NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

REFRIGERATION PRINCIPLES

NQF Level 2

April 2008

REFRIGERATION PRINCIPLES - LEVEL 2

CONTENTS

INTRODUCTION

A. What is Refrigeration Principles?

Refrigeration Principles is the study and application of the basic principles of a refrigeration plant and its associated electrical equipment, the tools required to work on the plant, the installation techniques and the knowledge required to work with refrigerants.

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

Refrigeration Principles teaches the student the basic principles of operation of cooling equipment, and the electrical equipment that is required to make it function. The student learns how to use trade tools and carry out tasks with these tools. The student also learns how to identify and handle the various types of refrigerants.

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

Refrigeration Principles as a subject will

- Develop the students' basic problem solving skills by requiring them to understand basic engineering concepts
- Develop hand skills and related workplace safety practices
- Instill in the student the discipline of working in a team
- Create a sense of respect for engineering equipment and the need for personal safety practices

D. Factors that contribute to achieving Refrigeration Principles Learning Outcomes

- A learning environment that will stimulate interest in the subject
- Qualified and competent lecturers, practical trainers and assessors who will encourage the students to develop their knowledge and skills
- A learning environment where personal safety and the safety of others is emphasized.

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

Understand the basic refrigeration system, know how to install refrigeration piping, handle refrigerants and use trade related tools

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 Principles Level 2 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 Principles Level 2 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 Principles Level 2.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Explain the operation of a basic vapour compression system	15%
2	Describe and explain the fundamentals of electricity used in Heating, Ventilation, Air Conditioning and Refrigeration (HVA&R) systems	10%
3	Identify, use and maintain refrigeration trade related tools and instruments	12%
4	Identify, use and store refrigerants	8%
5	Join and install refrigerant piping	20%
6	Identify and explain fixing methods, bracketing systems, keys and locking devices applicable to the trade	10%
7	Handle refrigerants, refrigerant containers, service cylinders, dial-a-charge and compressor oil	25%
	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 Principles Level 2, the student should have covered the following topics:

Topic 1: Explain the operation of a basic vapour compression system

Topic 2: Describe and explain the fundamentals of electricity used in Heating, Ventilation, Air-Conditioning and refrigeration (HVAC&R) systems

Topic 3: Identify, use and maintain refrigeration trade related tools and instruments

Topic 4: Identify, use and store refrigerants

Topic 5: Join and install refrigerant piping

Topic 6: Identify and explain fixing methods, bracketing systems, keys and locking devices applicable to the trade

Topic 7: Handle refrigerants, refrigerant containers, service cylinders, dial-a-charge and compressor oil

7.1 Topic 1: Explain the operation of a basic vapour compression system

7.1.1 Subject Outcome 1: Explain, with the aid of a block diagram, the operation of a vapour compression refrigeration system

Range: The single stage saturated refrigeration cycle

Learning Outcomes:
The student should be able to:
- Draw a block diagram of a vapour compression refrigeration system.
- Explain the operation of a vapour compression system.

7.1.2 Subject Outcome 2: Name components and pipes in a block diagram and indicate direction of flow of the refrigerant

Range: The single stage saturated refrigeration cycle;
Components: The compressor, the expansion valve, evaporator and condenser

Learning Outcomes:

The student should be able to:
- Name each component as indicated in the block diagram.
- Name each pipe run as indicated in the block diagram.
- Indicate the direction of flow of the refrigerant correctly.

7.1.3 Subject Outcome 3: Identify and explain the functions of components and accessories of a refrigeration system

Range: Accessories: Interconnecting piping, receivers, suction accumulators, vibration eliminators, crankcase heaters, sight glass/moisture indicators, service valves, shut-off valves, safety valves, Schraeder valves, filter-driers, mufflers, suction-liquid line heat exchangers, oil separators

Learning Outcomes:

The student should be able to:
- Indicate and identify the various components and accessories of a refrigeration system and explain each one's position in a refrigeration plant.
- Explain the purpose of each component and accessory in the refrigeration system.

7.1.4 Subject Outcome 4: Explain the relationship between pressure and temperature of a refrigerant

Range: Commonly used refrigerants R134A, R22, R404 and R410A

Learning Outcomes:

The student should be able to:

- Correctly state the relationship between the pressure and temperature of refrigerants.
- Explain why the gas increases in temperature when being compressed.
- Explain why evaporation and condensation of the refrigerant occur at a constant saturated temperature.

7.1.5 Subject Outcome 5: Explain the interaction between components in a refrigeration system

Range: Condenser, evaporator, compressor and expansion device

Learning Outcomes:

The student should be able to:

- Explain the purpose of the condenser, evaporator, compressor and expansion device and accessories in the system.
- Explain the processes taking place in each component.
- State the phase and temperature of the refrigerant at the inlet and outlet of each component.

7.2 Topic 2: Describe and explain the fundamentals of electricity used in Heating Ventilation Air-Conditioning and Refrigeration (HVAC&R) systems

7.2.1 Subject Outcome 1: Describe and explain the fundamentals of electricity

Range: Volts, Current, Resistance, Energy and Power, terms frequency, single-phase and three-phase, series circuits, parallel circuits and series-parallel circuits

Learning Outcomes:

The student should be able to:

- Define electricity.
- List and define the SI units for potential difference, current, resistance, energy and power with the quantity symbol, unit and unit symbol.
- Explain and define the terms frequency, single-phase and three-phase.
- Explain the terms AC and DC and list typical applications.
- Define the difference between power and energy.
- List the voltages supplied to large buildings, small buildings and private houses.
- List the instrumentation required to test for voltage, current and resistance.
- Define and demonstrate understanding of series circuits, parallel circuits and series-parallel circuits.

7.2.2 Subject Outcome 2: Explain characteristics and uses of conductors

Range: Copper and aluminium conductors up to 16 mm².

Learning Outcomes:

The student should be able to:

- Explain the commonly used types of conductors and list their properties.
- Explain the characteristics and uses of conductors.

7.2.3 Subject Outcome 3: Define and apply Ohm's law

Range: Series / parallel circuits

Learning Outcomes:

The student should be able to:

- Define Ohm's law.
- Calculate the total resistance in a series circuit.
- Calculate the resistances in a parallel circuit.
- Calculate the resistances in a series / parallel circuit.

- Calculate the current through each resistance, the voltage over each resistance and the power consumed by each resistance for a series circuit, a parallel circuit and a series / parallel circuit.

7.2.4 Subject Outcome 4: List potential hazards and methods to prevent injury when using electricity

Range: All potential hazards, electric shock, fires, earth leakage

Learning Outcomes:

The student should be able to:

- Explain potential hazards when using electricity.
- Explain and list the necessity and reasons for proper earthing of electrical equipment.
- Explain methods to prevent electric shock.

7.3 Topic 3: Identify, use and maintain refrigeration trade related tools and instruments

7.3.1 Subject Outcome 1: Identify, use and maintain the tools/instruments used in the refrigeration trade

Range: Instruments: Voltmeters, ammeters, ohmmeters, multi-testers, gauge manifolds Tools: Gas welding sets, arc welders and welding and brazing consumables, tube cutters, pipe benders, bending springs, flaring tools, swaging tools, crimping tools, lock ring pliers, piercing pliers, line tap valves, flare nut wrenches, service valve ratchet wrenches and pinch-off tools

Learning Outcomes:

The student should be able to:

- Identify each item correctly according to its manufacturer's name or by its generic/trade name.
- Use each tool/instrument only to perform the function for which it was designed and in a manner consistent with its manufacturer's intent so that no injury or damage occurs.
- Maintain each tool/instrument in accordance with the manufacturer's instructions.
- Inspect each tool/instrument for damaged or worn-out components before and after use.
- Report and replace faulty or damaged components.

7.4 Topic 4: Identify, use and store refrigerants

7.4.1 Subject Outcome 1: Name and identify refrigerant types in containers and systems

Range: R22, R134A, R404A, R410A

Learning Outcomes

The student should be able to:

- Name the refrigerants commonly used in South Africa.
- State the physical properties of the commonly used refrigerants.
- Correctly identify the group and type of refrigerant in various containers.
- Correctly identify the group and type of refrigerant in an unmarked system.
- Name and explain the methods used to identify refrigerants in containers and systems.
- Explain the consequences of mixing refrigerants or using the wrong refrigerant.
- Safely handle containers to ensure that no damage occurs and no refrigerant is released.

7.4.2 Subject Outcome 2: Demonstrate and explain storing of refrigerant containers without endangering self, others, the plant or the environment

Range: Refrigerant containers: Refrigerant storage cylinders, refrigerant service cylinders, disposable refrigerant containers. Reasons for rejecting refrigerant containers: non-approved containers, containers damaged, dented or showing burn marks, containers with leaking valves

Learning Outcomes:

The student should be able to:

- Explain the effects of refrigerants on humans if inhaled or spilt on the body.
- Name and explain the effects of releasing refrigerant into the atmosphere.
- Name and explain the restrictions imposed by the Montreal Protocol on the use of refrigerants in South Africa.
- Name and explain the safety procedures needed when handling, transporting and storing refrigerant containers.
- Name the personal protective equipment to be used when handling refrigerants and name their use.
- Name and explain the safety precaution to be established before starting work on a refrigeration plant in accordance with work site procedures.
- Identify and explain different work situations where at least two competent persons are required.
- Name and explain the procedures to be followed in the event of an accident or fire when working with refrigerants.
- Name and explain the additional hazards that can be encountered when working with flammable and high-pressure refrigerants.
- Explain the hazards when handling R410A.

7.4.3 Subject Outcome 3: Identify and describe the use of refrigerants in cooling systems

Learning Outcomes:

The student should be able to:

- Explain the relationship between the temperature and pressure of a refrigerant.
- Determine the saturation temperature or pressure for various refrigerants from tables or gauges.
- Name and discuss typical applications of various refrigerants.
- State the type(s) of oil used with each of the commonly used refrigerants.
- State and explain the consequences of using the wrong type of oil.
- Describe the labeling requirements in respect of the type of refrigerant and oil charged into an existing system.

7.5 Topic 5: Join and install refrigerant piping

7.5.1 Subject Outcome 1: List and describe the use of various materials for installation of piping and fittings.

Range: Steel, brass, copper, stainless steel, aluminum.

Learning Outcomes:

The student should be able to:

- Identify various materials used in air-conditioning and refrigeration installation piping and fittings.
- List the typical applications of various materials.
- Describe the reasons for the use of the various materials.

7.5.2 Subject Outcome 2: Identify and explain the application of various piping types and sizes

Range: Soft copper piping between 3mm (⅛") and 20mm (¾") diameter. Hard drawn copper piping between 6mm (¼") and 53mm (2⅛") diameter. Steel or aluminum piping up to 15mm (½") diameter, as used for domestic, commercial and industrial refrigeration and air-conditioning equipment (excluding systems using ammonia as a refrigerant)

Learning Outcomes:

The student should be able to:

- Identify various types and sizes of piping.
- State and discuss typical applications of and reasons for the use of the various types of piping.
- Identify various piping sizes.
- Describe piping handling and storage procedure.
- Explain the importance of keeping piping clean and dry.
- Explain the consequences of failing to keep piping sealed.
- List and explain the implications of mismatching piping and fittings.

7.5.3 Subject Outcome 3: Identify and explain the purpose of various pipe fittings and pipe jointing methods

Range: Jointing methods: Copper to copper joints including swaged joints; copper to brass, copper to aluminum and copper to steel. Flared connections. Flanged connections. Compression fittings. Threaded connections. Test pressures. Pipe fittings: Flare fittings, sweat fittings, flanged fittings, and compression fittings, slip-on glued, screwed, and welded. Elbows, tees, reducers, unions, adapters, couplings, check valves. Imperial and SI

Learning Outcomes:

The student should be able to:

- List and identify various piping fittings, sizes and threads.
- State the typical applications of and reasons for the use of various fittings.
- Identify various sizes of fittings.
- Identify various jointing methods.
- Name and explain the typical applications of and reasons for the use of one method over the other.
- Identify types of filler material and flux used in jointing of piping.
- Explain cleaning methods and use of solvents.

7.5.4 Subject Outcome 4: Identify and explain the purpose of insulation materials used in refrigeration and air-conditioning installations

Range: Insulation materials: Polystyrene, polyurethane, cork, flexible closed-cell rubber material, slabs, shells and foam types

Learning Outcomes:

The student should be able to:

- Identify different types of insulating material used for pipes and flat surfaces.
- Describe the purpose of insulating material.
- Describe types and aim of vapour barrier and cladding.
- Explain the implications of insufficient insulation and improper application of vapour barriers.

7.5.5 Subject Outcome 5: Identify and describe the purpose and applications of pipe support and securing fittings

Range: Pipe support and securing fittings: Horizontal brackets, vertical hangers, floor-mounted supports, saddle clamps

Learning Outcomes:

The student should be able to:

- Describe the methods of supporting and securing piping.
- Identify the various types of support and securing fittings.
- Identify the various sizes of support and securing fittings.

7.5.6 Subject Outcome 6: Plan and prepare to install refrigerant piping

Range: Flare fittings, sweat fittings, flanged fittings, and compression fittings, slip-on glued, screwed, and welded. Elbows, tees, reducers, unions, adapters, check valves. Imperial and SI. Pipe jointing methods: Soft solder, brazing, phosphorous-copper brazing, brass brazing, filler material, flux, joining dissimilar materials, swaged connections, flared connections, compression fitting connections, screwed, welded, flanged, glued.

Learning Outcomes:

The student should be able to:

- Obtain the works order for an installation.
- Determine the location of the jobsite.
- Prepare a list of the piping, fittings and accessories.
- Correctly select all piping, fittings, and accessories.
- List and explain the consequences of not preparing oneself for the installation.
- Explain the procedure to obtain permission to commence work.
- Check the work site for safety.
- Check the installation of plant components and verify against drawings and work instructions.
- Prepare a work plan.
- List and explain the consequences of bad planning.
- Correctly set out all pipe runs.
- Correctly measure off and cut all piping according to the drawing supplied and in accordance with work site requirements.
- Prevent metal shavings, dirt and moisture from entering the pipes.

7.5.7 Subject Outcome 7: Form brazed and non-brazed joints

Range: Soft solder, silver solder, brazing, phosphorous-copper brazing, brass brazing, filler material, flux, joining dissimilar materials, swaged connections, flared connections, compression fitting connections

Learning Outcomes:

The student should be able to:

- Correctly make copper to copper brazed joints.
- Correctly make copper to brass brazed joints.
- Make joints involving steel.
- Ensure that internal surfaces are free of scale upon completion of the brazing process.
- Ensure that filler material has penetrated the entire joint.
- List and explain the consequences of not using nitrogen when brazing.
- List and explain the consequences of using the wrong filler material.
- List and explain the advantages and disadvantages of the various brazed jointing methods.
- Correctly form flared joints.
- Correctly form flanged joints.
- Correctly form compression joints.
- Correctly form threaded joints.
- List and explain the advantages and disadvantages of the various non-brazed jointing methods.

7.5.8 Subject Outcome 8: Install piping and accessories

Range: Copper to copper joints including swaged joints, copper to brass, copper to aluminium and copper to steel. Flared connections. Flanged connections. Compression fittings. Threaded connections

Learning Outcomes:

The student should be able to:

- Install all pipes and accessories according to the supplied drawing.
- Support and anchor all pipes to prevent sagging and/or vibration.
- Protect all pipes against abrasion where they pass through openings, or touch one another or other pieces of equipment.
- Correctly and sufficiently slope all pipes carrying vapour to ensure proper oil return.
- Downsize vertical risers carrying vapour if indicated on the drawing

- Insert oil traps in strict accordance with the drawing.
- List and explain the consequences of oil trapping in the system.

7.5.9 Subject Outcome 9: Test installation for leaks

Range: Soap and water, electronic, dyes, ultra violet, ultra sound.
Various systems: Domestic to commercial applications, filler material, flux, joining dissimilar materials, swaged connections, flared connections, compression fitting connections

Learning Outcomes:

The student should be able to:

- Check for the safety and suitability of leak testing tools and equipment.
- Pressurize the installation to the correct pressure.
- Correctly carry out pressurising procedures.
- Test the installation for leaks.
- Find all leaks.
- Explain the consequences of leaks in the system.

7.5.10 Subject Outcome 10: Clear the work site

Range: Commercial worksite

Learning Outcomes:

The student should be able to:

- Remove all excess materials.
- Remove all tools.
- Explain the installation hand over information and procedure to the commissioning team.

Topic 6: Identify and explain fixing methods, bracketing systems, keys and locking devices applicable to the trade

7.6.1 Subject Outcome 1: Identify and explain the purpose of various fixing methods, bracketing systems, keys and locking devices applicable to the trade

Range: Fixing methods (fastening devices): Bolts, studs, and nuts: Extra fine, fine, average and coarse thread screws. Washers: Plain, spring, and lock washers. Socket screws: Socket head, flat head, headless and socket pipe plug types. Set screws: head and headless types with flat point, cone point, oval point, cup point, dog point and half dog point. Self-tapping screws: with round head, acorn head, hexagon head, pan head, flat head. Wood screws: with round, flat or oval head. Pop rivets: different sizes and materials. Keys and locking devices: Split pins: different sizes and types. Locking wire: different sizes and fixing methods. Keys: round and flat types. Bracketing systems: Bracketing systems for piping, ducting and equipment (including insulated piping and ducting)

Learning Outcomes:

The student should be able to:

- Identify fixing methods correctly.
- Correctly identify the purpose of each fixing method.
- State and explain the consequences of using the wrong fixing methods or devices.
- Correctly identify keys and mechanical securing devices.
- Correctly explain the purpose of each type of key and mechanical locking device.
- Explain and describe the consequences of not using the correct or using the incorrect keys or mechanical locking devices.

7.6.2 Subject Outcome 2: Identify and state the purpose, advantages and disadvantages of various bracketing systems

Range: Bracketing systems for piping, ducting and equipment (including insulated piping and ducting).

Learning Outcomes:

The student should be able to:

- Correctly identify bracketing systems.
- Correctly explain the purpose of each type of bracketing system.
- Explain the consequences of using the incorrect bracketing system.
- List and describe the advantages and disadvantages of the various systems.

7.6.3 Subject Outcome 3: Apply fixing methods

Range: Fixing methods (fastening devices): Bolts, studs, and nuts: Extra fine, fine, average and coarse thread screws. Washers: Plain, spring, and lock washers. Socket screws: Socket head, flat head, headless and socket pipe plug types. Set screws: head and headless types with flat point, cone point, oval point, cup point, dog point and half dog point. Self-tapping screws: with round head, acorn head, hexagon head, pan head, flat head. Wood screws: with round, flat or oval head. Pop rivets: different sizes and material

Learning Outcomes:

The student should be able to:

- Correctly select and apply fixing methods.
- Correct use of appropriate tools.
- Safely carry out work without damage to self, tools or equipment.

7.6.4 Subject Outcome 4: Apply keys and locking devices

Range: Split pins: different sizes and types. Locking wire: different sizes and fixing methods. Keys: round and flat types

Learning Outcomes:

The student should be able to:

- Correctly select and apply keys and locking devices.
- Use the correct tools.
- Work is carried out without damage to self, tools or equipment.
- Explain the selection of keys or locking devices.

7.6.5 Subject Outcome 5: Apply bracketing systems

Range: Bracketing systems: Bracketing systems for piping, ducting and equipment (including insulated piping and ducting).

Learning Outcomes:

The student should be able to:

- Correctly select and apply bracketing systems.
- Select the correct bracket for the application.
- Justify the selection of the type of bracket.
- Carry out work without danger to person and/or damage to tools or equipment.

Topic 7: Handle refrigerants, refrigerant containers, service cylinders, dial-a-charge and compressor oil

7.7.1 Subject Outcome 14: List and explain the hazards when handling refrigerants and containers

Range: Groups of refrigerants: CFCs, HCFCs, HFCs, HCs and natural refrigerants. Typical applications of refrigerants: comfort and industrial air-conditioning, cold rooms, freezer rooms, domestic refrigerators and freezers, automotive air conditioning and transport refrigeration units. Physical properties: smell, colour, toxicity and flammability.

Learning Outcomes:

The student should be able to:

- List and explain the fundamental properties of refrigerants.
- List and discuss the hazards when handling refrigerants.
- Name the personal protective equipment to be used when handling refrigerants and demonstrate their use.
- List the personal protection equipment to be worn and demonstrate their use.
- Explain the effect of refrigerants on humans if inhaled or spilt on the body.
- Demonstrate the action required in case of exposure to refrigerant liquid and/or vapour.
- Name and explain the procedures to be followed in the event of an accident or fire when working with refrigerants.
- Name and explain the effects of releasing refrigerant into the atmosphere.

7.7.2 Subject Outcome 2: Identify and inspect refrigerant containers

Range: CFCs, HCFCs, HFCs, HCs and natural refrigerants. Refrigerant storage cylinders, refrigerant service cylinders, disposable refrigerant containers. Reasons for rejecting refrigerant containers: non-approved containers, containers damaged, dented or showing burn marks, containers with leaking v

Learning Outcomes:

The student should be able to:

- List by refrigerant number the different commonly used refrigerants.
- Correctly identify and inspect refrigerant containers for the commonly used refrigerants.
- List and discuss the reasons for rejecting refrigerant containers.
- Reject unacceptable refrigerant containers.
- Check acceptable containers for markings, damage and/or leaking valves.
- List and discuss the consequences of using damaged or leaking containers.
- List and discuss the consequences of using unacceptable containers.
- List and explain the consequences of air or moisture in refrigerant containers.

7.7.3 Subject Outcome 3: Prepare containers for refrigerant transfer

Range: Refrigerant service cylinders

Learning Outcomes:

The student should be able to:

- Determine the maximum gross mass of a refrigerant container.
- Determine the maximum quantity of refrigerant that can be charged into a container.
- Evacuate a refrigerant container.
- Introduce a small amount of refrigerant into a container.
- Perform a leak test on a container.
- Check the markings on a cylinder for correctness.

7.7.4 Subject Outcome 4: Transfer refrigerant into an empty, evacuated container

Range: Refrigerant service cylinders

Learning Outcomes:

The student should be able to:

- Select the correct refrigerant to be transferred.
- Use the correct hoses and tools.
- Purge hoses and connect with a minimum loss of refrigerant.
- Transfer refrigerant using the evacuated container method.
- Transfer refrigerant by releasing vapour from the service cylinder.
- Fill the container with the required or maximum quantity of refrigerant.

7.7.5 Subject Outcome 5: Transfer refrigerant from a container to a service cylinder or a dial-a-charge

Range: Refrigerant service cylinders, dial-a-charge

Learning Outcomes:

The student should be able to:

- Select the correct equipment and instrumentation.
- Select the subject equipment and instrumentation for R410A.
- Check all equipment for suitability and safety.
- Name the methods to transfer refrigerant from a container to a service cylinder or charging cylinder and demonstrate the methods.
- Determine the maximum mass of refrigerant a cylinder can hold.
- Correctly determine the mass of refrigerant in a cylinder or charging cylinder.
- Release the minimum refrigerant into the atmosphere.
- Transfer the correct amount of refrigerant.
- Name and explain the possible hazards associated with transferring refrigerant.
- Adhere to safe working procedures according to workshop procedures.

7.7.6 Subject Outcome 6: Recover refrigerant from a charged system and transfer it into a service cylinder

Range: R134A or R22 and R410A direct systems

Learning Outcomes:

The student should be able to:

- Name and explain the methods of recovering refrigerant from a system.
- Check and select for suitability and safety, the correct equipment and instrumentation required for recovering the refrigerant.
- Select subject equipment and instrumentation for R410A. and check for safety,
- Name and explain the reasons for the positions where the recovery hoses are connected to the system.
- State and explain evacuation levels required for refrigerant recovery.
- Demonstrate the correct procedure to recover refrigerant from a system.
- Release the minimum amount of refrigerant into the atmosphere.
- Recover at least 80% of the refrigerant in the system.
- Name and explain methods to minimize the amount of refrigerant dissolving in compressor oil.
- Name and explain the consequences of recovering insufficient refrigerant from the system.

7.7.7 Subject Outcome 7: Test a system for leaks

Range: R134A or R22 and R410A direct systems

Learning Outcomes:

The student should be able to:

- Name and explain different leak test methods.
- Explain R410A rising leak test.
- Name the purposes of leak testing and explain the consequences of leaks in a system.
- Select the equipment and instrumentation required for leak testing and check for suitability and safety.
- Name and explain precautions to be taken when using nitrogen for pressurisation.
- Demonstrate the correct leak testing procedure.
- Name methods to minimise the loss of refrigerant from a system through leaks.

7.7.8 Subject Outcome 8: Evacuate a system

Range: R134A or R22 and R410A direct systems

Learning Outcomes:

The student should be able to:

- Name and explain the reasons for evacuating a system before charging.
- State the reasons for and explain the level to which the system is to be evacuated.
- Name and explain the deep vacuum method and the triple evacuation method to remove moisture and non-condensables from a system.
- Select the correct equipment and instrumentation required for evacuation.
- Check all equipment and instrumentation for suitability and safety.
- Demonstrate the correct procedure to evacuate a system.
- Demonstrate the Schroeder valve removal during evacuation.
- Demonstrate and explain the method to evaluate the system vacuum.
- Remove the vacuum pump and instrumentation from the system without the loss of vacuum and isolate the system correctly.

7.7.9 Subject Outcome 9: Charge an evacuated system with refrigerant

Range: R134A or R22 and R410A direct systems

Learning Outcomes:

The student should be able to:

- Name and explain the checks to be made before a system is charged.
- Name and explain the potential hazards when charging a system with liquid refrigerant.
- Name and explain the consequences of charging with the wrong refrigerant.
- State and describe the method of charging azeotropic blends.
- Name and explain the methods to charge refrigeration systems.
- Demonstrate the correct procedures to charge a system using a capillary tube-type metering device.
- Demonstrate the correct method to charge a system fitted with a thermostatic expansion valve.
- Indicate the type and mass of refrigerant and the oil the system is charged with.
- Name and explain the consequences of over- or undercharging a system.
- Name and explain the action to be taken if leaks are found after charging.
- Start the unit according to operating instructions.
- State correctly, with the unit charged and operating correctly, the state of the refrigerant (i.e. temperature, pressure and (sub-cooled) liquid or (superheated) vapour), at locations indicated.

7.7.10 Subject Outcome 10: Handle, check and store recovered compressor oil and refrigerant

Range: R134A or R22 and R410A direct systems, mineral and synthetic oils

Learning Outcomes:

The student should be able to:

- Demonstrate adding or removing oil from a system.
- Name and explain the methods to store recovered refrigerant and oil.
- State and explain the methods to determine whether recovered refrigerant is fit for re-use.
- State and explain the methods to determine whether recovered oil is fit for re-use.
- Name and explain the safety requirements when handling, transporting and storing recovered refrigerant or oil.

8 RESOURCE NEEDS FOR THE TEACHING OF REFRIGERATION PRINCIPLES - LEVEL 2.

8.1 Human resources

The educator for Refrigeration Principles Level 2 must be:

- refrigeration trade tested or in possession of a NQF L4 Refrigeration qualification
- in possession of a safe handling license.
- a competent lecturer
- a life-long learner
- conversant with OBE methodologies
- an instructor qualified in the field of study
- skilled in facilitating learning programme development

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

8.2 Physical resources

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

8.3 Learning materials and consumables

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, 700, 1400 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
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

DESCRIPTION	TYPE	QUANTITY
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
Manometer		
Clamp-on Tong tester		10
Capacitor tester		5
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
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

DESCRIPTION	TYPE	QUANTITY
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
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

DESCRIPTION	TYPE	QUANTITY
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
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 Consumables

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
	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

DESCRIPTION	TYPE	QUANTITY
	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
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
Réfrigérant Refillable service cylinders (11Kg)		5
Réfrigérant R134A		28Kg
Réfrigérant R22		28Kg
Réfrigérant R141B		28Kg
Réfrigérant 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