NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

REFRIGERATION PRACTICE

NQF Level 3

April 2008

REFRIGERATION PRACTICE - LEVEL 3

CONTENTS

INTRODUCTION

A. What is Refrigeration Practice?

Refrigeration Practice is the study and application of the science of refrigeration, the electrical equipment that forms part of cooling equipment, and the detection of equipment faults. Knowledge of water treatment systems and legal requirements for air conditioning and refrigeration plants are also included.

B. Why is Refrigeration Practice important in the Engineering and Related Design programme?

Refrigeration Practice provides the student with knowledge of cooling equipment, how it operates and basic detection of plant faults. The student also acquires knowledge of the legal requirements relating to plant safety.

C. The link between the Learning Outcomes for Refrigeration Practice and the Critical and Developmental Outcomes

Refrigeration Principles as a subject will

- Develop students' more advanced problem solving skills through understanding of mechanical and electrical engineering
- Develop understanding of personal safety and the safety of others in the environment, which is of prime importance and a legal requirement
- Develop students' application of problem solving skills and logical thinking to practical engineering problems

D. Factors that contribute to achieving Refrigeration Pracice Learning Outcomes

- A learning environment that will stimulate interest in the subject
- Qualified and competent lecturers who are able to encourage team work, healthy workplace relations and workplace safety
- Lecturers and trainers who promote logical thinking in engineering and problem solving.

1 DURATION AND TUITION TIME

This is a one-year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the student meets all the assessment requirements.

Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2 SUBJECT LEVEL FOCUS

Understanding of the principles of thermodynamics, fault finding of plants and legal requirements of refrigeration plants

3 ASSESSMENT REQUIREMENTS

3.1 Internal assessment (50 percent)

3.1.1 Theoretical component

The theoretical component forms 40 percent of the internal assessment mark.

Internal assessment of the theoretical component in Refrigeration Practice Level 3 takes the form of observation, class questions, group work, individual discussions with students, class, topic and semester tests and internal examinations. Observation can be done on completion of work piece.

Assignments, case studies and tests can be completed at the end of a topic. Tests and internal examinations must form part of the internal assessment.

3.1.2 Practical component

The practical component forms 60 percent of the internal assessment mark.

Practical components include applications and exercises. All practical components must be indicated in a Portfolio of Evidence (PoE).

Internal assessment of the practical component in Refrigeration Practice Level 3 takes the form of assignments, practical exercises and practical examinations in a workshop environment.

Students may complete practical exercises daily. Assignments can be completed at the end of a topic. Practical examinations can form part of internal practical assessment.

- **Some examples of practical assessments include, but are not limited to:**
  - Presentations (lectures, demonstrations, group discussions and observation, role-play, independent activity, synthesis and evaluation)
  - Exhibitions by students
  - Visits undertaken by students based on a structured assignment task
  - Task performance in a “Structured Environment”

- **Definition of the term “Structured Environment”**

For the purposes of assessment, “Structured Environment” refers to an actual or simulated workplace or a computer or workshop environment. Activities in the simulated workplace or environment must be documented in a logbook with a clear listing of the competencies to be assessed. The following information must be contained in the logbook:

- Nature of department or environment in which practical component was achieved
- Learning Outcomes
- Activities in the environment with which to achieve the Learning Outcomes
- Time spent on activities
- Signature of facilitator or supervisor and student

For the logbook to be regarded as valid evidence, it must be signed by an officially assigned supervisor.

- **Evidence in practical assessments**

All evidence pertaining to evaluation of practical work must be reflected in the student's Portfolio of Evidence. The tools and instruments used for the purpose of conducting these assessments must be part of the evidence contained in the PoE.

3.1.3 Processing of internal assessment mark for the year

A year mark out of 100 is calculated by adding the marks of the theoretical component and the practical component of the internal continuous assessment (ICASS).

3.1.4 Moderation of internal assessment mark

Internal assessment is subject to internal and external moderation procedures as set out in the *National Examinations Policy for FET College Programmes*.

3.2 External assessment (50 percent)

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. The practical component will also be assessed.

External assessment details and procedures are set out in the *Assessment Guidelines: Refrigeration Practice Level 3.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Define and apply the principles of thermodynamics	25%
2	Install and maintain electrical cables and single phase circuits	25%
3	Explain and apply fault finding, dismantling, re-assembly and oil analysis	25%
4	Explain and apply legal requirements or Group 1 refrigerants, layouts, drawings, sketches and technical specifications	20%
5	Explain and demonstrate water treatment systems	5%
	TOTAL	**100**

5 CALCULATION OF FINAL MARK

Internal assessment mark: Student's mark/100 x 50 = a mark out of 50 (a)

Examination mark: Student's mark/100 x 50 = a mark out of 50 (b)

Final mark: (a) + (b) = a mark out of 100

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, reporting, moderation and verification purposes.

6 PASS REQUIREMENTS

A student must obtain at least fifty percent in internal continuous assessment and fifty percent in the examination to achieve a pass in this subject.

7 SUBJECT AND LEARNING OUTCOMES

On completion of Refrigeration Practice Level 3, the student should have covered the following topics:

Topic 1: Define and apply the principles of thermodynamics

Topic 2: Install and maintain electrical cables and single phase circuits

Topic 3: Explain and apply fault finding, dismantling, re-assembly and oil analysis

Topic 4: Explain and apply legal requirements or Group 1 refrigerants, layouts, drawings, sketches and technical specifications

Topic 5: Explain and demonstrate water treatment systems

7.1 Topic 1: define and apply the principles of thermodynamics

7.1.1 Subject Outcome 1: Define and apply the relationship between force, work, power and energy

Range: Watts, Joules

Learning Outcomes:

The student should be able to:

- Define the units of force, work, power and energy.
- Explain the relationship between the units of force, work, power and energy.
- Carry out basic calculations involving force, work, power and energy

7.1.2 Subject Outcome 2: Define temperature and heat and explain the different forms of heat

Range: Kelvin, Celsius, Fahrenheit

Learning Outcomes:

The student should be able to:

- Explain and illustrate the difference between temperature and heat.
- Explain the difference between absolute and customary temperatures.
- Define and give examples of sensible heat and latent heat.
- Explain the name changes of the three phases of matter.
- Carry out basic calculations involving sensible heat and latent heat.

7.1.3 Subject Outcome 3: Define pressure and explain the different types of pressure

Range: absolute pressure, barometric pressure, gauge pressure and vacuum

Learning Outcomes:

The student should be able to:

- Define and explain the terms absolute pressure, barometric pressure, gauge pressure and vacuum.
- Explain the approximate barometric pressures at various altitudes.
- Carry out basic calculations involving absolute pressures, barometric pressures, gauge pressures and vacuum.

7.1.4 Subject Outcome 4: Define and apply the relationship between mass and volume

Range: density, specific volume air flow and mass flow

Learning Outcomes:

The student should be able to:

- Define and explain the terms density, specific volume, air flow and mass flow.
- Perform basic calculations involving density, specific volume, air flow and mass flow.

7.2 Topic 2: Install and maintain electrical cables and single phase circuits

7.2.1 Subject Outcome 1: Prepare to install and terminate cables, conductors and wire ways

Range: Maximum 1 000 volt, three-phase, four-wire

Learning Outcomes:

The student should be able to:

- Interpret job instructions correctly, and identify drawings and plans and the point of installation.
- Identify and find correct equipment to be connected.
- Interpret statutory requirements for a demarcated work area.
- Check cables, conductors and wire ways as specified, for suitability and functionality.
- Prepare and check equipment and tools required for suitability and functionality.
- Determine routing cables, conductors and wire ways.
- Prepare fixing materials required for installing terminating cables and wire ways.
- Identify and explain obstacles to installation.
- Obtain and check required personal protective clothing and equipment.

7.2.2 Subject Outcome 2: Install electrical cable, conductors and wire ways

Range: Maximum 1 000 volt, three-phase, four-wire

Learning Outcomes:

The student should be able to:

- Mark and terminate cables and conductors correctly according to drawing, work site procedures and manufacturer's specifications.
- Connect cables and conductors as per wiring diagram and work site instructions.
- Check that all terminations are tight and secure according to manufacturer's specifications and work site procedures.
- Re-instate work site in accordance with work site procedures, house keeping standards and environmental and customer requirements.
- Complete and submit the correct documentation.
- Explain why work has to be verified, certified and tested by an accredited person in accordance with SANS 10142-1.

7.2.3 Subject Outcome 3: Maintain electric cables, conductors and wire ways

Range: Maximum 1 000 volt, three-phase, four-wire

Learning Outcomes:

The student should be able to:

- Verify safe isolation of equipment as per safe working procedures.
- Verify safety and security lockout system in accordance with work site procedures.
- Safely maintain cables, conductors and wire ways in accordance with work site instructions to prevent breakdowns and loss of operation and/or service.
- Check and report damage and faults on cables and conductors that may endanger life.
- Check and repair fixing cables, conductors and wire ways.
- Identify and report possible reasons for malfunctioning.
- Complete and submit documentation.

7.2.4 Subject Outcome 4: Identify switches, components and loads

Range: Protection devices: Circuit breakers, earth leakage relays, overload protection devices, over/under voltage relays and typical control devices
Electrical control panel accessories: Door interlocked isolators (plain and fused), current transformers, running hour meters, Auto-off-manual selector switches,
Typical circuits: Circuits for 2, 4, 6 and 8 pole three-phase, single speed induction motors.

Learning Outcomes:

The student should be able to:

- Identify and draw symbols for switching devices as per range statement.
- Identify and draw symbols for the various types of protective devices.
- Identify and draw symbols for the various types of single-phase motors and accessories.
- Identify and draw symbols for the various types of control instruments.
- Identify and draw symbols for the various types of electrical control panel accessories.
- Define and compare resistive and inductive loads.

7.2.5 Subject Outcome 5: Sketch and interpret basic single-phase circuit diagrams and construct circuits

Range: Protection devices: Circuit breakers, earth leakage relays, overload protection devices, over/under voltage relays and typical control devices
Electrical control panel accessories: Door interlocked isolators (plain and fused), current transformers, running hour meters, Auto-off-manual selector switches,
Typical circuits: Circuits for 2, 4, 6 and 8 pole three-phase, single speed induction motors.

Learning Outcomes:

The student should be able to:

- Sketch basic single-phase circuit diagrams.
- Construct different circuits as per range statement.
- Explain selection of the relevant components.
- Explain why it is necessary to connect the suitable components correctly according to the diagram.
- Explain why all wiring must be done in accordance with work site instructions.
- Explain why the correct wire sizes must be used.
- Explain how to connect the circuit correctly to the power supply.
- Make sure the operation of the circuit is correct as intended.
- Use the correct tools appropriately.

7.3 Topic 3: Explain and apply fault finding, dismantling, re-assembly and oil analysis

7.3.1 Subject Outcome 1: Prepare for faultfinding of a plant

Range: Single phase refrigeration plant

Learning Outcomes:

The student should be able to:

- List the appropriate electrical and mechanical testing tools.
- Explain why it is important that the operating and maintenance instructions for the plant are available.
- Explain why knowing the exact location of the plant is important.
- Explain why service records for the plant should be inspected prior to work.
- Explain why it is necessary for all possible reasons for plant stoppage to be discussed with the user/operator.
- Explain possible faults causing plant failure.

7.3.2 Subject Outcome 2: Establish possible electrical faults causing plant stoppage

Range: Single phase refrigeration plant

Learning Outcomes:

The student should be able to:

- Explain why all possible causes of electrical faults are investigated and diagnosed.
- Explain the consequences of faulty selection of switching or protective devices.
- Explain the consequences of wrong power supply and faulty setting of overloads.

7.3.3 Subject Outcome 3: Establish possible control faults causing plant stoppage

Range: Single phase refrigeration plant

Learning Outcomes:

The student should be able to:

- Check all control instruments for faulty settings and compare with stipulated or normally acceptable settings required for correct and safe operations.
- Adjust control settings according to specified parameters or as required for correct and safe operation.
- Check operation of the defrost system.
- Explain the appropriate corrective action.
- Explain the consequences of faulty settings on controls.
- Explain why fault finding is done in a methodical manner and appropriate action taken.

7.3.4 Subject Outcome 4: Establish possible mechanical faults causing plant stoppage

Learning Outcomes:

The student should be able to:

- List and establish mechanical faults from plant operating conditions.
- List and investigate possible mechanical faults to establish a problem.
- List appropriate corrective action after diagnosing the problem.

7.3.5 Subject Outcome 5: Identify refrigeration oils

Range: synthetic and mineral oils

Learning Outcomes:

The student should be able to:

- List the different types of refrigeration oil and explain their applications
- Identify containers of different oils correctly.
- Explain the importance of using the correct oil.
- Explain the consequences of using incorrect oil.
- List the precautions to be taken when handling and storing refrigeration oil and explain the prevention of contamination.

7.3.6 Subject Outcome 6: Assess and report on the general condition of the oil used in a refrigeration system

Range: from observing the oil in the compressor sump sight glass and testing a sample of the oil.

Learning Outcomes:

The student should be able to:

- Explain why the lack or presence of foam in oil is an indication of the condition of the system and that it is correct and in accordance with industry norms.
- Explain the implications of the observed level in the oil sight glass for the operating conditions and capacity.
- Explain the method of obtaining an oil sample that is in line with the requirements of the testing laboratory and good refrigeration practice.
- Explain how the colour and smell of the oil observed is a means of establishing whether it is satisfactory or not and is in accordance with oil and compressor manufacturers' standards.

- List and explain the methods used to avoid external contamination of an oil sample.

7.3.7 Subject Outcome 7: Explain and carry out dismantling and assembly activities

Range: Refrigeration compressors, electric motors, pumps, fans and components used in air conditioning, refrigeration and ventilation plants.

Learning Outcomes:

The student should be able to:

- List reasons for dismantling and assembly.
- Explain the work sequence and techniques of dismantling and assembly and list the importance of the various sequences and techniques.
- List the functions of the various equipment components.
- Explain the common defects for which equipment parts should be examined.
- Plan work activities to maintain productive work output and ensure compliance with given work instructions.
- Explain possible long term damage to equipment, components and parts, as well as cost implications resulting from poor work techniques.
- Explain why safe handling of tools, equipment and instrumentation must be in accordance with their intended use and/or manufacturer's specification during dismantling and assembly.
- Explain the safety procedures to prevent harm to oneself and others and to prevent damage to equipment.
- List the procedures to ensure that dismantling and assembly is carried out according to manufacturer's specifications.
- List testing and commissioning procedures on completion of work.

7.4 Topic 4: Explain and apply legal requirements for Group 1 refrigerants, layouts, drawings, sketches and technical specifications

7.4.1 Subject Outcome 1: Describe the objectives of SANS 10147 and the requirements for personal protection equipment

Range: Refrigeration systems, containing Group 1 refrigerant, including plants associated with air-conditioning systems other than those listed under clause 1 (Scope) of SANS 10147 (SABS 0147).

Learning Outcomes

The student should be able to:

- State the objective of SANS 10147.
- List the refrigerant equipment not subject to SANS 10147.
- List and define the refrigerant groups dealt with in SANS 10147.
- State the definitions of 'pressure relief device', 'pressure relief valve', 'fusible plug', 'bursting disc', 'pressure limiting device', 'changeover device', 'packaged unit', and 'competent person'.
- List the requirements to provide respirators and self-contained breathing apparatus when the amount of refrigerant contained in a plant exceeds 1 000 kg.
- State the requirements regarding inspection, maintenance and storage of respirators and breathing apparatus.

7.4.2 Subject Outcome 2: List and describe the regulations regarding machinery areas, plant rooms and cold rooms

Range: Refrigeration systems, containing Group 1 refrigerant, including plants associated with air-conditioning systems, other than those listed under clause 1 (Scope) of SANS 10147 (SABS 0147).
Adhere to the standards of SANS 10147 (SABS 0147) when handling Group 1 refrigerants to prevent situations that could result in loss of life, injury to persons or damage to refrigeration plants operating with a Group 1 refrigerant as required according to by the OHS act and the Mines Health & Safety Act.

Learning Outcomes:

The student should be able to:

- Explain the requirements for ventilating plant rooms.
- Explain the special requirements with which plant rooms must comply.
- Explain the requirements regarding refrigerant detectors.
- List the safety provisions incorporated in the construction of refrigerated chambers.
- List the requirements for installations where the power input to the compressor(s) exceeds 20 kW.List the arrangements and operating procedures regarding emergency exits and personnel working inside cold rooms.

7.4.3 Subject Outcome 3: List and describe the operation, maintenance and provision of servicing of refrigerating systems

Range: Refrigeration systems, containing group 1 refrigerant, including plants associated with air-conditioning systems, other than those listed under clause 1 (Scope) of SANS 10147 (SABS 0147).
Adhere to the standards of SANS 10147 (SABS 0147) when handling group 1 refrigerants to prevent situations that could result in loss of life, injury to persons or damage to refrigeration plants operating with a Group 1 refrigerant as required according to by the OHS act and the Mines Health & Safety Act.

Learning Outcomes:

The student should be able to:

- List and describe the regulations regarding the personnel responsible for operating, servicing and maintaining a refrigeration plant.
- List and describe the regulations regarding instructions to be placed inside the plant room and instruction manuals required.
- List and describe the regulations regarding work to be carried out inside refrigerated chambers.
- List and describe the regulations regarding the use of refrigerant containers for charging and discharging refrigerants.
- List and describe the regulations regarding the storage of refrigerant in a plant room.
- List and describe the regulations regarding the replacement of metal signs after a refrigerant has been substituted.

7.4.4 Subject Outcome 4: List and describe the regulations regarding field tests on refrigerating systems and the duties of responsible persons as detailed in SANS 10147

Range: to advise the owner of the plant of any cases where the installation does not comply with the requirements of the standard and to recommend that the necessary changes be made in order to ensure compliance by generating a report, detailing all the applicable non conformance items and indicating recommendations of necessary changes to be made in order to ensure compliance.

Learning Outcomes:

The student should be able to:

- List and describe the regulations regarding the pressure testing of refrigerating systems.
- State the duty of any person operating, maintaining or repairing refrigeration equipment.

7.4.5 Subject Outcome 5: Explain the purpose of technical drawings and specifications

Range: Circuit and block diagrams, air-conditioning, refrigeration and ventilation, architectural and structural layout drawings

Learning Outcomes:

The student should be able to:

- Explain the purpose of engineering drawings and specifications as a means of communicating technical information in a given example.
- Illustrate knowledge of the technical services provided by the drawing office.
- Explain the need for component, sub-assembly and layout drawings.
- Explain from a drawing the materials, tools and equipment required and the sequence of operation to manufacture, install, dismantle, overhaul and assemble equipment.
- Explain the need for main items of supplementary information supplied with technical drawings to illustrate required material, finishes and tolerances.

7.4.6 Subject Outcome 6: Explain the methods of communicating technical information

Range: drawings and specifications and the importance of SABS and ISO standards in providing precise and unambiguous information.

Learning Outcomes:

The student should be able to:

- Explain orthographic, isometric and oblique methods of representing technical drawings for engineering components and equipment.
- Explain the need for construction drawings with regard to architectural drawings, structural engineering drawings, building services drawings, electrical and mechanical equipment layout.Explain the importance of understanding drawings drawn to different scales or units.

7.5 Topic 5: Explain and demonstrate water treatment systems

7.5.1 Subject Outcome 1: Explain the reasons for water treatment

Range: The commonly applied chemicals for treatment of chilled water, condenser water and hot water systems as used in air-conditioning and refrigeration plants.
Hot water, condenser water and chilled water circuits.

Learning Outcomes:

The student should be able to:

- Explain the factors that reduce heat exchange.
- List the effects of heating water on the heat exchanger.
- Explain the effect of non-treatment of water.
- Explain the need for taking precautions against samples becoming contaminated by external contaminants.
- Explain how to ensure that no water other than the amount required for the sample is lost from the circuit.

7.5.2 Subject Outcome 2: Explain and demonstrate water treatment application

Range: Relevant safety precautions, dosing procedures, and personal protective equipment (PPE) for handling biocides and other chemicals used in treating water

Learning Outcomes:

The student should be able to:

- Explain safe handling procedures for biocides and each of the other specified chemicals to ensure conformance to manufacturer's requirements for each product.
- Explain the need for accurate dosing.
- Explain how chemicals are correctly identified.
- Explain and demonstrate how the prescribed amount of chemical is transferred from its container into a dosing cylinder without spillage.
- Test that the chemical is successfully put into the correct water circuit.

8 RESOURCE NEEDS FOR THE TEACHING OF REFRIGERATION PRACTICE - LEVEL 3

8.1 Human resources

The educator for Refrigeration Practice Level 3 must be:

- a subject matter expert, a competent lecturer
- a life-long student
- refrigeration trade tested or be in possession of a NQF L4 Refrigeration qualification
- in possession of a safe handling licence
- conversant with OBE methodologies
- an instructor qualified in the field of study
- skilled in facilitating learning programme development
- trade tested would be an added advantage

It is important that educators working in this environment should attend seminars and upgrading workshops in order to be updated and re-skilled with respect to the latest developments in technology.

8.2 Physical resources

- Store room for consumable stocks
- Tool room
- Lecture room(s)
- Training area-work area
- Ablution facilities
- Fully Equipped workshop

8.3 Learning materials and other resources

Funds obtained from the learning provider or from funding bodies for the procurement of consumable resources, tools and equipment must be readily available for the effective operation of a workplace involved in a training program. Students must be individually equipped with the necessary tools. Learning materials must conform to approved training and industrial standard requirements and must articulate to Higher Education. Learning materials must cater for both academic and practical aspects of learning. Available material must address the following:

- Texts that fully address the task
- Workshop manuals using projection equipment
- Visual and audio-visual material
- Promotion of research
- Educational tours to relevant learning venues
- Educational and motivational talks from industry
- Models and demonstrations
- Sea level, 700m, 1400m and 1700m psychometric charts.

8.4 Equipment

For every 20 students:

DESCRIPTION	TYPE	QUANTITY
Centre punch	3x3x100	20
Crimpling pliers		20
Hacksaw frame	300mm	20
Flat-nose pliers		20
Gas-pliers		20
Digital multimeter		20
Junior saw frame	150mm	20

DESCRIPTION	TYPE	QUANTITY
Shifting spanner	200mm	20
Measuring tape metal case	3m	20
Outside micrometer	(0-25)	5
Soldering iron		20
Insulated Combination pliers	(180mm)	20
Insulated electricians long-nose pliers		20
Round nose pliers		20
Insulated electricians diagonal cutter		20
Tube spanners set	±5mm-12mm	20
Utility knife		20
Water pump pliers	250mm	20
Flat point screwdriver	3,5x75mm	20
Flat point screwdriver	4x150mm	20
Flat point screwdriver	6x150mm	20
Flat point screwdriver	10x250mm	20
Phillips screwdriver	#1 5x80mm	20
Phillips screwdriver	#2 8x150mm	20
Phillips screwdriver	#3 8x150mm	20
Wire stripper	160mm	20
Wire gauge		5
Toolbox 3-tier		20
V Belt tension tester	Fenner	2
Centrifugal water pump		3
Circlip pliers Inside		5
Circlip pliers outside		5
Flat nose pliers		20
Files: Rectangular	Barsted	10
	Medium	10
	Smooth	10
Extractor screw kit	Rigid set no.10 (No 35583)	4
Feeler gauge	Omni 25 blade	5
Hammer: Dead blow	Dia 54mm face	5
Ball peen	500gram	10
Hacksaw Frame	300m	20
Magnetic Base Clock gauge		2
Anemometer		2
Multimeter		20
Clamp-on Tong tester		10
Capacitor tester		5

DESCRIPTION	TYPE	QUANTITY
Insulation tester (Mega)		5
Allen key set	Metric (1,5-20mm)	4
Allen key set	Imperial ($^{1}/_{16}$ inch – ½ inch)	4
Torx set	Multi-splined (T_{10} – T_{50})	4
Line taps:	$4mm^2$	20
Brush: File	Wire	10
Cleaning	Wire	5
Painting	15mm	20
Painting	25mm	20
Measuring tape metal case	3m	20
Bearing Puller set		1
Ladder: Aluminium 1,5m		1
Ladder: Aluminium 2,5m		1
Oxy-Acetylene gas welding / brazing equipment, full size workshop sets		4
Personal protective equipment (PPE)		20
Nitrogen cylinders 11kg with regulator 4000kPa delivery pressure		4
Drill bits	1 box (1mm – 13mm) steel and masonry	5 boxes
Drill Electric (hand)		4
Refrigeration Gauge manifold sets (R22/R134A)		20
Velometer		5
Anometer		5
Infrared thermometer		5
R410A torque wrench		5
Refrigeration Gauge manifold sets (R410A)		20
Electronic refrigerant leak detectors		5
Tap a line tools		10
Pinch off pliers		10
Piercing pliers		10
Pipe cutters 6mm – 22mm copper tubing		20
Imp cutters		5
Flaring and swaging kit		10
2 stage 5-7 cfm vacuum pumps		5
Vacuum gauges (Micron)		5
Mechanical refrigeration pipe benders ¼''		5
Mechanical refrigeration pipe benders 3/8''		5
Mechanical refrigeration pipe benders 1/2''		5
Mechanical refrigeration pipe benders 3/4''		5

DESCRIPTION	TYPE	QUANTITY
Spring refrigeration pipe benders ¼''		5
Spring refrigeration pipe benders 3/8''		5
Spring refrigeration pipe benders 1/2''		5
Spring refrigeration pipe benders 3/4''		5
Thermometers 2 probe digital -40 to + 20 Celsius		10
Refrigerant charging scales		10
Lock ring pliers		1
Service vale spanners		20
Refrigerant recovery units		5
Fin combs		10
High pressure cleaner		2
Pipe reamers (Refrigerant)		20
Equipment		
Refrigeration Controls: Thermostats		5
Humidistat		5
Pressure stats		5
Selector switches		5
Smoke detectors		5
Overheating stats		5
Electric oil pressure switches		5
Defrost timers		5
Circuit breakers (5A→40A)		15 of each
Contactors	220v	50
High pressure switch		5
Dual pressure switch		5
Low pressure switch		5
Electrical control panel accessories:		
Voltmeters		5
Ammeters		5
Pilot lights		40
Isolator		20
Double pole switches (single throw)		15
Double pole switches (double throw)		15
Overload protection devices (3A→13A)		15 of each
Relays		50
Rotary switch		20
Single phase earth leakage		5
Single phase electric motor accessories: Capacitors	Applicable to 375w	5
Current relays	Applicable to 375w	5

DESCRIPTION	TYPE	QUANTITY
Potential relays	Applicable to 375w	5
Solid-state relays		5
Overload relays		5
Single phase motors: Shaded pole motor	375w	2
Permanent split motor	375w	2
Split phase motor	375w	2
Capacitor start motor	375w	2
Capacitor start-capacitor run motor	375w	2
Multi speed fan motors	375w	2
Single phase humidifiers		5
Single pole switches (single throw)		15
Single pole switches (double throw)		15
Timers	220v	5
Amour flex		2m per size
Pipe brackets		2
Trucking / plastic		2m 20x 50mm 2m 50x 100mm
Domestic fridge freezer		4
Operational single phase refrigeration units with semi hermetic compressors in 1.5 x 1.5 cold room installation, pressure switch and thermostatic control -10 to 5 Degrees C installation temperatures.	220V	10

8.5 Consumable resources

Per every 20 students

DESCRIPTION	TYPE	QUANTITY
Cables / conductors:		
	1,0mm^2 (solid)	20 rolls
	1,0mm^2 (stranded)	20 rolls
	1,5mm^2 (solid)	20 rolls
	1,5mm^2 (stranded)	20 rolls
	2,5mm^2 solid	20 rolls
	2,5mm^2 stranded	20 rolls
	4mm^2 solid	10 rolls
	4mm^2 stranded	10 rolls
	6mm^2 solid	8 rolls
	6mm^2 stranded	8 rolls
	10mm^2 solid	5 rolls
	10mm^2 stranded	5 rolls
	16mm^2 solid	5 rolls

DESCRIPTION	TYPE	QUANTITY
	16mm^2 stranded	5 rolls
	PVC steel wire armoured	12m
	Cable 16mm^2 (4 wire)	12m
	PVC steel wire armoured	12m
	Cable 16mm^2 (3 wire)	12m
Earth tags	for 16mm^2	20
Ferrules	4mm^2	100
Fuses	Glass (0,1→30A)	10 of each
Gland kit:	for SWA cables (16mm^2)	20
	for unarmoured cables (16mm^2)	20
Lugs:	Round lugs: M_3	100
	M_4	100
	M_5	100
	M_6	100
	M_8	100
	M_{10}	100
	Spade lugs: M_3	100
	M_4	100
	M_5	100
	M_6	100
	M_8	100
	M_{10}	100
	Push on lugs: (4,8x0,8)	100
	Push on lugs: (6,3x0,8)	100
Mutton cloth	400 grams	30
Plug tops		20
Terminal screw connectors	4mm^2	20
Terminals		100
Flare nuts:	¼ inch nuts	40
	$^3/_8$ inch nuts	40
	½ inch nuts	40
	$^5/_8$ inch nuts	40
Flared Tee Fitting, male flare x male flare	¼ inch	20
Flared Union Coupling, male flare x male flare	¼ inch	20
Manometer		5
Copper tubing: ¼ inch		5 Rolls
3/8 inch		5 Rolls
½ inch		5 Rolls
5/8 inch		5 Rolls

DESCRIPTION	TYPE	QUANTITY
Hacksaw blades:	300mm (blade capacity)	100
	Junior hacksaw blades	100
Loctite	50 grams	3
Mutton cloth	400grams	30
Oil: Mineral oil		20ℓ (litres)
Ester oil		20ℓ (litres)
Sand paper (emery board)	Grade P100 (50mmx50m)	2
Soap (hand)		
Schrader valves	¼ inch	20
Silver solder rod	3003u Flux	50 rods
Refillable refrigerant service cylinders (11Kg)		5
R134A		28Kg
R22		28Kg
R141B		28Kg
R410A		28Kg
Copper tech brazing rods		200g
Silver solder flux		2 x 100ml
69 kg Cylinder trolley		2
PVC pipe 19 and 25mm		2m
PVC Glue		2 X 100ml
Water purifying chemicals		1ℓ