the checklist for different types of material handling systems, such as conveyors, hoists, and automated storage systems.   3. Maintenance Tools and Equipment      1. Identifying maintenance tools and equipment         1. Reviewing the tools and equipment typically required for material handling system maintenance, including mechanical and electrical tools (e.g., wrenches, multimeters, lubrication tools).         2. Understanding the specifications of each tool and its intended use in maintenance tasks (e.g., torque wrenches for tightening bolts to manufacturer-recommended torque values).         3. Types of material handling tools * Assorted spanners * Hammer * Pliers * Pipe wrench * Screw drivers * Allen keys * Grinders * Drill * Power saws * Grease gun * Chain block   + - 1. Types pf material handling equipment * Fork lift * Cranes * Reach stacker * Lifting trolley * Hoist * Lifting chain * Chain block * Lifting rock * Topper * Conveyor’s system * Pallets   + - 1. Consumables * Hydraulic oil * Conveyors * Oil seals * Bearings * Chains * Grease * Oil filters * Air filters * Cleaning detergents   + 1. Selecting tools based on maintenance requirements        1. How to choose the right tools for specific maintenance tasks, including safety considerations (e.g., using non-sparking tools in areas where flammable materials are present).        2. Selecting appropriate measuring devices (e.g., thermometers, pressure gauges) to monitor system performance.     2. Assembling and organizing tools and equipment        1. Organizing tools and equipment for efficient use during maintenance (e.g., toolkits, maintenance carts).        2. Ensuring all necessary tools and replacement parts are available before beginning the maintenance work to prevent delays.   1. Housekeeping      1. Importance of housekeeping during maintenance         1. Preventing accidents and ensuring that the maintenance area remains safe for workers by keeping it organized and free from unnecessary clutter.         2. Maintaining a clean and tidy work environment to avoid tool misplacement, accidental spills, or slips.      2. Workplace procedures for housekeeping         1. Standard procedures for organizing tools, materials, and equipment before, during, and after maintenance.         2. Proper waste disposal (e.g., disposing of used lubricants, damaged parts) and recycling of materials where possible.      3. Post-maintenance cleanup         1. Ensuring the work area is left clean and ready for the next maintenance cycle or operational use. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 2. Conduct material handling system planned maintenance | * 1. Introduction to planned maintenance for material handling equipment      1. Overview of material handling systems         1. Types of material handling equipment (e.g., conveyors, hoists, cranes, forklifts).         2. Key components and functions of material handling systems: drives, motors, sensors, control panels, and structural components.      2. Planned maintenance         1. Preventive vs. corrective maintenance.         2. Importance of following a structured, planned maintenance approach to minimize downtime and improve equipment lifespan.         3. Role of maintenance schedules, checklists, and manufacturer guidelines in planned maintenance activities.      3. Goals of the planned maintenance process         1. Maximizing system efficiency and performance.         2. Ensuring workplace safety.         3. Reducing costly repairs through regular inspections and proactive maintenance.   2. Adhering to safety procedures (OSH Act, 2007)      1. Overview of OSH Act, 2007         1. Key safety standards and procedures outlined in the OSH Act relevant to material handling system maintenance.         2. Identifying potential hazards associated with material handling equipment maintenance: mechanical risks, electrical hazards, and slips/trips/falls.      2. Safety protocols during maintenance         1. Lockout/Tag out (LOTO) procedures for deactivating systems before maintenance.         2. Use of Personal Protective Equipment (PPE) during maintenance work: gloves, safety goggles, steel-toed boots, helmets, etc.         3. Procedures for working in confined spaces, handling hazardous materials, and working at heights.      3. Risk assessment and mitigation         1. Conducting a risk assessment prior to starting maintenance activities.         2. Implementing control measures to mitigate identified risks during maintenance tasks.      4. Emergency procedures         1. Responding to emergencies and accidents during maintenance (e.g., electrical shock, mechanical failure).         2. First aid procedures and fire safety protocols.   3. Data collection and analysis for maintenance      1. Data collection for maintenance         1. Types of data to collect: system performance metrics, equipment failure history, environmental conditions, operational usage data, and inspection results.         2. Methods for gathering maintenance data: manual inspections, sensor readings, automated monitoring systems.      2. Analyzing maintenance data         1. Using collected data to identify trends and patterns in system performance and component wear.         2. Predicting potential failures and determining maintenance priorities.         3. Understanding the relationship between maintenance data and system efficiency.      3. Documentation and record keeping         1. Maintaining accurate records of maintenance data to track equipment performance and history.         2. Using software tools or spreadsheets to manage and analyze data.   4. Conducting material handling system planned maintenance activities      1. Review of manufacturer’s maintenance manual         1. Key sections of the maintenance manual: maintenance schedules, component specifications, troubleshooting guidelines, safety precautions.         2. How to interpret and apply manufacturer’s recommendations for each maintenance task.      2. Routine maintenance activities         1. Inspection of critical components: motors, drives, control systems, belts, bearings, and load handling components.         2. Lubrication of moving parts, checking alignment, and tightening bolts.         3. Calibration of sensors, limit switches, and other control systems.      3. Repair and Replacement Tasks         1. Identifying when to replace or repair faulty components.         2. Common repair procedures: replacing worn-out bearings, adjusting motor settings, and correcting misalignments.      4. Troubleshooting and preventive maintenance         1. Identifying early warning signs of equipment failure.         2. Performing proactive repairs to prevent breakdowns.   5. Repainting of defaced material handling system components      1. Importance of repainting         1. Preventing corrosion and wear through proper coating and repainting of material handling equipment.         2. Aesthetic and safety benefits of maintaining clean and properly painted surfaces.      2. Repainting process         1. Surface preparation: cleaning, sanding, and priming components.         2. Choosing appropriate paints and coatings for different material handling system parts (e.g., conveyors, cranes, electrical panels).         3. Application techniques: brush, spray, or roller painting.      3. Job requirements for repainting         1. Understanding the specific paint types, colors, and finishes required by job specifications.         2. Ensuring compliance with safety guidelines when using painting materials (e.g., proper ventilation, PPE use).   6. Maintaining material control system      1. Material control system overview         1. The role of a material control system in managing parts, tools, and supplies for maintenance.         2. Inventory management: tracking spare parts, components, and consumables used in maintenance.      2. Updating material control system         1. Recording and tracking maintenance materials used: parts replaced, lubricants, tools, and equipment.         2. Ensuring accuracy and timeliness in updating inventory and material logs.      3. Compliance with plant guidelines         1. Following plant-specific procedures for material storage, handling, and tracking.         2. Understanding stock levels and ordering procedures to maintain an optimal inventory of maintenance materials.   7. Housekeeping      1. Importance of housekeeping in maintenance         1. Ensuring a safe and organized work environment during maintenance activities.         2. Reducing the risk of accidents, such as slips, trips, and falls, by maintaining a clean and clutter-free area.      2. Housekeeping procedures         1. Cleaning up workspaces after maintenance activities, including proper disposal of waste materials and used parts.         2. Organizing tools and materials for future use to avoid misplacement and downtime.      3. Plant guidelines for housekeeping         1. Plant-specific standards for cleanliness and organization.         2. Ensuring that all maintenance materials and tools are stored properly after use. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Trouble shoot material handling equipment faults | * 1. Introduction to fault troubleshooting in material handling equipment      1. Overview of Material Handling Systems         1. Types of material handling equipment (e.g., conveyors, hoists, cranes, forklifts).         2. Importance of troubleshooting in minimizing downtime and improving system reliability.      2. Fault troubleshooting process         1. The systematic approach to troubleshooting.         2. Differentiating between minor faults and major malfunctions.         3. The role of preventive and corrective maintenance in minimizing faults.      3. Common faults in material handling systems         1. Mechanical faults: misalignments, wear, friction, and overloads.         2. Electrical faults: wiring issues, motor failures, and control system errors.         3. Hydraulic faults: leaks, pressure drops, fluid contamination.         4. Software/system issues: control errors, communication failures, sensor faults.   2. Adhering to safety requirements during troubleshooting (Workplace Procedure)      1. Safety standards and regulations         1. Overview of workplace safety procedures during troubleshooting.         2. Key safety regulations for troubleshooting material handling equipment (e.g., OSH Act, 2007).      2. Lockout/Tag out (LOTO) procedures         1. Understanding and applying lockout/tag out procedures before conducting troubleshooting.         2. Ensuring all energy sources are isolated (electric, hydraulic, pneumatic).      3. PPE requirements for troubleshooting         1. Identifying and using the correct PPE (e.g., gloves, goggles, and steel-toed boots).         2. Safety measures when working with high-voltage equipment, moving parts, and hazardous materials.      4. Risk assessment and hazard identification         1. Conducting risk assessments to identify potential hazards during troubleshooting activities.         2. Implementing mitigation strategies to address risks (e.g., using barriers, warning signs).   3. Identifying Material Handling Equipment Using Standard Operating Procedures (SOP)      1. Understanding Standard Operating Procedures (SOP)         1. What SOPs are and their importance in identifying and troubleshooting equipment faults.         2. How SOPs provide detailed instructions on identifying equipment models, components, and configurations.      2. Identification process         1. How to identify material handling equipment by model number, serial number, and other markings.         2. Use of documentation to verify equipment and its specifications (e.g., manuals, inventory systems).      3. Common equipment identification tools         1. Barcode scanners, QR codes, and RFID for identification.         2. Labeling systems and manufacturer markings.   4. Interpreting Manufacturer’s Drawings and Manuals      1. Reading and Interpreting Manufacturer’s Manuals         1. Understanding common symbols and terminology in equipment manuals.         2. Navigating equipment-specific maintenance and troubleshooting sections in the manual.      2. Understanding Manufacturer’s Drawings and Diagrams         1. Identifying key components and their relationships in schematic diagrams.         2. Understanding wiring diagrams, hydraulic circuit diagrams, and layout drawings.      3. Using Manufacturer’s Documentation for Troubleshooting         1. How to find fault codes, recommended solutions, and troubleshooting procedures in the manual.         2. Correctly following troubleshooting flowcharts and decision trees.   5. Identifying material handling equipment faults/ malfunctions according to manufacturer’s specifications      1. CommonFaults and Symptoms         1. Understanding the symptoms of faults: strange noises, vibrations, overheating, lack of motion, etc.         2. How to systematically narrow down the potential causes of faults.      2. Mechanical Faults Identification         1. Identifying issues like misalignment, wear, belt slippage, or damaged components.         2. Diagnosing issues with drive systems, gears, and bearings.      3. Electrical Faults Identification         1. Identifying electrical issues like faulty wiring, tripped circuits, or failed motors.         2. Using multimeters and other diagnostic tools to identify electrical problems.      4. Hydraulic and Pneumatic Faults Identification         1. Recognizing leaks, pressure issues, and component failures in hydraulic and pneumatic systems.         2. Troubleshooting hydraulic pumps, valves, cylinders, and air systems.      5. Software/System Faults Identification         1. Understanding errors in control systems or software.         2. Diagnosing sensor issues, signal communication failures, and control panel malfunctions.   6. Preparing Material Handling Equipment Fault Reports According to Workplace Procedures      1. Importance of Fault Reporting         1. The role of fault reports in tracking and resolving equipment malfunctions.         2. Using fault reports to prevent future issues by identifying recurring problems and patterns.      2. Fault Report Documentation Standards         1. Required information in a fault report: fault description, equipment identification, symptoms, diagnostics, and resolution.         2. Using standardized reporting formats: written reports, digital logs, and maintenance software.      3. Workplace Procedures for Fault Reporting         1. Understanding internal procedures for submitting fault reports to supervisors or the maintenance team.         2. Importance of timely and accurate documentation for future reference and compliance. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Carry out material handling systems preventive maintenance | * 1. Introduction to Preventive Maintenance of Material Handling Systems      1. Preventive Maintenance         1. Definition and importance of preventive maintenance.         2. Benefits: Minimizing downtime, increasing equipment life, and reducing repair costs.      2. Types of Material Handling Equipment         1. Conveyors, hoists, forklifts, cranes, and automated storage systems.         2. Common faults and how preventive maintenance helps reduce these faults.      3. Overview of Maintenance Strategies         1. Preventive maintenance vs. corrective maintenance.         2. The role of preventive maintenance in a maintenance management system (MMS).      4. Best Practices in Preventive Maintenance         1. Regular checks, lubrication, cleaning, adjustments, and part replacements.         2. Establishing maintenance schedules to avoid over-maintenance or under-maintenance.   2. Preparing Maintenance Schedules as Per Workplace Procedures      1. Workplace Procedures for Preventive Maintenance         1. Understanding standard operating procedures (SOPs) for maintenance scheduling.         2. Aligning maintenance schedules with workplace procedures.      2. Preparing Maintenance Schedules         1. How to prepare and customize a maintenance schedule for specific equipment.         2. Setting up time-based, usage-based, or condition-based maintenance schedules.         3. Frequency of checks: daily, weekly, monthly, quarterly, and annual maintenance.      3. Documentation and Tracking         1. Using maintenance management software or logs to track schedules.         2. How to review and revise maintenance schedules for efficiency.   3. Identifying Material Handling Equipment as per Maintenance Schedule      1. Equipment Identification         1. Importance of correct equipment identification: serial numbers, model numbers, and manufacturer details.         2. Tools for identifying equipment in large systems (barcode scanners, RFID tags, etc.).      2. Cross-referencing Equipment with Maintenance Schedule         1. Verifying equipment’s maintenance requirements with the prepared schedule.         2. Identifying specific parts or components that require attention based on the manufacturer’s maintenance guidelines.   4. Isolating Material Handling Equipment as per Standard Operating Procedures (SOPs)      1. Overview of Lockout/Tag out (LOTO) Procedures         1. Importance of isolating equipment before maintenance to prevent accidents.         2. Steps for ensuring lockout/tag out procedures are followed.      2. Safety Requirements for Isolation         1. Proper identification of energy sources (electricity, hydraulics, and pneumatics).         2. Methods for physically isolating equipment (e.g., turning off power, closing valves, draining systems).      3. SOPs for Isolation         1. How to isolate different types of material handling equipment (conveyors, hoists, forklifts, etc.).         2. Steps to safely isolate equipment and confirm it is secure before starting maintenance.   5. Inspecting Material Handling Equipment as per Manufacturer’s Specifications      1. Inspection Guidelines         1. Understanding the inspection checklists provided by manufacturers.         2. Areas to inspect: mechanical systems, electrical systems, control panels, and safety mechanisms.      2. Mechanical Inspection         1. Checking for wear and tear in belts, bearings, gears, and motors.         2. Verifying alignment, lubrication, and functionality of moving parts.      3. Electrical and Control Systems Inspection         1. Inspecting wiring, switches, and electrical components.         2. Testing control systems, sensors, and emergency stop functions.      4. Manufacturer’s Specifications         1. How to interpret manufacturer’s guidelines for inspecting specific components?         2. How to use diagnostic tools for equipment inspection (e.g., multimeters, thermometers).   6. Material Handling Equipment Planned Maintenance as Per Job Requirements and OHS Standards      1. Conducting Planned Maintenance         1. How to carry out preventive maintenance tasks like cleaning, lubrication, adjustments, and part replacements.         2. Performing condition-based monitoring tasks (vibration analysis, temperature checks).      2. Compliance with Job Requirements         1. Understanding specific job requirements: manufacturers’ instructions, regulatory standards, and customer needs.         2. Following industry standards (e.g., ISO, OSHA) during the maintenance process.      3. Adhering to OHS Standards         1. How to integrate Occupational Health and Safety (OHS) practices into preventive maintenance.         2. Preventing accidents and ensuring the safety of personnel during maintenance tasks.   7. Completing Material Handling Systems Maintenance Checklist as Per Job Requirements      1. Maintenance Checklist Overview         1. What constitutes a comprehensive maintenance checklist: tasks, frequency, and tools?         2. Understanding the key sections of a maintenance checklist: inspection, cleaning, testing, repairs, and lubrication.      2. Documenting Maintenance Activities         1. How to record completed tasks, issues identified, and any repairs made.         2. Importance of maintaining accurate records for future reference and compliance.      3. Quality Control in Maintenance         1. Ensuring that the maintenance was completed as per the job requirement.         2. Reviewing checklists for completeness and accuracy. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct material handling system breakdown maintenance. | * 1. Introduction to Breakdown Maintenance for Material Handling Systems      1. Breakdown Maintenance         1. Definition and importance of breakdown maintenance.         2. Differences between preventive and breakdown maintenance.         3. When breakdown maintenance is necessary: unexpected failures, critical component failures, and emergency repairs.      2. Types of Material Handling Systems         1. Conveyor systems, cranes, hoists, automated systems, forklifts, etc.         2. Common breakdown issues in material handling systems.      3. Role of Breakdown Maintenance in Operational Efficiency         1. Minimizing downtime during breakdowns.         2. Maintaining operational performance through effective troubleshooting and repairs.      4. Challenges in Breakdown Maintenance         1. Identifying root causes of breakdowns.         2. Ensuring minimal impact on system downtime   2. Adhering to Safety Procedures as per OSH Act, 2007      1. OSH Act, 2007 Overview         1. Key provisions of the OSH Act related to breakdown maintenance.         2. Responsibilities of employers and employees under the OSH Act.      2. Personal Protective Equipment (PPE)         1. Importance of using appropriate PPE during breakdown maintenance.         2. Types of PPE: gloves, safety goggles, helmets, hearing protection, etc.      3. Lockout/Tag out (LOTO) Procedures         1. The necessity of isolation and de-energizing equipment before maintenance.         2. Proper lockout/tag out procedures as part of safety measures.      4. Safe Working Practices         1. Conducting hazard assessments before commencing maintenance work.         2. Ensuring a clear work environment free of risks.         3. Safe use of tools and equipment.   3. Troubleshooting Material Handling Systems According to Maintenance Manual      1. Understanding Maintenance Manuals         1. Interpreting the information provided in the manufacturer’s maintenance manual.         2. Types of maintenance manuals: operation manuals, repair guides, and troubleshooting sections.      2. Systematic Troubleshooting Process         1. Identifying common faults in material handling systems (e.g., mechanical failure, electrical issues, control malfunctions).         2. Steps in troubleshooting: Identify, diagnose, isolate, and resolve the issue.      3. Tools and Techniques for Troubleshooting         1. Common diagnostic tools (e.g., multimeters, pressure gauges, temperature sensors).         2. Using troubleshooting flowcharts and decision trees.   4. Interpreting Fault Reports as per Manufacturer’s Specifications      1. Understanding Fault Reports         1. What constitutes a fault report: symptoms, diagnostics, and potential causes?         2. Importance of clear and concise fault reports for effective troubleshooting.      2. Interpreting Manufacturer’s Specifications         1. How to refer to the maintenance manual for fault report interpretation.         2. Comparing fault symptoms with manufacturer’s recommendations.      3. Analyzing Common Faults and Their Causes         1. Electrical faults: motor failures, circuit malfunctions.         2. Mechanical faults: misalignments, bearing failures, belt wear.         3. Control system faults: sensor errors, PLC malfunctions.   5. Conducting Breakdown Maintenance Activities as per Maintenance Manual      1. Corrective Actions Based on Troubleshooting         1. Identifying and performing corrective maintenance based on troubleshooting results.         2. Replacing defective parts, repairing mechanical or electrical components, and recalibrating systems.      2. Adhering to Maintenance Manual Guidelines         1. Understanding maintenance tasks outlined in the manufacturer’s manual.         2. Best practices for executing repairs and replacements based on the specifications.      3. Rebuilding or Replacing Components         1. Procedures for replacing worn or defective parts (e.g., belts, motors, sensors).         2. When to rebuild or replace versus performing a simple repair.      4. Quality Control After Maintenance         1. Verifying functionality after maintenance work.         2. Testing material handling systems to ensure that all issues have been resolved.   6. Housekeeping      1. The Importance of Housekeeping         1. Why housekeeping is critical during maintenance: reducing hazards, ensuring efficiency, and maintaining a safe working environment.         2. Role of cleanliness in preventing additional system failures.      2. Housekeeping Tasks During Breakdown Maintenance         1. Cleaning equipment parts, tools, and work areas during maintenance.         2. Proper storage of tools, materials, and parts.         3. Disposing of waste materials, used components, and hazardous materials properly.      3. Post-Maintenance Housekeeping         1. Ensuring that the work area is tidy and free of clutter before resuming operations.         2. Inspecting and cleaning machinery after completing repairs. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission material handling system. | * 1. Introduction to Test and Commissioning of Material Handling Systems      1. Testing and Commissioning         1. Definition and differences between testing, commissioning, and handover.         2. Key objectives: Ensure system performance, safety, and compliance with design specifications.      2. Stages of Material Handling System Commissioning         1. Pre-commissioning checks.         2. System testing and calibration.         3. Handover to the operational team.      3. Key Factors in Testing and Commissioning         1. Safety, performance validation, troubleshooting, and ensuring compliance with specifications.         2. Importance of documentation and reporting.   2. Adhering to Safety Procedures According to OSH Act, 2007      1. Overview of the OSH Act, 2007         1. Key provisions related to commissioning and system tests.         2. Employer and employee obligations under the OSH Act.      2. Safety Precautions During Testing         1. Lockout/Tag out (LOTO) procedures during system commissioning.         2. PPE requirements: gloves, goggles, hearing protection, helmets, etc.         3. Electrical and mechanical safety during testing and commissioning.      3. Hazardous Situations to Look Out For         1. Electrical faults, moving machinery, system overloads.         2. Potential fire hazards and working with hazardous materials (if applicable).      4. Emergency Procedures         1. Evacuation protocols, first-aid, fire-fighting measures.         2. Reporting incidents and near misses.   3. Testing Material Handling System as Per Manufacturer’s Specifications      1. Understanding Manufacturer’s Specifications         1. Importance of interpreting and following manufacturer’s specifications during system testing.         2. Common specifications: load capacity, speed, power requirements, safety features, and operational parameters.      2. Testing Methods and Tools         1. Mechanical tests: Load testing, alignment checks, vibration analysis.         2. Electrical tests: Voltage, current, and resistance checks, PLC testing.         3. Functional testing: Testing control systems, sensors, and automation functions.      3. System Testing Process         1. Step-by-step procedures for testing material handling systems (e.g., conveyor systems, cranes, hoists, forklifts).         2. Verifying performance under various load and operational conditions.      4. Key Performance Indicators (KPIs) for Testing         1. Speed, load capacity, power efficiency, and safety functions.   4. Commissioning and Handover as Per Job Requirements      1. Commissioning Process Overview         1. Pre-commissioning checks (system assembly, power supply, safety systems).         2. Testing and validation of the system functionality.         3. Calibration and fine-tuning of systems to ensure optimal performance.      2. Key Commissioning Activities         1. Verifying system integration (mechanical, electrical, and control systems).         2. Final adjustments to achieve operational efficiency.         3. Ensuring all safety mechanisms are operational.      3. Handover Documentation         1. Preparing a checklist for handover: operational manuals, maintenance schedules, and test results.         2. Client training on system use, safety, and maintenance.   5. Preparing Material Handling Equipment Testing and Commissioning Report      1. Purpose of Testing and Commissioning Reports         1. Legal and operational significance of detailed reports.         2. Capturing results, issues, and solutions during the commissioning process.      2. Key Elements of the Report         1. System description, tests conducted, performance data, and any deviations from the specification.         2. Issues identified, troubleshooting efforts, and corrections made.         3. Final validation of system performance.      3. Standard Format of a Testing and Commissioning Report         1. Introduction, methodology, results, recommendations, and sign-off.         2. Reporting templates as per workplace requirements.      4. Best Practices in Report Writing         1. Clear, concise, and factual reporting.         2. Ensuring all critical issues are documented with solutions and timelines.   6. Proper Storage of Prepared Reports      1. Importance of Proper Report Storage         1. Ensuring reports are stored securely for future reference, audits, and compliance.         2. Maintaining a proper record for troubleshooting, maintenance, and performance monitoring.      2. Report Storage Methods         1. Digital storage: Cloud, server, and databases.         2. Physical storage: Filing systems and secure storage areas.      3. Organizing Reports for Easy Retrieval         1. Indexing reports based on system type, date, and issue.         2. Developing a file naming convention for easy reference.      4. Compliance with Regulatory Requirements         1. Ensuring report retention as per legal and organizational requirements.         2. Ensuring data security, confidentiality, and access control. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Clutch
* Gearboxes
* Chains
* Motors
* Lever
* Wheels

**RECOMMNDED RESOURCES**

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Material Handling, Repair and Maintenance of equipment’s.  By.Sanjivan Saini | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Lifting trolley | 1 ton | 1 | 1:25 |
|  | Hoist | 1 ton | 1 | 1:25 |
|  | Lifting rock | 1 ton | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 5 | 1:5 |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Material handling manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE IV

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| **MODULE IV** | | | |
| 0611 541 14A | Digital literacy | 40 | 4.0 |
| 0715 441 15A | Mechanical Science Principles | 80 | 8.0 |
| 0715 451 16A | Refrigeration and air conditioning systems installation | 120 | 12.0 |
| 0715 451 17A | Refrigeration and air conditioning systems maintenance | 120 | 12.0 |

## **DIGITAL LITERACY**

**UNIT CODE:** 0611 541 14A

**Duration of Unit:** 40 Hours

**Relationship with Occupational Standards**

This unit addresses the Unit of Competency: Apply Digital Literacy

**Unit Description**

This unit covers the competencies required to demonstrate digital literacy. It involves operating computer devices, solving tasks using the Office suite, managing data and information, performing online communication and collaboration, applying cybersecurity skills and job entry techniques, and performing jobs online.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Operate Computer Devices | **6** |
|  | Solve Tasks Using Office Suite | **14** |
|  | Manage Data and Information | **6** |
|  | Perform Online Communication and Collaborations | **4** |
|  | Apply Cybersecurity Skills | **4** |
|  | Perform Online Jobs | **4** |
|  | Apply job entry techniques. | **2** |
|  | **TOTAL** | **40** |

**Learning Outcomes, Content, and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested**  **Assessment Methods** |
| --- | --- | --- |
| 1. Operate Computer Devices | * 1. Meaning and importance of digital literacy   2. Functions and Uses of Computers   3. Classification of computers   4. Components of a computer system   5. Computer Hardware      1. The System Unit E.g. Motherboard, CPU, casing      2. Input Devices E.g. Pointing, keying, scanning, voice/speech recognition, direct data capture devices.      3. Output Devices e.g. hardcopy output and softcopy output      4. Storage Devices e.g. main memory e.g. RAM, secondary storage (Solid state devices, Hard Drives, CDs & DVDs, Memory cards, Flash drives      5. Computer Ports e.g. HDMI, DVI, VGA, USB type C etc.   6. Classification of computer software   7. Operating system functions   8. Procedure for turning/off a computer   9. Mouse use techniques   10. Keyboard Parts and Use Techniques   11. Desktop Customization   12. File and Files Management using an operating system   13. Computer Internet Connection Options       1. Mobile Networks/Data Plans       2. Wireless Hotspots       3. Cabled (Ethernet/Fiber)       4. Dial-Up       5. Satellite   14. Computer external devices management       1. Device connections       2. Device controls (volume controls and display properties) | * Observation * Written assessment * Oral assessment * Practical assessment |
| 1. Solve Tasks Using Office Suite | * 1. Meaning and Importance of Word Processing   2. Examples of Word Processors   3. Working with word documents      1. Open and close word processor      2. Create a new document      3. Save a document      4. Switch between open documents   4. Enhancing productivity      1. Set basic options/preferences      2. Help resources      3. Use magnification/zoom tools      4. Display, hide built-in tool bar      5. Using navigation tools   5. Typing Text   6. Document editing (copy, cut, paste commands, spelling and Grammar check)   7. Document formatting      1. Formatting text      2. Formatting paragraph      3. Formatting styles      4. Alignment      5. Creating tables      6. Formatting tables   8. Graphical objects      1. Insert object (picture, drawn object)      2. Select an object      3. Edit an object      4. Format an object   9. Document Print setup      1. Page layout,      2. Margins set up      3. Orientation.   10. Word Document Printing   11. Meaning & Importance of electronic spreadsheets   12. Components of Spreadsheets   13. Application areas of spreadsheets   14. Using spreadsheet application       1. Parts of Excel screen: ribbon, formula bar, active cell, name box, column letter, row number, Quick Access Toolbar.       2. Cell Data Types       3. Block operations       4. Arithmetic operators (formula bar (-, +, \*, /).       5. Cell Referencing   15. Data Manipulation       1. Using Functions (Sum, Average, SumIF, Count, Max, Max, IF, Rank, Product, mode etc.)       2. Using Formulae       3. Sorting data       4. Filtering data       5. Visual representation using charts   16. Worksheet printing   17. Electronic Presentations   18. Meaning and Importance of electronic presentations   19. Examples of Presentation Software   20. Using the electronic presentation application       1. Parts of the PowerPoint screen (slide navigation pane, slide pane, notes, the ribbon, quick access toolbar, and scroll bars).       2. Open and close presentations       3. Creating Slides (Insert new slides, duplicate, or reuse slides.)       4. Text Management (insert, delete, copy, cut and paste, drag and drop, format, and use spell check).       5. Use magnification/zoom tools       6. Apply or change a theme.       7. Save a presentation       8. Switch between open presentations   21. Developing a presentation       1. Presentation views       2. Slides       3. Master slide   22. Text       1. Editing text       2. Formatting       3. Tables   23. Charts       1. Using charts       2. Organization charts   24. Graphical objects       1. Insert, manipulate       2. Drawings   25. Prepare outputs       1. Applying slide effects and transitions       2. Check and deliver          1. Spell check a presentation          2. Slide orientation          3. Slide shows, navigation   26. Print presentations (slides and handouts) | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Manage Data and Information | * 1. Meaning of Data and information   2. Importance and Uses of data and information   3. Types of internet services      1. Communication Services      2. Information Retrieval Services      3. File Transfer      4. World Wide Web Services      5. Web Services      6. Automatic Network Address Configuration      7. News Group      8. Ecommerce   4. Types of Internet Access Applications   5. Web browsing concepts      1. Key concepts      2. Security and safety   6. Web browsing      1. Using the web browser      2. Tools and settings      3. Clearing Cache and cookies      4. URIs      5. Bookmarks      6. Web outputs   7. Web based information      1. Search      2. Critical evaluation of information      3. Copyright, data protection   8. Downloads Management   9. Performing Digital Data Backup (Online and Offline)   10. Emerging issues in internet | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Perform Online Communication and Collaborations | * 1. Netiquette principles   2. Communication concepts      1. Online communities      2. Communication tools      3. Email concepts   3. Using email      1. Sending email      2. Receiving email      3. Tools and settings      4. Organizing email   4. Digital content copyright and licenses   5. Online collaboration tools      1. Online Storage (Google Drive)      2. Online productivity applications (Google Docs & Forms)      3. Online meetings (Google Meet/Zoom)      4. Online learning environments      5. Online calendars (Google Calendars)      6. Social networks (Facebook/Twitter - Settings & Privacy)   6. Preparation for online collaboration      1. Common setup features      2. Setup   7. Mobile collaboration      1. Key concepts      2. Using mobile devices      3. Applications      4. Synchronization | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Apply Cybersecurity Skills | * 1. Data protection and privacy      1. Confidentiality of data/information      2. Integrity of data/information      3. Availability of data/information   2. Internet security threats      1. Malware attacks      2. Social engineering attacks      3. Distributed denial of service (DDoS)      4. Man-in-the-middle attack (MitM)      5. Password attacks      6. IoT Attacks      7. [Phishing Attacks](https://onlinedegrees.sandiego.edu/top-cyber-security-threats/#phishing-attacks)      8. [Ransomware](https://onlinedegrees.sandiego.edu/top-cyber-security-threats/#ransomware)   3. Computer threats and crimes   4. Cybersecurity control measures      1. Physical Controls      2. Technical/Logical Controls (Passwords, PINs, Biometrics)      3. Operational Controls   5. Laws governing protection of ICT in Kenya      1. The Computer Misuse and Cybercrimes Act No. 5 of 2018      2. The Data Protection Act No. 24 Of 2019 | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Perform Online Jobs | * 1. Introduction to online working   2. Types of online Jobs   3. Online job platforms      1. Remo task      2. Data annotation tech      3. Cloud worker      4. Up work      5. Oneforma      6. Appen   4. Online account and profile management   5. Identifying online jobs/job bidding   6. Online digital identity   7. Executing online tasks   8. Management of online payment accounts. | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Apply job entry techniques. | * 1. Types of job opportunities      1. Self-employment      2. Service provision      3. product development      4. salaried employment         1. Sources of job opportunities   2. Resume/ curriculum vitae      1. What is a CV      2. How long should a CV be      3. What to include in a CV?      4. Format of CV      5. How to write a good CV?      6. Don’ts of writing a CV   3. Job application letter      1. What to include      2. Addressing a cover letter      3. Signing off a cover letter   4. Portfolio of Evidence      1. Academic credentials      2. Letters of commendations      3. Certification of participations      4. Awards and decorations   5. Interview skills      1. Listening skills      2. Grooming      3. Language command      4. Articulation of issues      5. Body language      6. Time management      7. Honesty   6. Generally knowledgeable in current affairs and technical area | * + Observation   + Oral assessment   + Portfolio of evidence   + Third party report * Written assessment |

**Suggested Methods Instruction**

* + Instructor-led facilitation using active learning strategies
  + Demonstration by trainer
  + Practical work by trainees
  + Viewing of related videos
  + Group discussions
  + Project
  + Role play
  + Case study

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive texts books on Digital Literacy | 30 pcs | 1:1 |
|  | Installation Manuals | Detailed guides for equipment and software installation and troubleshooting | 5 pcs | 1:5 |
|  | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
|  | Templates | Templates for creating various documents e.g. CV, Cover Letter, etc. | 30 | 1:1 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
|  | Lecture/Theory Room  /Learning Resource  Area\* | Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m) | 1 | 1:30 |
|  | Computer Laboratory | Equipped with at least 30 functional computers with internet connectivity and the following software:   * + - Windows/ Linux/ Macintosh Operating System     - Microsoft Office Software     - Google Workspace Account     - Antivirus Software | 30 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
|  | Printing Papers | A4 and A3 Printing papers suitable for the task | Enough |  |
|  | Whiteboard Marker Pens | Dry-erase markers for trainers use. Assorted colours | Enough |  |
|  | Storage devices | Any of the following storage devices:   * USB Flash Drive * USB Hard Drive * Compact Disks (CDs) * Digital Versatile Disks (DVDs) | Enough |  |

## **MECHANICAL SCIENCE**

**UNIT CODE**: 0715 441 15A

**Duration of Unit**: 80 Hours

**Relationship with Occupational Standards**:

This unit addresses the unit of competency; Apply Mechanical Science

**Unit Description**

This unit describes the competences required in order to apply mechanical science. It includes resolving forces, determining effects of loads in mechanical systems, analysing properties of materials, determining the nature of friction in mechanical systems and solving problems related to motion.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Resolve forces | **10** |
|  | Determine effects of loads in mechanical systems. | **20** |
|  | Analyze properties of materials. | **10** |
|  | Determine the nature of friction in mechanical systems | **20** |
|  | Solve problems related to motion. | **20** |
|  | **TOTAL** | **80** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Resolve forces | * 1. Definition of force   2. Types of force systems      1. Collinear      2. Coplanar      3. Concurrent   3. Theorems of forces      1. Triangle      2. Parallelogram      3. Polygon   4. Resolution of forces      1. Analysis      2. Graphical Method | * Written Tests * Portfolio of Evidence |
| 1. Determine effects of loads in mechanical systems. | * 1. Types of Forces      1. Friction      2. Centrifugal      3. Centripetal      4. Gravitational      5. Inertia   2. Moments      1. Definition      2. Calculations of moment of force about an axis   3. Principles of Moments      1. Clockwise and anticlockwise moments   4. Application of Moments of Forces in Engineering      1. Simply supported beams having point loads   5. Determination of moment couples      1. Simply supported beams with couples | * Written Tests * Portfolio of Evidence |
| 1. Analyze properties of materials. | * 1. Mechanical Properties of Materials:      1. Strength (Compressive, Shear. And Tensile)      2. Brittleness      3. Hardness      4. Malleability      5. Plasticity      6. Elasticity      7. Toughness   2. Mechanical Materials Properties Tests      1. Tensile Test      2. Hardness Test   3. Direct Stresses      1. Define Stress      2. Types of Stress:         1. Tensile stress         2. Compressive stress      3. Calculate Stress   4. Selection of Materials      1. Factors to Consider in Materials Selection | * Written Tests * Portfolio of Evidence |
| 1. Determine the nature of friction in mechanical systems | * 1. Friction      1. Definition      2. Advantages and disadvantages of friction   2. Laws of Friction:      1. Laws of static friction      2. Laws of dynamic friction   3. Effects of Friction   4. Applications of Friction      1. Lubrication      2. Tyre Traction      3. Braking Systems      4. Bearing and Bushings      5. Grinding of Tools      6. Transmission Systems | * Written Tests * Portfolio of Evidence |
| 1. Solve problems related to motion.. | * 1. Definition of terms      1. Distance      2. Displacement      3. Time      4. Speed      5. Velocity      6. Acceleration   2. Laws of Motion      1. Newton’s First Law of Motion      2. Newton’s Second Law of Motion      3. Newton’s Third Law of Motion   3. Calculating Parameters of Motion      1. Equations of linear and angular motion      2. Calculations         1. Displacement         2. Speed         3. Velocity         4. Acceleration   4. Linear and Angular Motion      1. Converting         1. Angular to Linear Motion         2. Linear to angular motion   5. Motion Graphs      1. Displacement/Time Graphs      2. Velocity/Time Graphs | * Written Tests * Portfolio of Evidence |

**Suggested Delivery Methods**

* Group discussions
* Demonstration by the trainer
* Online video clips
* Power point presentation

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Comprehensive textbooks on Engineering Mathematics | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |
| **D** | **Tools and Equipment** | | | |
|  | Set of Mathematical instruments | For constructions and measurements | 30 | 1:1 |
|  | Scientific Calculator | For Calculations | 30 | 1:1 |
| **E** | **Reference Materials** | | | |
|  | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:30 |
|  | Standard Mathematical Tables | For reference on formulae, identities, laws and principles | 30 | 1:1 |

## **REFRIGERATION AND AIR CONDITIONING SYSTEM INSTALLATION**

**UNIT CODE:** 0715551 16A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Refrigeration and air conditioning system installation.

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train refrigeration and air conditioning installation. The learning outcomes shall enable the learner to prepare for installation of refrigeration and air conditioning, install refrigeration system, install air conditioning system and test and commission refrigeration and air conditioning system.

**Summary of learning outcomes**

By the end of this unit, the trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for Installation of Refrigeration and Air Conditioning | **20** |
|  | Install Refrigeration system | **40** |
|  | Install Air Conditioning system. | **40** |
|  | Test and commission refrigeration and air conditioning system | **20** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare for Installation of Refrigeration and Air Conditioning | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site         2. Correct use of tools and equipment   2. Introductionto refrigeration and air conditioning systems      1. Provide an overview of refrigeration and air conditioning systems and their applications.      2. Types of refrigeration and air conditioning systems      3. Components and their functions      4. Importance of proper installation and maintenance      5. Visual identification of refrigeration and air conditioning components      6. Discussion on refrigeration and air conditioning system applications   3. Site conditions and installation requirement      1. Site conditions         1. Temperature         2. Structure support         3. Topography         4. Humidity         5. Ventilation      2. Site survey         1. Importance of site survey         2. Procedure for site survey         3. Site inspection         4. Verify access points         5. Determine the location      3. Civil works         1. Definition of civil works         2. Reasons for carrying out civil works         3. Civil work activities * Measuring * Marking out * Excavation * Levelling * Site clearance   + 1. Site confirmation        1. Checking of dimensions        2. Checking of access points        3. Confirmation     2. Factors to consider during site inspection        1. Availability of utilities * Water * Electricity * Road network * Environmental impact assessment   + 1. Refrigeration and air conditioning specifications     2. Introduction to refrigeration and air conditioning system        1. Definitions and principles refrigeration and air conditioning        2. Components of refrigeration and air conditioning * Compressor * Expansion valve * Evaporator * Condenser * Separator   1. Tools, equipment and materials      1. Installation tools and equipment         1. Hand tools * Assorted spanners * Crimping tools * Assorted pliers * Allen keys * Tube expansion kit * Gas welding kit * Gas gauge * Refrigerant * Compressor lubricant oil * brazing, kit * pressure gauge * Compressor * lubricant oil * screw driver * Allen keys * Pliers * Files * Multimeter * Thermometer * charging kit * leak detector * tuber cutter * Vacuum pump * Recovery unit * refrigeration hose * flaring and swaging tool * spirit level * tape measure   + - 1. Measuring and marking out tools       2. Cutting tools       3. Measuring equipment       4. Working space –offices, stores       5. Technical drawings/machinery installation manuals       6. Maintenance requirements: * Grease * Hydraulic oil   1. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 2. Install Refrigeration system | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures associated with hydraulic and pneumatic system installation.      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES   2. Work site safety demarcation barriers.      1. Methods of demarcating a work site      2. Installation manuals interpretation      3. Introduction to Installation Manuals      4. Purpose of Installation Manuals * Provide detailed instructions for correctly installing equipment or systems. * Ensure safety, optimal performance, and compliance with standards. * Offer troubleshooting, maintenance, and operational guidelines.   + 1. Types of Installation Manuals * Equipment manuals (e.g., machines, HVAC systems) * System manuals (e.g., refrigeration) * Electrical installation manuals (e.g., wiring diagrams, control panels)   + 1. Structure of Installation Manuals * Table of contents and overview * Safety instructions and warnings * Tools and materials required * Step-by-step installation instructions * Post-installation checks and maintenance information * Troubleshooting guides and FAQs   + 1. Interpreting Installation Manuals        1. Reading Installation Instructions * Decoding diagrams, illustrations, and charts * Understanding technical terms and abbreviations * Identifying common symbols in wiring diagrams, system layouts, and mechanical drawings   + - 1. Following Step-by-Step Instructions * Breaking down complex installation procedures into manageable tasks * Ensuring correct sequence of operations (e.g., assembling components before connecting power) * Double-checking measurements, orientations, and connections   + - 1. Checking for Compatibility * Verifying that components match the installation requirements and specifications * Identifying and addressing any discrepancies or missing parts * Ensuring correct system integration (e.g., electrical)   1. Refrigeration system components mounting      1. Pre-mounting Preparation * Reviewing the installation manual thoroughly before starting * Verifying all required tools and materials are available * Conducting site inspections for proper placement and setup * Ensuring safety protocols are in place   + 1. Step-by-Step mounting * Following the manual to assemble and install components * Ensuring each step is performed according to the manual to prevent errors * Using measuring tools and test equipment to verify correct installation   + 1. Post-mounting Checks * Ensuring the system or equipment functions as expected * Conducting performance tests and verifying the system meets manufacturer specifications * Inspecting all connections for security and proper fit * Reviewing calibration requirements (e.g., pressure, temperature, voltage calibration)   1. Refrigeration system pipes and hoses connection      1. Sizing and Length of Pipes and Hoses * Ensure pipes and hoses are sized to meet the system’s flow and pressure requirements. Too small a diameter may cause pressure drops, while too large can result in inefficient flow. * Calculate the appropriate length to prevent slack, bending, or undue tension that could cause wear.   + 1. Step-by-Step Process for Connecting Pipes and Hoses        1. Preparing for Installation           1. Check Components: Verify that all pipes, hoses, fittings, and tools are available and compatible with the system’s specifications.           2. Cleanliness: Ensure all components are clean, especially the inside of the pipes, hoses, and fittings. Use clean clothes or flushing techniques to remove debris, dirt, or oil.           3. Safety Measures: Wear appropriate personal protective equipment (PPE) like gloves, goggles, and hearing protection. Also, ensure the system is depressurized before beginning the installation.        2. Installing Pipes and Tubing           1. Measure and Cut Pipes: Cut pipes to the required length using pipe cutters or saws, ensuring clean edges to avoid burrs that could damage seals.           2. Deburring and Cleaning: After cutting, remove any burrs or rough edges, then clean the cut ends to prevent contamination.           3. Threading and Fitting: For threaded connections, ensure that threads are clean and correctly aligned. Apply appropriate thread sealant (if required by the manufacturer) to prevent leaks.           4. Bending: If pipes need to be bent, use a pipe bender to ensure the bends are smooth and gradual to avoid damage.           5. Installation of Fittings: Attach fittings securely to both the pipe and the component (e.g., pump, valve). Tighten to the manufacturer’s torque specifications to ensure a leak-free connection.        3. Connecting Hoses           1. Measure and Cut Hoses: Select hoses that match the required length, ensuring they do not sag or stretch under pressure. Cut hoses using proper hose cutters to avoid fraying or damaging the material.           2. Install Hose Fittings: Attach the appropriate fittings to the ends of the hoses. Depending on the system, these may be threaded, crimped, or push-on fittings. Follow the manufacturer’s recommendations for securing and tightening the fittings.           3. Positioning Hoses: Install hoses without sharp bends or kinks. Ensure the hoses are positioned to avoid abrasion, excessive stretching, or contact with high-heat surfaces.           4. Clamping and Securing Hoses: Use hose clamps or brackets to secure hoses, ensuring they remain in place and are protected from external damage.   1. Refrigeration system assembly      1. Ensure proper assembly of refrigeration system components.      2. Component integration and sequence of assembly      3. Common challenges during assembly      4. Troubleshooting assembly issues      5. Pressure Testing      6. Purpose and methods of pressure testing      7. Safety consideration during testing      8. Perform pressure tests on assembled system      9. Analyzing test results   2. Deep evacuation of refrigeration system      1. Tools and equipment for deep evacuation      2. Steps for effective evacuation      3. Operating vacuum pumps for deep evacuation      4. Measuring vacuum levels   3. Charging the Refrigeration System with Refrigerant      1. Types of refrigerants and their properties      2. Procedures for refrigerant charging      3. Refrigerant charging techniques      4. Monitoring system performance post charging   4. Housekeeping      1. Importance of housekeeping      2. Disposal of waste materials      3. Final inspection and documentation      4. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 3. Install Air Conditioning system. | * 1. Safety Procedures in Air Conditioning System Installation      1. Overview of the OSH Act, 2007      2. Personal Protective Equipment (PPE) for air conditioning installation      3. Identifying and mitigating potential hazards      4. 2.1 Safety procedures are adhered to according to OSH Act, 2007.      5. Conducting a risk assessment      6. Demonstrating the use of PPE   2. Reading and Interpreting Installation Manuals      1. Understanding symbols and terminologies in manual      2. Steps for reviewing and following manufacturer’s guidelines      3. Installation manuals are interpreted according to manufacturer’s specifications.      4. Group analysis of sample installation manuals      5. Practical task: Interpreting a manual to identify installation steps   3. Mounting Air Conditioning System Components      1. Tools and techniques for mounting      2. Aligning and securing components      3. Air conditioning system components are mounted according to manufacturer’s specifications.      4. Hands-on practice mounting components      5. Review of mounted systems   4. Connecting Pipes and Hoses      1. Pipe and hose materials and types      2. Techniques for secure and leak-free connections      3. Air conditioning system pipes and hoses are connected according to manufacturer’s specifications.      4. Practical session on connecting pipes and hoses      5. Leak testing exercises   5. Assembling Air Conditioning System Components      1. Component integration and sequence of assembly      2. Common challenges during assembly      3. Air conditioning system components are assembled according to manufacturer’s specifications.      4. Step-by-step assembly of an air conditioning system      5. Troubleshooting assembly issues   6. Pressure Testing      1. Purpose and methods of pressure testing      2. Safety considerations during testing      3. Pressure testing is carried out as per manufacturer’s specifications.      4. Performing pressure tests on assembled systems      5. Analyzing test results   7. Deep Evacuation of Air Conditioning System      1. Tools and equipment for deep evacuation      2. Steps for effective evacuation      3. Deep evacuation of air conditioning system is carried out as per manufacturer’s specifications.      4. Operating vacuum pumps for deep evacuation      5. Measuring vacuum levels   8. Charging the Air Conditioning System with Refrigerant      1. Safely charge the system with refrigerant.      2. Types of refrigerants and their properties         1. R134a         2. R410         3. Ammonia         4. R407         5. R600         6. R290      3. Procedures for refrigerant charging      4. Air conditioning system is charged with refrigerant as per manufacturer’s specifications.      5. Demonstrating refrigerant charging techniques      6. Monitoring system performance post-charging   9. Housekeeping and Post-Installation Practices      1. Importance of housekeeping      2. Disposal of waste materials      3. Final inspection and documentation      4. Housekeeping is carried out according to workplace standards.      5. Cleaning the work area post-installation      6. Completing and reviewing checklists | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission refrigeration and air conditioning system | * 1. Introduction to testing and commissioning      1. Definition and purpose of testing and commissioning      2. Overview of commissioning process and standards      3. Understand system design and operation   2. Adherence to testing safety standards      1. Safety procedures for testing and commissioning      2. Workplace hazard identification      3. Risk assessment and mitigation strategies      4. Practical demonstration of safety practices and PPEs usage.   3. Interpreting assembly layout and Operational Manuals      1. Understand technical drawings and specifications      2. Manufacturer manuals and guidelines      3. Analyzing system manuals and diagrams      4. Identify key components and process      5. Checklist for verifying assembly layouts   4. Refrigeration and air conditioning run checks      1. Starting and running refrigeration and air conditioning system.      2. Identify common operational abnormalities         1. Failure to achieve set temperature         2. Noise         3. Overheating         4. Stoppage of system         5. Leakages      3. Documenting and addressing abnormalities   5. Refrigeration and air conditioning system troubleshooting      1. Diagnostic tools and their applications      2. Steps for fault identification      3. Leak detection techniques      4. Refrigerant overcharging      5. Refrigerant undercharging      6. Electrical faults in the system      7. Mechanical issues and component failures   6. End user training      1. Key operational features and controls      2. Maintenance requirements and schedules      3. Safety precautions for users   7. Documentation and system handover      1. Preparing detailed commissioning reports      2. Final system walkthrough      3. Drafting commissioning reports   8. Housekeeping      1. Workplace cleaning procedures      2. Final inspection checks      3. Disposal of waste | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Compressor
* Expansion valve
* Evaporator
* Condenser
* Separator
* Tube expansion kit
* Gas welding kit
* Gas gauge
* Refrigerant
* Compressor lubricant oil
* Pliers
* Screwdrivers
* Hammers
* Chisels
* Files
* Fin combs
* Nut drivers
* Socket wrenches
* Brazing equipment
* Arc welding equipment
* Multi-meters
* Leak detectors

Recommended Resources For 25 Trainees

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Refrigeration and air conditioning Technology 3rd edition  Author William C. Whiteman  William M. Johnson  HVAC and Refrigeration Preventive Maintenance  Author: Erick Kleinert | 5(each) | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Filters | Stainless steel | 5 | 1:5 |
|  | Refrigerant | R134 | 14kgs | 1 |
|  | Copper tubes | ½ inch size | 1 Roll | 1:25 |
|  | Insulation | ½ inch size | 1 Roll | 1:25 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Tube cutter | 3-30MM | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Flaring tool kit | Flaring tool kit set | 5 | 1:5 |
|  | Tube bender | 3mm to 30mm | 5 | 1:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Flame torch |  | 5 set | 1:5 |
|  | Refrigerant cylinder tank | 14kg | 1 | 1:25 |
|  | Vacuum pump |  | 1 |  |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Compressor | Portable compressor 25 liters | 5 | 1:5 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Installation manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **REFRIGERATION AND AIR CONDITIONING SYSTEMS MAINTENANCE**

**UNIT CODE:** 0715 551 17A

**Duration of Unit:** 120 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency; Refrigeration and air conditioning maintenance

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train refrigeration and air conditioning maintenance. The learning outcomes shall enable the learner to prepare for refrigeration and air conditioning system maintenance, conduct refrigeration system preventive maintenance, conduct refrigeration system corrective maintenance, conduct air conditioning system preventive maintenance, conduct air and refrigeration system corrective maintenance and test and commission refrigeration and air conditioning system

**Summary of learning outcomes**

By the end of this unit, the trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for refrigeration and air conditioning system maintenance. | **10** |
|  | Conduct refrigeration system preventive maintenance | **20** |
|  | Conduct refrigeration system corrective maintenance | **30** |
|  | Conduct air conditioning system preventive maintenance | **20** |
|  | Conduct air conditioning system corrective maintenance | **30** |
|  | Test and commission refrigeration and air conditioning system | **10** |
|  | **TOTAL** | **120** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| * + - 1. Prepare for refrigeration and air conditioning system maintenanc | * 1. Introductionto refrigeration and air conditioning systems      1. Provide an overview of refrigeration and air conditioning systems and their applications.      2. Types of refrigeration and air conditioning systems      3. Components and their functions      4. Importance of proper installation and maintenance      5. Visual identification of refrigeration and air conditioning components      6. Discussion on refrigeration and air conditioning system applications   2. Introduction to maintenance      1. Importance of regular maintenance      2. Overview of maintenance planning      3. Key documentation requirements   3. Safety procedures      1. Overview of the OSHAct,2007      2. Safety procedures specific to refrigeration and air conditioning systems      3. Risk assessment and mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   4. Identify system maintenance requirements      1. Maintenance manuals      2. Maintenance checklist   5. Selecting tools and equipment      1. Overview of maintenance tools and their uses      2. Selecting tools based on system requirements         1. Pliers         2. Screwdrivers         3. Hammers         4. Chisels         5. Files         6. Fin combs         7. Nut drivers         8. Socket wrenches         9. Brazing equipment         10. Arc welding equipment         11. Multi-meters         12. Leak detectors         13. System analysers         14. Recovery units         15. Vacuum pumps         16. Vacuum gauges         17. Weighing balance   6. Preparing for maintenance tasks      1. Setting up a maintenance workspace      2. Ensuring availability of required parts and materials      3. Planning for efficient task execution | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 2. Conduct refrigeration system preventive maintenance | * 1. Safety procedures      1. Overview of the OSHAct,2007      2. Safety procedures specific to refrigeration and air conditioning systems      3. Risk assessment and mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   2. Identifying preventive maintenance activities      1. Review manufacturer maintenance manuals      2. Common maintenance activities (e.g., cleaning, lubrication, inspection)      3. Troubleshooting and addressing minor issues during maintenance   3. Developing a preventive maintenance schedule      1. Importance of scheduling in maintenance      2. Tools and software for creating maintenance schedules      3. Allocating resources and setting timelines   4. Conducting Preventive Maintenance Activities      1. Identify refrigeration components         1. Compressor         2. Expansion valve         3. Evaporator         4. Condenser         5. Separator         6. fan or blower      2. Inspection and cleaning of condenser coils      3. Checking and cleaning evaporator coils      4. Examining refrigerant levels      5. Inspecting of fans and blades      6. Testing electrical connection and components      7. Lubricating moving parts      8. Checking and replacing filters      9. Inspecting thermostats      10. Inspection of drain valves      11. Refrigerant charging.   5. Housekeeping      1. Workplace cleaning procedures      2. Final inspection checks      3. Disposal of waste | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct refrigeration system corrective maintenance | * 1. Introduction to corrective maintenance      1. Definition and importance of corrective maintenance      2. Differences between preventive and corrective maintenance      3. Overview of common corrective maintenance tasks   2. Adherence to Safety Standards      1. Overview of the OSH Act, 2007      2. Specific safety procedures for refrigeration systems      3. Risk assessment and hazard mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   3. Troubleshooting Refrigeration Systems      1. Systematic troubleshooting techniques      2. Common refrigeration system faults and their symptoms      3. Use of diagnostic tools and equipment   4. Recovering Refrigerants      1. Legal and environmental considerations for refrigerant recovery      2. Step-by-step refrigerant recovery procedures      3. Use of recovery machines and tools   5. Repairing Faulty Components      1. Identifying faulty components      2. Repair and replacement procedures for common components (e.g., compressors, valves, pipes)      3. Testing repaired components for functionality   6. Pressure Testing      1. Importance of pressure testing      2. Equipment and tools required for pressure testing      3. Step-by-step pressure testing procedures   7. System Evacuation      1. Importance of system evacuation      2. Use of vacuum pumps and gauges      3. Step-by-step evacuation procedures   8. Charging Refrigeration Systems      1. Types of refrigerants and their properties      2. Refrigerant charging methods (e.g., by weight, pressure, or superheat)      3. Safety considerations during charging   9. Housekeeping      1. Workplace cleaning procedures      2. Proper disposal of waste and unused materials      3. Final system checks and documentation | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct air conditioning system preventive maintenance | * 1. Safety procedures      1. Overview of the OSHAct,2007      2. Safety procedures specific to refrigeration and air conditioning systems      3. Risk assessment and mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   2. Identifying preventive maintenance activities      1. Review manufacturer maintenance manuals      2. Common maintenance activities (e.g., cleaning, lubrication, inspection)      3. Troubleshooting and addressing minor issues during maintenance   3. Developing a preventive maintenance schedule      1. Importance of scheduling in maintenance      2. Tools and software for creating maintenance schedules      3. Allocating resources and setting timelines   4. Conducting Preventive Maintenance Activities      1. Inspection and cleaning of condenser coils      2. Checking and cleaning evaporator coils      3. Examining refrigerant levels      4. Inspecting of fans and blades      5. Testing electrical connection and components      6. Lubricating moving parts      7. Checking and replacing filters      8. Inspecting thermostats      9. Inspection of drain valves      10. Refrigerant charging.   5. Housekeeping      1. Workplace cleaning procedures      2. Final inspection checks      3. Disposal of waste | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Conduct air conditioning system corrective maintenance | * 1. Introduction to corrective maintenance      1. Definition and importance of corrective maintenance      2. Differences between preventive and corrective maintenance      3. Overview of common corrective maintenance tasks   2. Adherence to Safety Standards      1. Overview of the OSH Act, 2007      2. Specific safety procedures for refrigeration systems      3. Risk assessment and hazard mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   3. Troubleshooting Refrigeration Systems      1. Systematic troubleshooting techniques      2. Common refrigeration system faults and their symptoms      3. Use of diagnostic tools and equipment   4. Recovering Refrigerants      1. Legal and environmental considerations for refrigerant recovery      2. Step-by-step refrigerant recovery procedures      3. Use of recovery machines and tools   5. Repairing Faulty Components      1. Identifying faulty components      2. Repair and replacement procedures for common components (e.g., compressors, valves, pipes)      3. Testing repaired components for functionality   6. Pressure Testing      1. Importance of pressure testing      2. Equipment and tools required for pressure testing      3. Step-by-step pressure testing procedures   7. System Evacuation      1. Importance of system evacuation      2. Use of vacuum pumps and gauges      3. Step-by-step evacuation procedures   8. Charging Refrigeration Systems      1. Types of refrigerants and their properties      2. Refrigerant charging methods (e.g., by weight, pressure, or superheat)      3. Safety considerations during charging   9. Housekeeping      1. Workplace cleaning procedures      2. Proper disposal of waste and unused materials | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 6. Test and commission refrigeration and air conditioning system | * 1. Introduction to testing and commissioning      1. Definition and importance of testing and commissioning      2. Overview of system performance metrics      3. Key phases of the testing and commissioning process      4. Familiarity with system components and their testing requirements   2. Adherence to Safety Standards      1. Overview of the OSH Act, 2007      2. Specific safety procedures for refrigeration systems      3. Risk assessment and hazard mitigation strategies      4. Personal protective equipment’s      5. Correct use of tool and equipment      6. Switching off of equipment      7. Electrical isolation   3. System Testing Procedures      1. Pre-start checks and system inspection      2. Functional and performance testing      3. Use of diagnostic tools and equipment   4. Housekeeping Practices      1. Workplace cleaning procedures      2. Proper disposal of waste and unused materials      3. Final system checks and organization   5. Documentation and Reporting      1. Importance of detailed maintenance and commissioning reports      2. Key elements of a commissioning report      3. Guidelines for compliance with workplace requirements | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Pliers
* Screwdrivers
* Hammers
* Chisels
* Files
* Fin combs
* Nut drivers
* Socket wrenches
* Brazing equipment
* Arc welding equipment
* Multi-meters
* Leak detectors
* System analyzers
* Recovery units
* Vacuum pumps
* Vacuum gauges
* Weighing balance
* Refrigerant identifier
* Compressor
* Expansion valve
* Evaporator
* Condenser
* Separator
* Tube expansion kit

RECOMMENDED RESOURCES FOR 25 TRAINEES

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Refrigeration and air conditioning Technology 3rd edition  Author William C. Whiteman  William M. Johnson  HVAC and Refrigeration Preventive Maintenance  Author: Erick Kleinert | 5(each) | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Filters | Stainless steel | 5 | 1:5 |
|  | Refrigerant | R134 | 14kgs | 1 |
|  | Copper tubes | ½ inch size | 1 Roll | 1:25 |
|  | Insulation | ½ inch size | 1 Roll | 1:25 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | Hydraulic fluids | Multipurpose heavy duty | 20litres | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Tube cutter | 3-30MM | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Flaring tool kit | Flaring tool kit set | 5 | 1:5 |
|  | Tube bender | 3mm to 30mm | 5 | 1:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Flame torch |  | 5 set | 1:5 |
|  | Refrigerant cylinder tank | 14kg | 1 | 1:25 |
|  | Vacuum pump |  | 1 |  |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Compressor | Portable compressor 25 liters | 5 | 1:5 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Maintenance manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE V

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| 0541 541 18A | Engineering Mathematics | **60** | **6.0** |
| 0715 541 19A | Thermodynamics Principles | **120** | **12.0** |
| 0715 541 20A | Fluid Mechanics Principles | **90** | **9.0** |
| 0715 551 21A | Steam system installation | **200** | **20.0** |

## **ENGINEERING MATHEMATICS**

**Unit Code:** 0541 541 18A

**Unit Duration:** 100 Hours

**Relationship to Occupational Standards**

**This unit addresses the Unit of Competency:** Apply Engineering Mathematics

**Unit Description**

This unit describes the competences required in order to apply engineering mathematics. It enables the learner to; Apply complex numbers, perform coordinate geometry, carry out binomial expansion, apply calculus, apply vector theorem and Apply matrices

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/No.** | **Learning Outcomes** | **Duration (Hours)** |
|  | Apply complex numbers | 10 |
|  | Perform coordinate geometry | 10 |
|  | Carry out binomial expansion | 20 |
|  | Apply calculus | 40 |
|  | Apply vector theorem | 10 |
|  | Apply matrices | 10 |
|  | | 100 |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply complex numbers | * 1. Complex geometry      1. Real part      2. Imaginary part      3. Argand diagram      4. Modulus/Magnitude      5. Argument /Angle      6. Conjugate   2. Operations      1. Addition      2. Subtraction      3. Multiplication      4. Division      5. Conversions         1. Polar form to rectangular form         2. Rectangular form to polar form   3. De Moivre’s theorem      1. Expansion of complex numbers      2. Roots of complex numbers      3. Trigonometric identities using complex numbers | * Written tests |
| 1. Perform coordinate geometry | * 1. Cartesian geometry      1. Cartesian plane         1. x and y axes         2. Positive and negative coordinates      2. Gradient         1. Positive         2. Negative         3. Zero         4. Infinite         5. Gradients of parallel line         6. Gradients of perpendicular lines      3. y-intercept   2. Linear equations      1. Straight line      2. Parallel lines      3. Perpendicular lines   3. Graphs of linear equations      1. Straight lines   4. Polar geometry      1. Magnitude      2. Direction      3. Graphs   5. Conversions      1. Linear to polar      2. Polar to linear   6. Solving polar equations | * Written tests |
| 1. Carry out binomial expansion | * 1. Binomial series      1. Powers      2. Coefficients      3. Pascals triangle      4. Expansion   2. Binomial theorem      1. Positive powers of n      2. Negative powers of n      3. Fractional powers of n (roots)      4. Estimation of errors of small changes | * Written tests |
| 1. Apply calculus | * 1. Differentiation up to third order      1. Functions         1. Linear         2. Trigonometric         3. Logarithmic         4. Exponential      2. Rules         1. Power         2. Product         3. Chain         4. Quotient      3. Applications         1. Stationary points         2. Rates of change   2. Integration      1. Standard integral      2. Definite integral      3. Techniques         1. By parts         2. Substitution         3. Partial fractions      4. Applications         1. Area between and under curves         2. Volume      5. DIifferential equation      6. Double and triple integral      7. Laplace transform      8. Fourior series | * Written tests |
| 1. Apply vector theorem | * 1. Differentiate between vector and scalar quantities      1. Magnitude      2. Direction         1. Positive         2. Negative   2. Operation on vectors      1. Addition      2. Subtraction      3. Dot product      4. Cross product   3. Resolution of vectors      1. Analysis      2. Graphical Methods         1. Triangle theorem         2. Parallel theorem         3. Polygon theorem | * Written tests |
| 1. Apply matrices | * 1. Matrices      1. Types         1. Row         2. Column         3. Square         4. Zero         5. Identity         6. Diagonal   2. Matrices operations (up to 3 x 3)      1. Addition      2. Subtraction      3. Multiplication   3. Inverse of matrices (up to 3 x 3)      1. Determinant      2. Transpose      3. Adjoint      4. Inverse   4. Simultaneous equations   (up to 3 equations)   * + 1. Inverse method     2. Crammers Rule     3. Row reduction | * Written tests |

**Suggested Delivery Methods**

* Demonstration
* Group discussions
* Online materials
* Direct instructions
* Simulation

**Recommended Resources for 30 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Comprehensive textbooks on Engineering Mathematics | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
| **D** | **Tools and Equipment** | | | |
|  | Set of Mathematical instruments | For constructions and measurements | 30 | 1:1 |
|  | Firefighting extinguishers | Water, carbon dioxide and chemical powder fire extinguishers for fire fighting | 1 | 1:30 |
| **F** | **Reference Materials** | | | |
|  | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:30 |
|  | Standard Mathematical Tables | For reference on formulae, identities, laws and principles | 30 | 1:1 |

## **THERMODYNAMICS PRINCIPLES**

**UNIT CODE:** 0715 541 04A

**Duration of Unit**: 90 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: apply Thermodynamic principles

**Unit Description**

This unit describes the competences required in order to apply thermodynamics in their work. It includes applying steady flow processes, perfect gas, steam cycles, fuel and combustion.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Apply Thermodynamic Processes | **15** |
|  | Apply knowledge of perfect gases | **15** |
|  | Apply knowledge of steam cycle | **15** |
|  | Apply knowledge of fuel combustion | **15** |
|  | Apply heat transfer and heat exchangers in fluid | **15** |
|  | Operate air compressors | **15** |
|  | **TOTAL** | **90** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply Thermodynamic Processes | * 1. Basic thermodynamics terms definition      1. work,      2. Power      3. Internal Energy      4. Heat      5. Temperature   2. Laws of Thermodynamics      1. First law of thermodynamics      2. Second law of thermodynamics      3. Zeroth law of thermodynamics   3. Thermodynamic Processes      1. Non-flow Process.      2. Constant Volume Process      3. Constant Pressure Process      4. Hyperbolic Process.      5. Constant Temperature Process      6. Adiabatic Process      7. Polytrophic Process.   4. Thermodynamics systems      1. Boundary and surrounding      2. Closed systems      3. Open systems      4. Isolated systems      5. Adiabatic system      6. Homogeneous systems      7. Heterogeneous systems   5. Heating and expansions of gases      1. Determine work done      2. Application of First Law of Thermodynamics      3. Reversible non-flow processes.      4. Irreversible non-flow processes   6. General Laws for Expansion and Compression      1. Define the terms:         1. Expansion         2. compression      2. Apply PVn = Constant for various values of n      3. Curves of pressure against volume for various values of n (index)   7. Application of Steady Flow Energy Equation to:      1. boilers      2. condensers      3. nozzles      4. diffusers      5. compressors      6. turbines | * Written tests |
| 1. Apply knowledge of perfect gases | * 1. Laws of Perfect Gases      1. Boyle's Law      2. Charles' Law      3. Gay-Lussac Law      4. Joule's Law      5. Avogadro's Law   2. General Gas Equation      1. Derive and apply general gas equation PV=nRT   3. Characteristic Equation of Gas      1. Application in engineering calculations   4. Universal Gas Constant      1. Define universal gas constant      2. Apply universal gas constant equation in engineering calculation   5. Specific Heat      1. Constant Volume      2. Constant Pressure | * Written tests |
| 1. Apply knowledge of steam cycle | * 1. Steam cycles      1. Rankine         1. Schematic diagram of a steam engine or turbine plant.         2. Determine Rankine efficiency         3. T-S and h-s graphs         4. Modified Rankine Cycle         5. Work-done using Rankine equations         6. Efficiency of Modified Rankine Cycle         7. Theoretical loss of work per kg of steam due to incomplete expansion         8. Loss in Rankine efficiency due to restricted expansion of steam         9. Enthalpy- entropy chart      2. Carnot         1. Draw schematic diagrams of Carnot engine         2. Carnot Cycle with Steam as Working Substance         3. Performance Criteria for Carnot Cycle      3. Reheat         1. T-S diagram of reheat steam cycle         2. Determine work-done using reheat equations         3. Determine efficiency of reheat cycles      4. Regenerative         1. Ideal regenerative cycle diagram         2. Regenerative Cycle with Single Feed Water Heater         3. Regenerative cycle with single feed water heater diagram         4. Determine work-done by Regenerative cycle         5. Determine Regenerative cycle efficiency         6. Regenerative Cycle with Two Feed Water Heaters and its efficiency   2. Thermodynamics steam turbines      1. Characteristics of steam turbines      2. classification of Steam Turbines      3. Pressure and Velocity of Steam in an Impulse Turbine      4. Velocity Triangles for Moving Blade of an Impulse Turbine      5. Combined Velocity Triangle for Moving Blades      6. Power Produced by an Impulse Turbine | * Written tests |
| 1. Apply knowledge of fuel combustion | * 1. Elements and Compounds of fuel      1. Define of terms         1. Element         2. Compound         3. Atoms         4. Molecules         5. Atomic Mass         6. Molecular Mass      2. Element and symbols table sketches   2. Combustion Equations of Fuels and calculations      1. Balanced Combustion Equations of Solid Fuels      2. Write a balanced Combustion Equations of Gaseous Fuels   3. Conversion analysis of fuels      1. Theoretical or Minimum Volume of Air Required for Complete Combustion      2. Conversion of Volumetric Analysis into Mass Analysis or Gravimetric Analysis      3. Conversion of Mass Analysis into Volumetric Analysis   4. Mass of Carbon in Flue Gases      1. Calculation of mass of carbon, contained in 1 kg of flue or exhaust gases   5. Mass of Flue Gases per kg of Fuel Burnt      1. Calculate the mass of dry flue gases by comparing the mass of carbon present in the flue gases with the mass of carbon in the fuel.   6. Excess Air Supplied calculations      1. Mass of excess air supplied by the mass of unused oxygen, found in the flue gases.      2. Total mass of air supplied   7. Flue Gas Analysis by Orsat Apparatus      1. Components      2. Use of the apparatus      3. Operation      4. Diagram sketches | * Written tests |
| 1. Apply heat transfer and heat exchangers in fluid | * 1. Heat transfer media      1. Heat Transfer methods:         1. Conduction         2. Convection         3. Radiation      2. Newton's Law of Cooling      3. Derivation and application of Fourier's\* Law of Heat Conduction equation   2. Heat Transfer by Conduction   through   * + 1. Slab        1. Thermal Conductivity        2. Temperature Gradient     2. Composite Wall     3. Thick Cylinder     4. Thick Sphere   1. Overall Coefficient of Heat Transfer      1. Heat exchangers | * Written tests |
| 1. Operate air compressors | * 1. Classification of air compressors      1. According to working      2. According to action      3. According to number of stages   2. Single Stage Reciprocating Air Compressor      1. Work done by a Single Stage Reciprocating Air Compressor without Clearance Volume   3. Work done during      1. isothermal compression      2. polytrophic compression (pv" = Constant)      3. isentropic compression   4. Power Required to Drive a Single-stage Reciprocating Air Compressor      1. Calculations   5. Work-done by Reciprocating Air Compressor with Clearance Volume      1. Calculations      2. Determine Multistage Compression   6. Power Required to Drive a Two-stage Reciprocating Air Compressor   7. Minimum Work Required for a Two-stage Reciprocating Air Compressor |  |

**Suggested Delivery Methods**

* Group discussions
* Demonstration by trainer
* Online videos
* Power point presentation
* Exercises by trainee

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | * + - 1. Applied Thermodynamics for Engineering Technology (fifth edition) by T.D. Eastop and A. McConkey       2. Engineering Thermodynamics by R.K.Rajput | 30 |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
| 4. | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 30 | 1: |
|  | Fire extinguishers | Protect against fire | 30 | 3 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |

## **FLUID MECHANICS**

**UNIT CODE:** 0715 541 05A

**Duration of Unit:** 90 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply Fluid mechanics principles

**Unit Description**

This unit describes the competences required in order to apply fluid mechanics in their work. It includes applying fluid mechanics concepts and operating of air compressors and fluid pumps.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | To Apply the knowledge of the flow of fluids | **10** |
|  | To Apply the knowledge of viscous flow of fluids | **20** |
|  | To Apply dimensional and models analysis fluids | **30** |
|  | To Operate fluid pumps | **30** |
|  | **TOTAL** | **90** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. To Apply the knowledge of the flow of fluids | * 1. Types of Fluid Flow      1. Steady and unsteady flows      2. Uniform and non-uniform flows      3. Rotational and irrotational flows      4. Laminar and turbulent flows      5. Compressible and incompressible flows   2. Loss of Energy (or Head) in Pipes      1. Darcy-weisbach formula      2. Chezy’s formula for loss of head due to friction      3. Loss of head due to sudden enlargement      4. Loss of head due to sudden contraction      5. Loss of head due to obstruction in pipe      6. Loss of head at the entrance to pipe      7. Loss of head at the exit of a pipe      8. Loss of head due to bend in the pipe   3. Hydraulic Gradient and Total Energy Lines      1. Pipes in Series or Compound Pipes      2. Pipes in Parallel      3. Power Transmission through Pipes | * Written tests |
| 1. To Apply the knowledge of viscous flow of fluids | * 1. Flow of viscous flow      1. Flow of Viscous Fluid in Circular Pipes      2. Flow of Viscous Fluid through an Annulus      3. Flow of Viscous Fluid Between Two Parallel Plates         1. One plate moving and other at rest         2. Both plates at rest         3. Both plates moving in opposite directions      4. Kinetic energy correction and momentum      5. Power Absorbed in Viscous Flow      6. Viscous Resistance of Journal Bearings      7. Viscous Resistance of Foot-step      8. Viscous Resistance of Collar Bearing | * Written tests |
| 1. To Apply dimensional and models analysis fluids | * 1. Definition of terms      1. Dimensional homogeneity      2. Methods of solving dimensional analysis         1. Rayleigh’s theorem         2. Buckingham π theorem   2. Dimensional analysis similitude      1. Geometric      2. Kinematic      3. Dynamic   3. Dimensionless Numbers      1. Reynold’s Number (Re)      2. Froude’s Number (Fe)      3. Euler’s Number (Eu)      4. Weber’s Number (We)      5. Mach’s Number (M)   4. Model test analysis and calculations      1. Classification of Models         1. Undistorted Models         2. Distorted Models         3. Scale Ratios for Distorted Models | * Written tests |
| 1. To Operate fluid pumps | * 1. Principles of operation of:      1. Reciprocating pumps      2. Centrifugal pumps   2. Derivation of equations for a reciprocating pump      1. Coefficient of discharge      2. percentage slip      3. Work done      4. Acceleration head      5. Friction head      6. Pressure head in the cylinder   3. Application of reciprocating pumps equations to solve problems   4. Derivation of equations for a centrifugal pump      1. Effective head      2. Manometric head      3. efficiency      4. Mechanical efficiency      5. Discharge      6. Torque      7. Work done unit weight      8. Specific speed   5. Application of centrifugal pumps equations to solve problems | * Written tests |

**Suggested Delivery Methods**

* Group discussions
* Demonstration by trainer
* Online videos
* Power point presentation
* Exercises by trainee

**Recommended Resources for 30 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | * + - 1. Applied Thermodynamics for Engineering Technology (fifth edition) by T.D. Eastop and A. McConkey       2. Engineering Thermodynamics by R.K.Rajput       3. A Textbook of Fluid Mechanics and Hydraulic Machines by R.K.Rajput       4. A Textbook Of Fluid Mechanics And Hydraulic Machines by R.K Bansal | 30 |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
| 4. | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 30 | 1: |
|  | Fire extinguishers | Protect against fire | 30 | 3 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |

## **STEAM SYSTEM INSTALLATION**

**UNIT CODE:** 0715 551 08A

**Duration of Unit**: 200 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency; steam system installation.

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train steam system installation. The learning outcomes shall enable the learner to prepare for installation of steam system, assemble steam system, fit distribution system and accessories and test and commission steam system.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Prepare for installation of Steam system. | **40** |
|  | Assemble steam system equipment. | **60** |
|  | Fit steam distribution system and accessories. | **60** |
|  | Test and commission steam system | **40** |
|  | **TOTAL** | **200** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare for installation of Steam system. | * 1. Workshop safety      1. Definition of terms      2. Types of workshop hazard      3. Hazards and control measures      4. Personal protective equipment         1. Importance of PPEs         2. Types of PPEs:         3. Use of PPEs         4. Maintenance of PPEs         5. Disposal of PPES      5. Work site safety demarcation barriers.         1. Methods of demarcating a work site         2. Correct use of tools and equipment   2. Site conditions and installation requirement      1. Site conditions         1. Temperature         2. Structure support         3. Topography         4. Humidity         5. Ventilation      2. Site survey         1. Importance of site survey         2. Procedure for site survey         3. Site inspection         4. Verify access points         5. Determine the location      3. Civil works         1. Definition of civil works         2. Reasons for carrying out civil works         3. Civil work activities * Measuring * Marking out * Excavation * Levelling * Site clearance   + 1. Site confirmation        1. Cchecking of dimensions        2. Checking of access points        3. Confirmation     2. Factors to consider during site inspection        1. Availability of utilities * Water * Electricity * Road network * Environmental impact assessment   1. Introductionto steam systems      1. Provide an overview of steam systems and their applications.      2. Types of stem systems      3. Components and their functions         1. Boiler         2. Steam header         3. Steam receiver         4. Steam pipes         5. Fuel system         6. Stack pipe         7. Steam traps         8. Safety valves      4. Importance of proper installation and maintenance      5. Visual identification of steam components      6. Discussion on steam system applications      7. Steam system components specifications      * 1. Selection of tools, equipment and materials      1. Installation tools and equipment         1. Hand tools * Pipe wrenches * Ladders * Chain blocks * Forklifts * Assorted spanners * Assorted spanners * Crimping tools * Assorted pliers * Allen keys * Tube expansion kit * Gas welding kit * refrigeration hose * flaring and swaging tool * spirit level * tape measure   + - 1. Measuring and marking out tools       2. Cutting tools       3. Measuring equipment       4. Working space –offices, stores       5. Technical drawings/machinery installation manuals       6. Maintenance requirements:   1. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

|  |  |  |
| --- | --- | --- |
| * + - 1. Assemble steam system equipment | * 1. Introduction to boiler system      1. Types of boilers (e.g., fire-tube, water-tube)      2. Components of a boiler system         1. Sight glasses         2. Pressure gauges         3. Safety valves         4. Blow down valve         5. Water level sensors         6. Burner         7. Stop valve      3. Auxiliary components of a boiler         1. Feed water pump         2. Steam header         3. Service water tank         4. Feed water         5. Forced draught fan         6. Induced draught fan         7. Air pre-heater         8. Economizer      4. Functionality and operation of boilers   2. Safety procedures for assembly of a boiler system      1. Definition of terms      2. Identifying potential hazards      3. Working with hazardous materials (e.g., fuels, high-pressure systems)      4. Handling risks during boiler assembly      5. Hazards and control measures      6. Personal protective equipment      7. Importance of PPEs      8. Types of PPEs:         1. Use of PPEs         2. Maintenance of PPEs         3. Disposal of PPES   3. Boiler mounting and fitting      1. Boiler mounting procedures         1. Checking the foundation and support structure         2. Ensuring correct alignment and level installation         3. Securely bolting the boiler in place      2. Manufacturer’s specifications         1. Key measurements and tolerances         2. Reviewing manufacturer’s guidelines for mounting   4. Fitting boiler components      1. Types of boiler components         1. Pressure gauges, valves, and safety devices         2. Burner and ignition systems         3. Heat exchangers and pumps      2. Fitting Procedures         1. Fitting components with appropriate tools and techniques         2. Ensuring correct placement of components      3. Manufacturer’s Specifications         1. Torque values and fittings         2. Inspection for leaks or malfunctions   5. Feed Water System fitting      1. Feed Water System Overview         1. Components of a feed water system (e.g., water pumps, filters, valves)         2. Role in boiler efficiency and safety      2. Installation Procedures         1. Positioning and connecting feed water pipes         2. Installing feed water pumps and filtration systems      3. Manufacturer’s Specifications         1. Correct positioning and fittings for system components         2. Pressure and temperature considerations   6. Fuel System fitting      1. Fuel System Overview         1. Types of fuels used (e.g., natural gas, oil, coal)         2. Components of a fuel system (e.g., burners, valves, regulators)      2. Fuel System Installation         1. Installing fuel lines, burners, and control mechanisms         2. Connecting fuel supply and ensuring leak-free operation      3. Manufacturer’s Specifications         1. Fuel pressure and flow requirements         2. Safety measures in fuel handling and combustion systems   7. Flue Gas System fitting      1. Flue Gas System Components         1. Chimney, flue pipes, and dampers         2. Monitoring and filtration systems for emissions      2. Installation Procedures         1. Correct fitting of exhaust piping and flue systems         2. Ensuring proper ventilation and air circulation      3. Manufacturer’s Specifications         1. Ventilation requirements         2. Smoke and emissions regulations   8. Auxiliary Components fitting      1. Auxiliary Components Overview         1. Steam separators         2. Economizers         3. Blow-off tanks         4. Feed water pump         5. Steam header         6. Service water tank         7. Feed water         8. Forced draught fan         9. Induced draught fan         10. Air pre-heater         11. Economizer         12. Electrical components, control panels, and instrumentation      2. Installation Procedures         1. Correct installation of auxiliary systems and controls         2. Wiring, testing, and calibration of control systems      3. Manufacturer’s Specifications         1. Electrical and mechanical installation standards         2. Ensuring compatibility and performance   9. Housekeeping      1. Importance of Housekeeping         1. Safe handling of tools and materials         2. Preventing contamination and damage to components      2. Workplace Cleanliness Standards         1. Following company policies for site cleanliness         2. Disposal of waste and hazardous materials | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Fit steam distribution system and accessories. | * 1. Introduction to steam distribution system      1. Overview of Steam Distribution Systems         1. Definition and components (pipes, valves, traps, insulation)         2. Purpose of steam distribution systems in industrial applications      2. Key System Components         1. Piping systems, steam traps, control valves, safety valves         2. Distribution manifolds and accessories      3. Importance of Manufacturer’s Specifications         1. Ensuring system efficiency and safety         2. Consequences of improper installation   2. Safety procedures      1. Understanding OSH Act, 2007 Compliance         1. Occupational health and safety obligations for steam system installation         2. Identifying and assessing risks during installation         3. Safe handling of steam, pressure vessels, and components      2. Safety Practices in Steam System Installation         1. Steam pressure hazards and control measures         2. Safe use of tools and equipment         3. Hazardous material handling (insulation materials, pipe joints)         4. Lock-out/tag-out procedures for system maintenance   3. Piping of the Steam Distribution System      1. Understanding Piping Systems         1. Types of piping materials (steel, copper, plastic)         2. Pipe fittings and joints (elbows, tees, couplings, etc.)         3. Insulated vs. non-insulated piping      2. Installation of Piping         1. Proper pipe sizing and routing according to design specifications         2. Techniques for pipe cutting, welding, and threading         3. Correctly aligning and securing pipes      3. Job Specifications and Codes         1. Adhering to design plans and manufacturer’s specifications         2. Pressure and temperature tolerances         3. Plumbing codes and industry standards   4. Fitting Steam Distribution Accessories      1. Types of Steam Distribution Accessories         1. Steam traps, steam pipes, condensate pump, check valves, pressure-reducing valves, and gauges         2. Expansion joints, manifolds, and condensate return systems      2. Installation Techniques         1. Correct fitting and securing of accessories         2. Testing and calibration of valves and gauges         3. Ensuring smooth flow and pressure regulation      3. Manufacturer’s Specifications         1. Ensuring accessories are fitted in the correct orientation         2. Torque values and pressure settings for valves and gauges   5. Lagging and Cladding of Steam Distribution System      1. Purpose of Lagging and Cladding         1. Heat loss prevention and energy efficiency         2. Protecting personnel from hot surfaces      2. Materials for Lagging and Cladding         1. Types of insulation materials (mineral wool, calcium silicate, fiberglass)         2. Cladding materials (aluminum, stainless steel)      3. Fitting Lagging and Cladding         1. Proper installation methods for insulation and cladding         2. Ensuring airtight seals and effective heat retention      4. Manufacturer’s Specifications         1. Correct thickness, material, and fitting methods         2. Safety considerations when handling insulation materials   6. Housekeeping      1. Importance of Housekeeping         1. Maintaining a safe and organized workspace to prevent accidents         2. Ensuring tools, materials, and components are properly stored and handled      2. Workplace Housekeeping Procedures         1. Clearing debris, disposing of waste, and managing materials         2. Keeping work areas free from tripping hazards      3. Final Checks and Site Cleanliness         1. Reviewing all installation tasks for completeness         2. Ensuring that all tools and materials are properly stored or disposed of waste. | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Test and commission steam system | * 1. Introduction to Steam System Testing and Commissioning      1. Overview of Steam Systems         1. Key components and functions of a steam system (boilers, piping, valves, steam traps, controls)         2. The importance of proper testing and commissioning      2. Testing and Commissioning Process         1. Steps involved in testing and commissioning (initial checks, operational tests, system start-up, final checks)         2. Roles and responsibilities during testing and commissioning      3. Safety Considerations         1. Introduction to OSH Act, 2007: Health and safety regulations relevant to steam systems         2. High-pressure steam safety         3. Importance of safety equipment (PPE) during testing   2. Adhering to safety procedures      1. OSH Act, 2007 Compliance         1. Occupational health and safety responsibilities during steam system commissioning         2. Identifying and controlling hazards (high pressure, steam leaks, hot surfaces)         3. Emergency procedures in case of system failures or accidents      2. Pre-commissioning Safety Checks         1. Inspection of system components (pressure vessels, piping, control systems)         2. Safety checks before operating the system   3. Checking assembly layout according to installation manual      1. Reviewing the Installation Manual         1. Understanding the layout and design specifications         2. Verifying component placement, connections, and alignment         3. Identifying discrepancies and ensuring corrections      2. Assembly Layout Inspection         1. Ensuring proper pipe routing, valve positioning, and system integration         2. Checking for correct installation of steam traps, pressure regulators, and safety valves   4. Running the steam system and checking for abnormalities      1. System start-up procedures         1. Proper procedures for system start-up and bringing the system online         2. Monitoring pressures, temperatures, and flow rates      2. Checking for abnormalities         1. Identifying common issues (leaks, irregular pressure, improper flow)         2. Monitoring system behavior for abnormal sounds, vibrations, or warning indicators         3. Ensuring system pressure and temperature levels meet job specifications      3. Troubleshooting early issues         1. Pinpointing and diagnosing minor issues         2. Taking corrective actions during the commissioning phase   5. Steam system troubleshooting according to manufacturer’s specifications      1. Understanding troubleshooting protocols         1. Manufacturer’s troubleshooting guides and technical manuals         2. Key symptoms and diagnostic steps for common steam system problems (e.g., pressure drops, excessive noise, leaks)      2. Troubleshooting Methodology         1. Systematic approach to troubleshooting: visual checks)   pressure   * Temperature readings * Checking fuel preheaters * Checking thermostat * Checking burner nozzles * Checking fuel filters * Checking boiler water level * valve and gauge inspections   + - 1. Addressing faults in components (e.g., steam traps, control valves, boilers)   1. End-user training for steam system operation      1. End-user training overview         1. Importance of proper operator training for system longevity and safety         2. Key operational tasks (startup, monitoring, shutdown)         3. Maintenance schedules and routine checks      2. Training material         1. Review of user manuals, operational procedures, and safety guidelines         2. Visual and hands-on training with the steam system   2. Documentation and handing over the steam system      1. Documenting the commissioning process         1. Hand over documents * Engineering drawings * Installation report * Certificate of warranty * Training of operators   + - 1. Creating commissioning reports: performance tests, safety checks, system configurations       2. Documenting adjustments made during testing and troubleshooting       3. Completing checklists and ensuring all required documentation is filled     1. Handing over process        1. Final system handover procedures to the client or operations team        2. Providing documentation: warranties, maintenance guides, as-built drawings        3. Reviewing the operational and safety procedures with the client   1. Housekeeping      1. Importance of Housekeeping         1. Maintaining a clean and safe work environment         2. Preventing accidents and protecting system components      2. Site Cleanliness Standards         1. Disposal of waste materials, used tools, and equipment         2. Ensuring no leftover debris or hazardous materials remain on-site | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

**Suggested Methods of Delivery**

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Feed water pump
* Steam header
* Feed water tank
* Feed water conditioning unit
* Economizer
* Steam pipes
* Steam traps
* Safety valves
* Condensate pump
* Steam valves
* Sight glasses
* Pressure gauges
* Safety valves
* Blow down valve
* Water level sensors
* Boiler
* Steam header
* Steam receiver
* Steam pipes
* Fuel system
* Stack pipe
* Steam traps
* Safety valves

**Recommended resources**

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Industrial Boilers and Heat Recovery Steam Generators" by V. Ganapathy | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Lifting trolley | 1 ton | 1 | 1:25 |
|  | Hoist | 1 ton | 1 | 1:25 |
|  | Lifting rock | 1 ton | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 5 | 1:5 |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Boiler installation manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE VI

|  |  |  |  |
| --- | --- | --- | --- |
| 0715 541 22A | Engineering Mechanics Principles | **80** | **8.0** |
| 0732 551 23A | Computer Aided Drawing | **120** | **12.0** |
| 0715 551 24A | Boiler and steam system maintenance | **200** | **20.0** |

## **ENGINEERING MECHANICS**

**UNIT CODE: 0715 541 16A**

**Relationship to Occupational Standards**: Apply Engineering Mechanics

**Duration of Unit**: 80 Hours

**Unit Description**

This unit of competency describes the competences required in order to apply engineering mechanics principles. This includes, applying simple mechanisms, designing belts, ropes and chain drives, designing toothed gears and gear trains, designing mechanical rotor dynamic machines, applying stress and strain concepts, determining loading conditions, applying simple bending theory and applying torsion theory in mechanical systems.

**Summary of Learning Outcomes**

By the end of this unit, trainees should be able to;

|  |  |  |
| --- | --- | --- |
| **S/No** | **Learning Outcome** | **Duration (Hours)** |
|  | Simple Mechanisms | 10 |
|  | Belts, Ropes and Chain Drives | 10 |
|  | Toothed Gears and Gear Trains | 10 |
|  | Mechanical Rotor Dynamic Machines | 10 |
|  | Stress And Strain Concepts in Mechanical Systems | 10 |
|  | Loading Conditions in Mechanical Systems | 10 |
|  | Simple Bending Theory in Mechanical Systems | 10 |
|  | Torsion Theory in Mechanical Systems | 10 |
| **Total** | | **80** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. simple mechanisms | * 1. Define simple mechanism   2. Components of simple mechanism      1. Link      2. Element   3. Types of mechanisms      1. Single slider mechanism      2. Double slider mechanism | * Written Tests |
| 1. belts, ropes and chain drives | * 1. Definition      1. Belt      2. Rope      3. Chain   2. Belts      1. Material used for belt         + 1. Rubber           2. Cotton           3. Leather      2. Types of belts   2.2.2.1 Flat  2.2.2.2 V belt  2.2.2.3 Circular   * + 1. Configuration of belt drive   2.2.3.1Open   * + - 1. Crossed     1. Design Analysis of Flat and V-Belts   2.2.4.1Velocity ratio   * + - 1. Length of belt       2. Angle of contact       3. Power transmitted   1. Rope Drives      1. Types of rope drives   2. Chain Drives      1. Types of chain drives | * Written Tests |
| 1. toothed gears and gear trains | * 1. Types of Gears      1. Spur      2. Helical      3. Double helical   2. Types of Gear Trains      1. Simple gear train         1. Design calculations      2. Compound gear train         1. Design calculations      3. Reverted gear train         1. Design calculations      4. Epicyclic gear train   3. Lubrication of gears | * Written Tests |
| 1. Design mechanical rotor dynamic machines | * 1. Types of pumps and operation principle      1. Reciprocating pump      2. Centrifugal pump   2. Derivation of equations for      1. Reciprocating pumps      2. Centrifugal pumps   3. Analysis of pumps      1. Discharge      2. Efficiency      3. Power      4. Head      5. Weight per unit   4. Types and operation principle of rotary compressors      1. Rotary screw compressors      2. Rotary vane compressors      3. Scroll compressor      4. Rotary lobe   5. Analysis of compressors      1. Inlet and outlet flow      2. Work done      3. Mass flow rate      4. Power requirement      5. Efficiency   6. Compressor Fans and Vanes      1. Structure and functions of compressor fans and vanes      2. Operation principles of fans and vanes in rotary compressors      3. Maintenance of fans and vanes   7. Design Analysis      1. Vane efficiency      2. Fan efficiency      3. Power consumption | * Written Tests |
| 1. Apply stress and strain concepts in mechanical systems | * 1. Define stress and strain   2. Types of simple stresses      1. Direct      2. Shear      3. Ultimate tensile stress      4. Yield stress      5. Breaking stress      6. True stress   3. Analysing stress on      1. Beams      2. Thin cylinders      3. Thin shells   4. Applications of stress and strain concepts      1. Bolts and nuts      2. Shafts | * Written Tests |
| 1. Determine loading conditions in mechanical systems | * 1. Define structure   2. Types of loading      1. Point load      2. Uniformly distributed load      3. Varying load   3. Types of beams      1. Simply supported beams      2. Cantilever beam   4. Overhanging beam |  |
| 1. Apply simple bending theory in mechanical systems | * 1. Engineers Bending Equation   2. Types of Beams      1. Simply supported beams      2. Cantilever beam      3. Overhanging beam   3. Analysis of Beams      1. T-section      2. L-section      3. I-section   4. Types of Shafts      1. Solid      2. Tubular      3. stepped   5. Analysis of shafts      1. Solid      2. Tubular      3. Stepped | * Written Tests |
| 1. Apply torsion theory in mechanical systems | * 1. Define Torsion   2. Torque Analysis   3. Analysis of Shafts      1. Series arranged shafts      2. Parallel arranged shafts   4. Determine angle of twist      1. Engineers’ torsion equation | * Written tests |

**Suggested Delivery Methods**

* Group discussions
* Demonstration by the trainer
* Online video clips
* Power point presentation
* Exercises by trainee

**Recommended resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Comprehensive textbooks on Engineering Mathematics | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and Supplies** | | | |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:30 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
| **D** | **Tools and Equipment** | | | |
|  | Calculators | For calculations | 30 | 1:1 |
|  | Firefighting extinguishers | Water, carbon dioxide and chemical powder fire extinguishers for fire fighting | 1 | 1:30 |
| **F** | **Reference Materials** | | | |
|  | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:30 |

## **COMPUTER AIDED DRAWING**

**UNIT CODE:** 0715 51 23A

**UNIT DURATION:** 120 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Perform computer aided drawing.

**Unit description**

This unit covers the competences required to perform computer aided drawing. It involves navigating CAD software, producing geometric, pictorial, orthographic and assembly drawings as well as designing mechanical components.

**Summary of Learning Outcomes**

By the end of the Unit of Learning, the trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Navigate CAD software | **10** |
|  | Produce geometric drawings | **10** |
|  | Produce pictorial drawings | **20** |
|  | Produce orthographic drawings. | **20** |
|  | Produce assembly drawings | **30** |
|  | Design mechanical components | **30** |
|  | **TOTAL** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Navigate CAD software | * 1. Overview of CAD      1. Definition and significance of CAD in engineering and design.      2. Historical development of CAD technologies.   2. Computing Equipment and Software      1. Identify hardware requirements for CAD operations.      2. List popular CAD software options (e.g., AutoCAD, SolidWorks, Inventor).   3. Drawing CAD Software      1. Overview of the software interface.      2. Functions and capabilities of CAD tools.   4. CAD Software Templates      1. Explore various templates available for different drawing requirements.   5. Importing CAD Files      1. Process of importing files (DWG, STL, DXF, STEP) into the working space.   6. User Interface Navigation      1. Familiarization with the CAD software interface.      2. Understanding toolbars, menus, and command lines.   7. Setting Up the Drawing Environment      1. Units and measurement settings.      2. Creating a new drawing and saving files.   8. Symbols, Codes, and Standards      1. Identify relevant symbols and codes according to software functionality.   9. Understand and utilize drawing Elements      1. Points      2. Line angles      3. Circles and arcs      4. Planes (horizontal, vertical)      5. Figures and solids      6. Shapes      7. Objects snapping settings      8. Polar tracking settings.      9. Orthomode utilization   10. Use editing commands Editing Tools       1. Delete, undo and redo commands       2. Fillet and chamfer commands       3. Trim, extend and break commands       4. Zoom and pan commands       5. Move, copy, and paste commands       6. Rotate and mirror commands       7. Object snapping and grouping commands       8. Dimension and scaling commands | 1. Written tests 2. Oral Questioning 3. Portfolio of evidence |
| 1. Produce geometric drawings | * 1. Setting Drawing Lines      1. Recognize standard drawing line conventions * Dimension lines * Hidden detail lines * Extension lines * Section lines * Break lines * Chain   1. Using drawing lines   2. Constructing Types of Angles      1. Use trigonometry principles to construct acute, obtuse, and right angles.   3. Constructing Geometrical Forms      1. Create circles, rectangles, triangles, and polygons according to standards.   4. Developing Geometric Drawings      1. 2-Dimensional      2. Orthographic      3. Isometric |  |
| 1. Produce pictorial drawings | * 1. Drawing Symbols and Abbreviations      1. Apply standard drawing symbols and abbreviations in pictorial drawings.   2. Producing Pictorial Drawings      1. Techniques for creating isometric, oblique, cabinet, and cavalier drawings.   3. Saving Pictorial Drawings      1. Procedures for saving drawings in appropriate formats. |  |
| 1. Produce orthographic drawings. | * 1. Fundamentals of Orthographic Projection      1. Definition and importance of orthographic drawing.      2. Differences between orthographic and other drawing types (isometric, perspective).   2. Types of Orthographic Projections      1. First-angle projection.      2. Third-angle projection.   3. Understanding Views      1. Front, top, and side views.      2. Additional views (sectional, auxiliary).   4. First Angle Orthographic Drawings      1. Develop first-angle drawings adhering to standard conventions.   5. Third Angle Orthographic Drawings      1. Create third-angle drawings based on standard practices.   6. Saving Orthographic Drawings      1. Techniques for properly saving orthographic drawings.   7. Dimensioning Orthographic Views   8. Printing orthographic views   9. Creating isometric drawing      1. Choosing isometric cursor      2. Dimensioning isometric drawing      3. Printing isometric drawing   10. Creating 3D model       1. Choosing 3D workspace       2. 3D workspace modifying tool (3D orbit, 3D mirrors, union, extrude, press pull, etc.)       3. Rendering       4. Pring 3D models |  |
| 1. Produce assembly drawings | * 1. Overview of Assembly Drawings      1. Definition and purpose of assembly drawings.      2. Importance in manufacturing and engineering.   2. Types of Assembly Drawings      1. General assembly drawings vs. detailed assembly drawings.      2. Exploded view vs. isometric assembly drawings.   3. Exploding Orthographic Views      1. Techniques for exploding views in accordance with standard conventions.   4. Exploding Pictorial Views      1. Create exploded pictorial views based on drawing specifications.   5. Assembling Views      1. Assemble orthographic and pictorial views accurately.   6. Producing Sectional Views      1. Generate sectional views according to drawing standards.   7. Developing Parts List      1. Creating a parts list based on the drawing schematic. |  |
| 1. Design mechanical components | * 1. Designing Mechanical Components      1. Apply CAD principles to design mechanical components per work requirements.   2. Applying CAE in Simulation      1. Use computer-aided engineering tools for simulating mechanical designs.   3. Determining Improvements      1. Analyze design results to identify efficiency improvements.   4. Creating a Manufacturing Database      1. Develop a database to support the manufacturing process.   5. Improving Design Documents      1. Make enhancements to design documents based on manufacturing feedback.   6. Practical Activity |  |

**Suggested Delivery Methods**

* Demonstration
* Group discussions
* Exercises
* Online materials
* Direct instructions
* Simulation

**Recommended resources for 30 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item**  **)** |
| **A** | **Learning Materials** |  |  |  |
| 1 | Textbooks | Comprehensive texts on CAD basics, history, and hardware requirements. | 5 pcs | 1:5 |
| 2 | Charts | Visual aids covering CAD software evolution and industry applications. | 10 pcs | 1:2.5 |
| 3 | PowerPoint Presentations | For trainer’s use, covering CAD definitions, history, and hardware requirements. | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
| 1 | Lecture/Theory Room | Equipped with projector, seating for 25 trainees, ~60 sqm. | 1 | 1:25 |
| 2 | Computer Laboratory | Equipped with 25 computers installed with CAD software, ~80 sqm. | 25 | 1:1 |
| 3 | Printer/plotter | For printing CAD drawings | 2 | 1:13 |
| 4 | 3D printer | For printing 3D models | 2 | 1:13 |
| 5 | 3D printer filament | 3D printing material | 2 rolls | 1:13 |
| **C** | **Consumable Materials** |  |  |  |
| 1 | USB Drives | For storing and transferring CAD project files. | 25 pcs | 1:1 |
| 2 | Notebooks | For trainees to take notes during CAD sessions. | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
| 1 | Computers | Equipped with CAD software and compatible hardware (e.g., high RAM, graphics support). | 25 pcs | 1:1 |
| 2 | Projector | For displaying CAD software demonstrations and presentations in lecture room. | 1 | 1:25 |
| 3 | External Hard Drives | For backing up CAD files and course materials. | 5 pcs | 1:5 |
| 4 | Drawing Tablets | For CAD software use, supporting stylus input for design precision. | 5 pcs | 1:5 |
| **E** | **Reference Materials** |  |  |  |
| 1 | CAD Software Manuals | Documentation detailing CAD software functionalities and hardware requirements. | 25 pcs | 1:1 |
| 2 | CAD Industry Case Studies | Case studies showcasing CAD applications in engineering and design. | 5 pcs | 1:5 |
| 3 | Practical Assessment Guides | Worksheets for practical assessments on CAD navigation and hardware requirements. | 25 pcs | 1:1 |
| 4 | Training Presentations/Slides | Digital format for shared access among trainees covering CAD course content. | 1 | 1:25 |

## BOILER AND STEAM SYSTEM MAINTENANCE

**UNIT CODE:** 0715 551 23A

**Duration of Unit:** 200 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency; boiler and steam system maintenance

**UNIT DESCRIPTION**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train boiler and steam system maintenance. The learning outcomes shall enable the learner to carry out boiler and planned maintenance, carry out boiler corrective maintenance, carry out steam system planned maintenance and carry out steam system corrective maintenance.

**Summary of learning outcomes**

By the end of this unit, the learner will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Carry out boiler and planned maintenance | **40** |
|  | Carry out boiler corrective maintenance | **60** |
|  | Carry out steam system planned maintenance | **40** |
|  | Carry out steam system corrective maintenance | **60** |
|  | **TOTAL** | **200** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Carry out boiler planned maintenance | * 1. Workshop safety   2. Safe work practices and procedures for workshop.      1. Minimize Hazards and put control measures associated with Boiler and steam systems maintenance procedure.      2. Work site safety demarcation barriers.         1. Methods of demarcating a work site      3. Correct use of tools and equipment.   3. Perform boiler and start-up operation      1. Definition of terms      2. Boiler and steam system components and their functions         1. Burner         2. Heat exchanger         3. Makeup Pump         4. Thermostat         5. Pressure relief valve         6. Condensate recovery system      3. Types of boilers      4. Boiler and steam system start-up         1. Cold start         2. Warm start      5. Parameters that need to be set when performing cold start         1. Pressure gauges         2. Temperature gauges         3. Water level sensor/Mobrey switch valve         4. Main valves         5. Water leakages from inspection holes      6. Parameters to check when performing warm start         1. Level of water in the reserve tanks         2. Quality of water         3. Level of water in the boiler and steam system         4. Valves for make-up water         5. Boiler and steam system control systems         6. Mobrey blow down         7. Steam motive line         8. Functioning of FD and ID fans         9. Fire the boiler and steam system.   4. LOCKOUT/TAGOUT procedure      1. Shutdown the boiler and steam system      2. Isolate energy source      3. Apply lockout/Tag out devices      4. Dissipate stored energy   5. Boiler and steam system components      1. Boiler and steam system components         1. Safety valve         2. Safety valves         3. Pressure gauges      2. Steam system components         1. Steam traps         2. Safety valves         3. Pressure gauges         4. Steam headers         5. Gauge glass   6. Inspection of boiler and steam system      1. Definition of terms      2. Objectives of inspection      3. Types of inspections         1. Routine         2. Periodic         3. On-ground         4. Pre-operational         5. Major      4. Inspection tools         1. Basic visual tools         2. Precision measuring tools         3. Vibration analysis tools      5. Advantages of boiler and steam system inspection      6. Inspection Checks         1. Lag on steam line         2. Pump operations         3. Steam leaks         4. Operating parameters         5. Stack temperature      7. Inspection checklist   7. Boiler and steam system planned maintenance      1. Maintenance schedule      2. Preventive maintenance activities         1. Cleaning         2. Soot blowing         3. Ash removal         4. Tightening of lose parts         5. Replacing worn out parts         6. Lubrication   8. Boiler and steam system test      1. Test-run boiler and steam system      2. Preparation of a test run checklist      3. Procedure followed when performing test runs   9. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Carry out boiler corrective maintenance | * 1. Workshop safety      1. Safe work practices and procedures for workshop.         1. Minimize Hazards and put control measures associated with Boiler and steam systems maintenance procedure.         2. Work site safety demarcation barriers.         3. Methods of demarcating a work site         4. Correct use of tools and equipment.   2. Maintenance tools      1. Types of Maintenance tools      2. Correct use of maintenance tools      3. Care and maintenance of tools   3. Troubleshooting      1. Definition of term      2. Safety precaution during troubleshooting      3. Troubleshooting techniques         1. Testing electrical components         2. Testing mechanical faulty components         3. Visual inspection      4. Boiler and steam system faults         1. Thermostat malfunction         2. Failure of pressure vessels         3. Water hammers         4. Insufficient water in the tank         5. Failure of boiler and steam system fans (Induced Drought fans and Forced drought fans)         6. Valve failures         7. Failure of gauge glasses.         8. Failure of water pumps         9. Corrosion         10. Faulty seals         11. Failure of electrical control system         12. Failure of electrical supply         13. Faulty and loose component         14. Scaling         15. Steam leaks         16. Pump failure         17. Waterlogging         18. Pipe insulation   4. Boiler and steam system repair/service      1. Definition of terms         1. Corrective maintenance         2. Down-time         3. Root Cause Analysis         4. Mean Time to Repair (MTTR)      2. Working principle         1. Combustion         2. Heat transfer         3. Water circulation      3. Repair/service tools      4. Boiler and steam system control      5. Boiler and steam system repair procedure         1. Disassemble and assemble component         2. Replace faulty components         3. Welding and brazing         4. Pipefitting         5. Valve replacement         6. Pump repair         7. Burner replacement      6. Boiler and steam system service         1. Lubrication         2. Cleaning         3. Soot blowing         4. Ash removal         5. Tightening of lose parts         6. Replacing worn out parts      7. Testing of boiler and steam system         1. Inspection of safety components of a boiler and steam system * Mobrey Switches * Sight glass * Alarm/Siren * Safety valves * Low water cut-off * Pressure switch * Pressure gauges * Operational test   1. House keeping      1. Waste disposal method      2. Recycling Reusing and Reducing methods      3. Resource management      4. Pollution control      5. Cleaning   2. Maintenance report      1. Test and results      2. Operational data      3. Inspection record      4. Maintenance schedule      5. Maintenance description | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Carry out steam system planned maintenance | * 1. Introduction to steam system maintenance      1. Overview of steam systems         1. Key components: boilers, piping, valves, steam traps, control systems         2. Importance of regular maintenance for efficiency, safety, and longevity      2. Planned maintenance         1. Benefits of planned maintenance in reducing downtime and improving system performance         2. Adhering to safety standards and OSH Act, 2007 during maintenance work         3. Identifying steam system components and their function in overall maintenance   2. Adhering to safety procedures (OSH Act, 2007)      1. OSH Act, 2007 overview         1. Health and safety regulations for steam systems and maintenance work         2. Identifying potential hazards (high pressure, steam leaks, electrical safety)         3. Ensuring proper use of Personal Protective Equipment (PPE)      2. Safety protocols during maintenance         1. Lock-out/Tag-out (LOTO) procedures for system isolation         2. Handling high-pressure steam, hot surfaces, and hazardous materials      3. Emergency procedures         1. Responding to steam system accidents or failures         2. First aid and fire safety procedures      4. Conducting a safety inspection and creating a safe working environment before starting maintenance   3. Identifying steam system maintenance tools      1. Types of tools for steam system maintenance         1. Hand tools (wrenches, screwdrivers, pipe cutters, hammers)         2. Power tools (drills, grinders, and saws)         3. Specialized tools (pressure gauges, thermometers, calibration equipment)      2. Tool selection for specific maintenance tasks         1. Identifying tools based on maintenance needs (e.g., cleaning, repairs, valve adjustments)         2. Ensuring tools are in proper working condition before use      3. Tool Maintenance and Safety         1. Inspecting tools for wear and tear         2. Storing and organizing tools properly to maintain safety      4. Identifying and using the appropriate tools for a given maintenance task on the steam system   4. Planned maintenance according to manufacturer’s manual      1. Manufacturer’s maintenance manual overview         1. Importance of following the maintenance manual for reliability and performance         2. Common tasks included in planned maintenance (cleaning, inspections, lubrication, part replacements)      2. Planned maintenance procedures         1. Reviewing maintenance schedules and task lists         2. Performing routine checks (pressure relief valves, steam traps, safety valves)         3. Inspecting and cleaning the boiler and its components         4. Maintaining and calibrating pressure gauges, thermostats, and other monitoring equipment      3. Systematic maintenance         1. Ensuring all tasks are completed according to specified intervals and requirements         2. Verifying that maintenance tasks do not disrupt system operation      4. Conducting a planned maintenance procedure on a simulated steam system based on the manufacturer’s manual   5. Test running the steam system      1. Test running procedures         1. Preparing the system for a test run after maintenance (system checks, reassembly)         2. Steps to initiate a test run safely         3. Monitoring key parameters (pressure, temperature, flow rate, and steam quality)      2. Checking for abnormalities         1. Identifying and addressing issues such as leaks, unusual noises, or irregular readings         2. Ensuring that all system components are functioning as per design specifications      3. Manufacturer’s test requirements         1. Review of the manufacturer’s specifications for test running (pressure levels, operating conditions)         2. Verifying the system is within safe operational limits after maintenance      4. Performing a full test run on the steam system post-maintenance, ensuring compliance with specifications and identifying any abnormalities   6. Housekeeping      1. Importance of housekeeping         1. Preventing accidents and maintaining a safe work environment         2. Reducing the risk of contamination, equipment damage, and downtime      2. Housekeeping procedures for steam systems         1. Cleaning tools, equipment, and components         2. Proper disposal of waste materials, such as used parts and cleaning agents         3. Maintaining a clutter-free workspace to prevent hazards      3. Post-maintenance cleanliness         1. Ensuring the system and worksite are clear of tools, debris, and hazardous materials         2. Organizing tools and materials after maintenance completion | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |
| 1. Carry out steam system corrective maintenance | * 1. Introduction to corrective maintenance of steam systems      1. Overview of steam systems         1. Key components of a steam system: boilers, piping, valves, steam traps, gauges, and control systems         2. What is corrective maintenance: reactive versus proactive maintenance         3. Importance of diagnosing and correcting faults promptly to ensure system reliability and safety      2. Safety considerations in corrective maintenance         1. Understanding potential risks (high pressure, hot surfaces, system leaks)         2. Corrective maintenance safety hazards and protocols         3. Importance of Personal Protective Equipment (PPE) and lock-out/tag-out (LOTO) procedures during corrective work   2. Adhering to safety procedures (OSH Act, 2007      1. OSH Act, 2007 overview         1. Legal obligations related to safety during maintenance activities         2. General safety measures: preventing accidents, injuries, and damage during corrective maintenance         3. Hazard identification: risks related to steam pressure, high temperatures, and mechanical failure      2. Safety protocols during corrective maintenance         1. Lock-out/Tag-out (LOTO) and isolating the system before commencing work         2. Handling steam leaks, pressure valve malfunctions, and over-heating issues         3. Emergency shutdown procedures for steam system faults   3. Identifying corrective maintenance tools      1. Common tools for corrective maintenance         1. Hand tools: Wrenches, screwdrivers, pipe cutters, pliers, hammers         2. Power tools: Drills, saws, and grinders for component repairs         3. Specialized tools: Pressure gauges, flow meters, calibration equipment, thermometers      2. Tool selection for corrective tasks         1. Choosing the right tool for tasks such as valve replacement, pipe repair, leak detection, or component testing         2. Inspecting tools for wear and ensuring they are in proper working condition      3. Proper tool handling and maintenance         1. Handling power tools and specialized equipment safely         2. Ensuring the maintenance tools are kept organized and accessible   4. Corrective maintenance according to manufacturer’s manual      1. Importance of manufacturer’s manual         1. Understanding the need for adhering to the manufacturer’s specifications for repairs and replacements         2. Interpreting the manual: recommended parts, repair techniques, and replacement intervals      2. Corrective maintenance procedures         1. Performing repairs on steam system components such as valves, steam traps, pressure gauges, and piping         2. Replacing faulty components and ensuring proper reassembly         3. Adjusting system settings according to design specifications      3. Documentation of maintenance actions         1. Keeping records of repairs and maintenance performed according to the manual         2. Updating the system’s maintenance log   5. Test running the steam system      1. Test Running Procedures         1. Verifying the system is reassembled correctly before starting the test         2. Monitoring system parameters: temperature, pressure, steam quality, and flow rate      2. Test Criteria Based on Manufacturer’s Manual         1. Review of manufacturer’s guidelines for system performance testing         2. Ensuring that pressure, temperature, and flow rates are within safe and optimal operating ranges      3. Identifying issues during test runs         1. Troubleshooting common problems during test runs (leaks, irregular pressure, component malfunction)         2. Addressing abnormal behaviour such as fluctuating pressure or temperature levels   6. Troubleshooting steam system issues      1. Common steam system issues and symptoms         1. Leaks in pipes, valves, and joints         2. Pressure drops, steam flow issues, and system noise         3. Faulty steam traps, regulators, or controllers      2. Troubleshooting methodology         1. Systematic approach: isolating and diagnosing problems step by step         2. Using diagnostic tools: pressure gauges, thermometers, and flow meters to monitor system behavior         3. Identifying component failures (e.g., valves, seals, gauges) and proposing corrective actions      3. Manufacturer’s guidelines for troubleshooting         1. Following the troubleshooting procedures outlined in the manufacturer’s manual         2. Checking the operational settings and verifying repairs or replacements   7. Housekeeping      1. Importance of housekeeping         1. Keeping the work environment clean and safe to avoid hazards such as slips, falls, and tool misplacement         2. Preventing dirt, dust, and grease buildup on system components      2. Housekeeping procedures for steam systems         1. Cleaning tools and equipment after use         2. Proper disposal of waste materials (old parts, used tools, packaging materials)         3. Ensuring the steam system components are clean, well-lubricated, and protected from corrosion      3. Post-maintenance site cleanup         1. Properly storing equipment, tools, and materials for the next use         2. Checking that the worksite is clear of hazards and that the steam system is ready for normal operation | Practical  Projects  Portfolio of evidence  Third party report  Written tests  Oral assessment |

Suggested Methods of Delivery

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for at least Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment (Not limited to.)

* Heat exchanger.
* Steam traps.
* Separators.
* Condensate recovery system
* Condensate lifting pump
* Hot well.
* Assorted valves.
* Economizer.
* Super heater.
* Strainers.

**RECOMMNDED RESOURCES**

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Boiler Operator Handbook by Cary Leighton | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Gasket and seals |  | 5 | 1:5 |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | Hydraulic fluids | Multipurpose heavy duty | 20litres | 1:25 |
|  | **Cleaning detergents** | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
|  |  | **Measuring tools** |  |  |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Boiler | Training kit | 1 | 1:25 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Boiler and steam manuals | Manufactures drawings | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

# MODULE VII

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **Unit code** | **Unit name** | **Duration**  **in**  **Hours** | **Credit factor** |
| 0713541 25A | Electronics and Control Principles | **160** | **16.0** |
| 0715551 26A | Mechanical plant system design | **200** | **20.0** |

## **ELECTRONICS AND CONTROL PRINCIPLES**

**UNIT CODE:** 0713 541 25A

**UNIT DURATION:** 160 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply Electrical and Control principles.

**Unit description**

This unit describes the competences required in order to apply electrical and electronics principles. It involves applying safety requirements for electricity, understanding of electronics, performing single and three phase power supply, applying sensors and transducers principles and applying control principles.

**Summary of Learning Outcomes**

By the end of the Unit of Learning, the trainee will be able to;

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION (HOURS)** |
|  | Apply Safety requirements for electricity | **10** |
|  | Apply understanding of electronics | **25** |
|  | Perform Single and three phase power supply | **35** |
|  | Apply Sensors and transducers principles | **45** |
|  | Apply Control principles | **45** |
|  | **TOTAL** | **160** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply Safety requirements for electricity | * 1. Personal Protective Equipment (PPE)      1. Types of PPE         1. Head protection, insulating gloves, eye protection         2. Usage guidelines and importance   2. Control of Electrical Hazards      1. Identification of Hazards         1. Shocks, explosions, electrocution, burns, fires, electric arcs         2. Risk assessment and management   3. Electric Hazard Prevention      1. Preventative Measures         1. Lockout/Tag out (LOTO) procedures         2. Safe work practices | * Written tests * Practical |
| 1. Apply understanding of electronics | * 1. Introduction to Electronic Components      1. Overview of electronics: What are electronic components?      2. Classification of components: Passive, active, and electromechanical.      3. Introduction to circuit symbols and schematic diagrams.      4. Basic electrical quantities and units (voltage, current, resistance).      5. Understanding datasheets and component specifications.      6. Overview of testing and measurement tools (multimeters, oscilloscopes).   2. Passive Components      1. Resistors: Types, color codes, power ratings, and applications.      2. Capacitors: Types (ceramic, electrolytic, film), capacitance value, and working voltage.      3. Charging and discharging of capacitors in DC circuits.      4. Applications of capacitors in filtering, timing, and energy storage.      5. Inductors: Types, inductance value, and applications.      6. Inductor behavior in DC and AC circuits.      7. Introduction to filters: RC, RL, and RLC circuits.   3. Semiconductor Devices      1. Diodes: Introduction to PN junctions, characteristics, and types (LEDs, Zener diodes, Schottky diodes).      2. Applications of diodes in rectification, voltage regulation, and signal clipping.      3. Transistors: Types (BJT and MOSFET), characteristics, and configurations.      4. Basic transistor circuits: Switches and amplifiers.      5. Hands-on lab: Building and testing simple diode and transistor circuits.      6. Special semiconductor devices: Thyristors, TRIACs, and optoelectronic devices.      7. Characteristics and applications in switching and control.   4. Integrated Circuits (ICs)      1. Overview of integrated circuits: Analog vs. digital ICs.      2. Operational amplifiers (Op-Amps): Characteristics and basic configurations.      3. Applications of Op-Amps in signal processing.      4. Timers and oscillators: 555 timer IC and its applications.      5. Voltage regulators: Linear and switching regulators.      6. Introduction to data converters (ADC and DAC).      7. Digital ICs: Logic gates and flip-flops.      8. Applications of digital ICs in basic logic circuits.      9. Hands-on lab: Building circuits using Op-Amps, timers, and logic gates.   5. Electromechanical and Specialized Components      1. Relays: Types, operation, and applications in switching.      2. Switches and connectors: Types and usage in electronic circuits.      3. Transformers: Basic operation, step-up/step-down functions, and isolation.      4. Displays: LED, LCD, and seven-segment displays.      5. Circuit Design and Practical Applications      6. Basic circuit design principles: Bread boarding, PCB layout, and soldering.      7. Introduction to circuit simulation tools (e.g., Multisim, LTSpice).      8. Testing and troubleshooting techniques.      9. Real-world applications of electronic components.      10. Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits.      11. Hands-on lab: Final project assembly and testing. | * Written tests * Practical |
| 1. Perform Single and three phase power supply | * 1. Overview of Electrical Power Systems      1. Definition and importance of power supply systems      2. Types of power systems: Single-phase vs. three-phase      3. Basic Electrical Concepts         1. Voltage, current, power, and frequency         2. Phase relationships and power factor   2. Single-Phase Power Supply      1. Characteristics of Single-Phase Systems         1. Voltage and current waveforms         2. Applications and limitations of single-phase power      2. Circuit Design and Implementation         1. Basic circuit configurations: Series and parallel         2. Wiring techniques and component selection      3. Measurement Techniques         1. Measuring voltage, current, and power in single-phase circuits         2. Tools and instruments for measurements   3. Three-Phase Power Supply      1. Fundamentals of Three-Phase Systems         1. Characteristics of three-phase power: Star (Y) and Delta (Δ) configurations         2. Advantages of three-phase systems over single-phase      2. Circuit Design and Implementation         1. Wiring and connection techniques for three-phase systems         2. Component selection and configuration      3. Measurement Techniques         1. Measuring line and phase voltages, currents, and power in three-phase circuits         2. Use of power analyzers and other measurement tools   4. Power Calculations and Analysis      1. Power Calculations         1. Active, reactive, and apparent power calculations         2. Understanding the power triangle in both single and three-phase systems      2. Power Factor Correction         1. Importance of power factor in electrical systems         2. Techniques for improving power factor in both types of systems   5. Troubleshooting and Maintenance      1. Common Issues in Power Supply Systems         1. Identifying and diagnosing faults in single and three-phase systems         2. Troubleshooting techniques and best practices | * Written tests * Practical |
| 1. Apply Sensors and transducers principles | * 1. Introduction to Sensors and Transducers      1. Definitions and Concepts         1. Differences between sensors and transducers         2. Overview of their roles in measurement and control systems      2. Basic Principles of Operation         1. How sensors and transducers convert physical phenomena into electrical signals         2. Common physical quantities measured (e.g., temperature, pressure, moisture, position, oxygen, light)   2. Types of Sensors      1. Temperature Sensors         1. Thermocouples, thermistors, and infrared sensors         2. Principles of operations         3. Applications and selection criteria      2. **Pressure Sensors**         1. **Strain gauge, piezoelectric, and capacitive pressure sensors**         2. **Principles of operations**         3. **Measurement techniques and applications**      3. **Proximity and Displacement Sensors**         1. **Inductive, capacitive, and photoelectric sensors**         2. **Principles of operations**         3. **Use cases and installation considerations**      4. Other **Sensor Types**         1. Humidity, moisture, oxygen, flow, level, and gas sensors         2. Overview of their principles and applications   3. Types of Transducers      1. Definition **and Functionality**         1. Types of transducers (active vs. passive)         2. Examples and applications      2. Electrical **Transducers**         1. Strain gauges, load cells, and piezoelectric transducers         2. Principles of operation and usage      3. Mechanical **Transducers**         1. Overview of mechanical types and their applications         2. Integration into automated systems   4. Hands-on experiments on testing sensors and actuators. | * Written tests * Practical |
| 1. Apply Control principles | * 1. Introduction to Control Systems      1. Definition of terms and Importance of control systems         1. Introduction to control systems in engineering and automation         2. Types of control systems: Open-loop vs. closed-loop      2. Basic Terminology         1. Key terms: feedback, set point, error, actuator, sensor         2. Understanding system dynamics   2. Types of Control Strategies      1. Proportional Control (P Control)         1. Principles and characteristics         2. Applications and limitations      2. Proportional-Integral Control (PI Control)         1. Understanding integral action and its effects         2. Applications in process control      3. Proportional-Integral-Derivative Control (PID Control)         1. Components of PID control and their significance         2. Tuning methods and practical applications      4. Advanced Control Strategies         1. Feedforward control, adaptive control, and fuzzy logic control         2. Overview of model predictive control (MPC)         3. Types of controllers.   3. Introduction to PLCs      1. Overview of PLCs,      2. Applications      3. PLC Hardware         1. PLC components (CPU, I/O modules, power supply) and wiring.         2. PLC Programming Basics Programming languages (Ladder Logic, Function Block, etc.) and         3. Software tools.   4. Ladder Logic Programming      1. Creating basic programs using timers, counters, logic gates, and arithmetic operations.      2. Inputs/Outputs      3. Digital/analog inputs and outputs,      4. Interfacing with sensors and actuators. | * Written tests * Practical |

**Suggested Methods of Instruction**

* Demonstration by trainer
* Practice by the trainee
* Field trips
* Discussions

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** |  |  |  |
| 1 | Textbooks | Comprehensive texts on electrical and control principle. | 5 pcs | 1:5 |
| 2 | Charts | Visual aids covering electrical theories and safety protocols | 10 pcs | 1:2.5 |
| 3 | PowerPoint Presentations | For trainer’s use, covering course content and practical applications | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** |  |  |  |
| 1 | Lecture/Theory Room | Equipped with projectors and seating for 25 trainees, ~60 sqm | 1 | 1:25 |
| 2 | Workshop | Hands-on training area with workbenches, tools, and safety equipment, ~80 sqm | 1 | 1:25 |
| 3 | Computer Laboratory | Equipped with testing setups for electrical experiments, ~50 sqm.  Equipped with computers installed with Circuit simulation software. | 25 | 1:1 |
|  |  |  |  |  |
| **C** | **Consumable Materials** |  |  |  |
| 1 | Electrical Wires | Assorted sizes and color-coded (e.g., 1.5mm², 2.5mm², 4mm²) | 5 rolls | 1:5 |
| 2 | Insulation Tapes | For securing connections and insulation, assorted colors | 25 pcs | 1:1 |
| 3 | Breadboard | For prototyping and testing circuits | 5 pcs | 1:5 |
| 4 | Sensors | Assorted types (temperature, pressure, proximity) | 10 pcs | 1:2.5 |
| 5 | Signal generators | For generating AC signals | 5pcs | 1:5 |
| 6 | Transducers | Assorted | 10 pcs | 1:3 |
| 7 | Electronic components | Resistors, transistors, capacitors, relays, transformers. Integrated IC, OPAM. | 100pcs | 4:25 |
|  |  |  |  |  |
| **D** | **Tools and Equipment** |  |  |  |
| 1 | Screwdrivers | Assorted sets for various applications | 2 sets | 1:12.5 |
| 2 | Side Cutters | For cutting wires and cables | 4 pcs | 1:6.25 |
| 3 | Pliers | For gripping and bending wires | 3 pcs | 1:8.33 |
| 4 | Stripping Knives | For stripping insulation from wires | 4 pcs | 1:6.25 |
| 5 | Computers | Equipped with electrical and electronics simulation software | 5 pcs | 1:5 |
| 6 | Multimeters | For measuring voltage, current, and resistance | 5 pcs | 1:5 |
| 7 | Clamp Meters | For measuring current flow in circuits | 5 pcs | 1:5 |
| 8 | Oscilloscope | For observing waveforms and signals | 1 | 1:25 |
| 9 | Voltmeter | For measuring voltage | 1 | 1:25 |
| 10 | Ammeter | For measuring current | 1 | 1:25 |
| 11 | Signal Generator | For generating electrical signals for testing | 1 | 1:25 |
| 12 | Soldering gun | For soldering | 10 | 1:3 |
| 13 | Soldering wire | For making joints in electrical circuits | 10 | 1:3 |
| 14 | PLC | For program practice | 5 | 1:5 |
| 15 | Cells and batteries | For learning | 5 | 1:5 |
|  |  |  |  |  |
| **E** | **PPE (Personal Protective Equipment)** |  |  |  |
| 1 | PPE Sets | Includes helmets, gloves, safety goggles, shoes, and harnesses | 25 sets | 1:1 |
| 2 | Safety Signs and Barriers | For simulating safety zones and hazards | 10 sets | 1:2.5 |
| 3 | Earthing Test Kits | For ground testing and demonstrating earthing procedures | 5 pcs | 1:5 |
| 4 | Electrical Test Benches | For hands-on testing of functionality and circuit design | 5 pcs | 1:5 |
|  |  |  |  |  |
| **F** | **Reference Materials** |  |  |  |
| 1 | Industrial Automation Manuals | Covering principles and practices in automation | 25 pcs | 1:1 |
| 2 | Electrical Standards | Reference on industry standards (e.g., IEEE Guidelines) | 5 pcs | 1:5 |
| 3 | Technical Handbooks | On motors, drives, and wiring systems | 25 pcs | 1:1 |
| 4 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 5 | Multimedia Learning Modules | Digital licenses for videos and tutorials | 25 pcs | 1:1 |
| 6 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |

## **MECHANICAL PLANT SYSTEM DESIGN**

**UNIT CODE:** 0715 551 26A

**Duration of Unit:** 200 Hours

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Mechanical plant systemdesign

**Unit Description**

This unit of learning covers the learning outcomes, content, assessment methods, methods of delivery and resources required to train mechanical plant system design. The learning outcomes shall enable the learner to analyse plant system requirements, select mechanical plant equipment and design mechanical plant layout.

**Summary of learning outcomes**

By the end of this unit of learning, the trainee will be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning outcomes** | **DURATION (HOURS)** |
|  | Analyze plant System Requirements | **30** |
|  | Select Mechanical Plant Equipment | **50** |
|  | Design Mechanical Plant Layout | **120** |
|  | **TOTAL** | **200** |

**Learning outcome, content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Assessment methods** |
| 1. Analyze plant System Requirements | * 1. Mechanical plant system requirements      1. Define the scope or the problem identification      2. Gathering of data      3. Analyzing data      4. Generating alternatives      5. Evaluating alternatives   2. Site conditions and regulation      1. Regulatory requirements analysis         1. Zoning laws         2. Building codes         3. Environmental regulations         4. Health and safety standards      2. Site conditions assessment         1. Topography and geotechnical evaluations         2. Climate conditions         3. Utility availability         4. Access and transportation         5. Hazardous material management      3. Community and social impact         1. Proximity to residential areas         2. Public consultation and engagement         3. Labor availability      4. Design requirements compliance         1. Operational needs         2. Sustainability goals         3. Technology and equipment compatibility      5. Legal and permit requirements         1. Construction permits         2. Operating licenses   3. Mechanical plant critical parameters      1. Heat transfer and thermal efficiency         1. Heat load calculations         2. Thermal efficiency      2. Pressure and flow rate         1. Flow rate calculations         2. Pressure drops calculations      3. Mechanical power requirements         1. Power for mechanical equipment      4. Pump and compressor sizing         1. Pump head and flow calculations         2. Compressor capacity      5. Vibration analysis and structural integrity         1. Vibration and stress analysis         2. Fatigue stress calculations      6. Energy consumption and efficiency         1. Energy efficiency calculations         2. Power factor      7. Cooling system requirements         1. Cooling load calculations | * Practical * Projects * Portfolio of evidence * Third party report * Written tests * Oral assessment |
| 1. Select Mechanical Plant Equipment | * 1. Mechanical plant system equipment      1. Plant equipment         1. Pumps         2. Compressors         3. Boiler         4. Tanks         5. Motors         6. Gauges         7. Heat exchangers         8. Reservoirs         9. Control system         10. Pipes         11. Valves      2. Process needs analysis         1. Type of process         2. Flow requirements         3. Temperature and pressure conditions      3. Operating conditions and environment         1. Ambient conditions         2. Chemical compatibility         3. Operational and maintenance needs      4. Energy efficiency and sustainability         1. Energy consumption         2. Sustainability goals      5. Industry standards and compliance         1. Regulatory compliance         2. Safety standards         3. Certification and quality control      6. Equipment selection for specific systems         1. Pump and compressors         2. Heat exchangers         3. Motors and actuators         4. Heat recovery and cooling systems      7. Cost and lifecycle         1. Initial cost         2. Life cycle costing         3. Reliability and warranty   2. Mechanical plant system equipment calculations and sizing      1. Heat transfer and thermal efficiency         1. Heat load calculations         2. Thermal efficiency      2. Pressure and flow rate         1. Flow rate calculations         2. Pressure drops calculations      3. Mechanical power requirements         1. Power for mechanical equipment      4. Pump and compressor sizing         1. Pump head and flow calculations         2. Compressor capacity      5. Vibration analysis and structural integrity         1. Vibration and stress analysis         2. Fatigue stress calculations      6. Energy consumption and efficiency         1. Energy efficiency calculations         2. Power factor      7. Cooling system requirements         1. Cooling load calculations   3. Mechanical plant equipment options      1. Types of pumps         1. Centrifugal pumps         2. Positive displacement         3. Peristaltic pumps      2. Selection criteria         1. Flow rate and head (pressure requirements)         2. Fluid properties (viscosity, abrasiveness, temperature)         3. Energy efficiency         4. Maintenance requirements and durability      3. Compressors         1. Types of compressors            1. Reciprocating compressors            2. Rotary screw compressors            3. Centrifugal compressor            4. Diaphragm compressor         2. Selection criteria            1. Flow rate and head (pressure requirements)            2. Fluid properties (viscosity, abrasiveness, temperature)            3. Energy efficiency            4. Maintenance requirements and durability      4. Heat exchangers         1. Types of heat exchangers            1. Shell and tube heat exchanger            2. Plate heat exchanger            3. Air cooled heat exchangers            4. Double pipe heat exchangers         2. Selection criteria            1. Thermal load and temperature difference            2. Flow rates (both fluids)            3. Pressure drops and available space for installation            4. Material compatibility (corrosion resistance)      5. Motors and drive         1. Types of motors            1. Electric motors            2. Dc motors            3. Induction motors            4. Synchronous motors         2. Types of drives            1. Variable frequency drives            2. Direct drive systems            3. Gearboxes and coupling         3. Selection Criteria            1. Power rating and efficiency            2. Speed control needs (for VFDs)            3. Load characteristics (e.g., constant or variable loads)            4. Duty cycle and environmental conditions (temperature, humidity)      6. Valves         1. Types of valves            1. Gate valves            2. Globe valves            3. Ball valves            4. Check valves            5. Pressure relief valves         2. Selection criteria            1. Pressure, temperature, and fluid compatibility            2. Function (on/off, throttling, or check)            3. Safety requirements (e.g., pressure relief)            4. Material (corrosion resistance)      7. Boilers and steam generation systems         1. Types of boilers            1. Fire tube boilers            2. Water tube boilers            3. Electric boilers         2. Selection criteria            1. Pressure and temperature ratings            2. Fuel type (natural gas, coal, oil, or electric)            3. Efficiency (e.g., flue gas recovery, economizers)            4. Capacity (steam output, thermal load)      8. Air handling units(AHUs)         1. Types of AHUs            1. Single zone AHUs            2. Multi zone AHUs         2. Selection criteria            1. Airflow capacity (CFM or m³/h)            2. Energy efficiency (e.g., heat recovery)            3. Temperature and humidity control needs            4. Filtration requirements (e.g., for clean rooms or sensitive environments)      9. Pressure vessels         1. Types of pressure vessels            1. Storage vessels            2. Reaction vessels            3. Heat exchange vessels         2. Selection criteria            1. Pressure rating and design conditions            2. Material compatibility (e.g., for corrosive substances)            3. Safety and regulatory compliance (e.g., ASME, PED)            4. Capacity and required fittings (e.g., inlet/outlet nozzles)      10. Conveyors          1. Types of conveyors             1. Belt conveyor             2. Screw conveyor             3. Chain conveyor          2. Selection criteria             1. Load capacity and material characteristics             2. Distance and incline             3. Speed and throughput             4. Environmental factors (dust, moisture, temperature)      11. Cooling systems          1. Types of cooling systems             1. Cooling towers             2. Chillers             3. Air cooled heat exchangers          2. Selection criteria             1. Cooling capacity (BTU/hr. or kW)             2. Operating temperature range             3. Efficiency and maintenance requirements | * Practical * Projects * Portfolio of evidence * Third party report * Written tests * Oral assessment |
| 1. Design Mechanical Plant Layout | * 1. Mechanical plant layout      1. Understanding job requirements         1. Project scope         2. Functional requirements      2. Site assessment         1. Topography and site constraints         2. Access and transportation      3. Process flow design         1. Material flow         2. Utility systems      4. Equipment placement         1. Equipment location         2. Safety and accessibility      5. Safety considerations         1. Fire and explosion hazards         2. Ventilation and exhaust systems         3. Escape routes and emergency systems      6. Zoning and functional areas      7. Space and layout optimization         1. Minimizing space usage         2. Modular design         3. Interconnection and cabling   2. Mechanical plant system detailed layout      1. Site plan      2. Building layout      3. Equipment arrangement      4. Piping plan      5. Equipment tagging      6. Utility systems      7. Safety features      8. Electrical and control systems   3. Mechanical plant system model simulation      1. Types of models         1. 3 D models done by CAD software         2. Physical models      2. Creating system models      3. Modelling methods         1. First principle modelling         2. Data driven modelling         3. Hybrid modelling      4. Simulating the plant system         1. Steady state simulation         2. Dynamic simulation         3. Monte Carlo simulation         4. Fault and failure simulations      5. Analyzing simulation results         1. Energy usage vs throughput         2. Flow and pressure profiles         3. Loading distribution         4. Operational bottlenecks         5. Maintenance schedules         6. Optimization   4. Plant layout review      1. Review of optimized model      2. Alignment of layout drawings with optimized model      3. Piping, instrumentation, and control systems      4. Maintenance and access considerations      5. Utilities and ancillary systems      6. Space optimization and equipment grouping      7. Review of structural and safety codes   5. Detailed mechanical plant layout drawing preparation.      1. Review of optimized model      2. Creating the layout drawing      3. Integration of equipment      4. Piping layout      5. Final drawing detailing         1. Annotation and labels         2. Multiple views            1. Top view            2. Elevations            3. Isometric views            4. Cross sectional views         3. Dimensioning         4. Material specifications         5. Installation and assembly   6. Design documents      1. Types of documents         1. Drawings         2. Bill of quantities         3. Process flow charts      2. Preparation of design documents         1. Plant layout drawings         2. System schematics         3. Equipment specifications         4. Process flow diagrams         5. Piping and instrumentation         6. Bill of materials         7. Energy efficiency reports         8. Safety and compliance documents      3. Relevant personnel         1. Project manager         2. Process engineers         3. Electrical engineers         4. Mechanical engineers         5. Civil/structural engineers         6. Safety officers         7. Regulatory authority         8. Procurement team         9. Quality assurance team | * Practical * Projects * Portfolio of evidence * Third party report * Written tests * Oral assessment |

Suggested Methods of Delivery

* Practical
* Projects
* Demonstrations
* Group discussion
* Direct instructions

Recommended Resources for Twenty-five (25) Trainees

Tools

Equipment

Machinery

Informed equipment

* First Aid Boxes
* Personal protective equipment
* Fire extinguishers
* Water Hydrants
* 25 Desktops
* Internet Access
* Computer software

RECOMMENDED RESOURCES FOR 25 TRAINEES

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/Specifications** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Learning Materials** | | | |
|  | Textbooks | Mechanical Engineering Design by J.E. Shigley | 5 | 1:5 |
|  | Drawing papers | A4, A3 and A2 size drawing papers for drafting of sketches and working drawings | 1 ream |  |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:25 |
|  | Computer | Functional desktop computer with AutoCAD | 1 | 1:25 |
|  | White board | Quality whiteboard of approximately 6 ft. by 3 ft. for writing during theory instruction | 1 | 1:25 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Standard workshop with bench/fitting area approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 25 | 1: |
|  | Gloves | Shields hands from sharp edges, heat, and chemical exposure | 25 | 1:1 |
|  | Safety boots | Protects feet from heavy objects, sharp materials, and impact. | 25 | 1:1 |
|  | Ear muffs/ ear plugs | Shields against prolonged exposure to high noise levels from machinery | 25 | 1:1 |
|  | Safety goggles | Protects eyes from flying metal particles, sparks, and dust | 25 | 1:1 |
|  | Utilities | Water (10,000 liters)  Electricity (3 phase/single phase)  Gas (set) | 1 | 1:25 |
|  | Assorted screws | Flat head (set)  Star head (set) | 1 (set)  1(set) | 1:25  1:25 |
|  | First Aid kit | Fully equipped First Aid kit for use in case of accidents | 1 | 1:25 |
|  | Brooms and cleaning stuff | Hand brooms and mops for cleaning | 10 | 2:5 |
|  | Cotton waste | Absorbent cotton waste for cleaning of oils and other dirt on machines, tools and equipment |  |  |
|  | Filters | Stainless steel | 5 | 1:5 |
| **Lubricants** | | | | |
|  | Grease | Multipurpose heavy duty | 4kgs | 1:25 |
|  | Hydraulic fluids | Multipurpose heavy duty | 20litres | 1:25 |
|  | Cleaning detergents | General degreasers | 10 liters | 1:25 |
| Floor detergents | 10 liters |
| Hand detergents | 10 liters |
| **D** | **Tools and Equipment** | | | |
| **Tools** | | | | |
|  | Spanner sets | Assorted spanner set | 5 | 1:5 |
|  | Wrench set | Combination set | 5 | 1:5 |
|  | Screwdriver set | Combination set | 5 | 1:5 |
|  | Allen keys | Combination set | 5 | 1:5 |
| **Measuring tools** | | | | |
|  | Steel rules | Calibrated steel rules for linear measurements | 20 | 4:5 |
|  | Vernier calipers | Calibrated Vernier calipers for linear measurements | 20 | 4:5 |
|  | Tri squares | Properly aligned steel Tri-square for checking perpendicular edges | 5 | 1:5 |
|  | Vernier height gauge and surface plates | Calibrated Vernier height gauges and surface plates for measurement of heights | 5 | 1:5 |
|  | Measuring tapes | Calibrated measuring tapes for linear measurements | 20 | 4:5 |
|  | Angle gauges | Calibrated steel rules for linear measurements | 5 | 1:5 |
| **Marking out tools** | | | | |
|  | Scribers | Quality steel pencil scribers for marking out lines on metal surfaces | 20 | 4:5 |
|  | Dot punches | Quality steel dot punches for marking out centers | 20 | 4:5 |
|  | Calipers | Quality steel calipers for marking out arcs on metal surfaces | 5 | 1:5 |
| **Cutting Tools** | | | | |
|  | Assorted hand files | Flat and round hand files for material preparation and finishing | 20 | 4:5 |
|  | Hacksaws | Hack saws with functional frames and blades for cutting metal plates and pipes | 20 | 4:5 |
|  | Tinsnips |  | 10 | 2:5 |
|  | Angle grinders | Portable angle grinders with cutting and grinding disks for cutting and grinding metal plates and pipes | 5 | 1:5 |
|  | Hand drill | Portable hand drill | 5 | 1:5 |
| **Work holding tools** | | | | |
|  | Work benches | Stable work benches for carrying out bench work | 5 | 1:5 |
|  | Bench vices | Functional bench vices/clamps for holding work pieces during bench work | 20 | 4:5 |
|  | Tongs | Functional pairs of tongs for holding hot pieces of metal during welding | 10 | 2:5 |
| **Finishing tools** | | | | |
|  | Wire brushes | To clean metal surfaces | 20 | 4:5 |
|  | File cards | Cleaning tool used to maintain files | 5 | 1:5 |
| **E** | **Machines and Equipment** | | | |
|  | Guillotine machines | Used for cutting large sheets of metal into smaller pieces with precision | 1 | 1:25 |
|  | Greasing gun | Hand grease gun | 5 | 1:5 |
|  | Pallet truck | Hand pallet truck | 1 | 1:25 |
|  | Firefighting equipment | for ensuring safety in fabrication workshops where fire hazards are present, such as sparks | 3 |  |
|  | Rolling machines | used to bend and shape metal sheets into curved shapes, cylinders, or tubes | 1 | 1:25 |
|  | Bending machine | Used to bend metal sheets or bars into angles and specific shapes. | 1 | 1:25 |
| **F** | **Reference Materials** | | | |
| 1 | Working drawings | Mechanical drawings | 25pcs | 1;1 |
| 2 | Technical manuals | Technical manuals | 1 pc | 1:25 |
| 3 | Training Presentations/Slides | Digital format for shared access among trainees | 1 | 1:25 |
| 4 | Practical Assessment Guides | Worksheets for practical assessments | 25 pcs | 1:1 |