2.17 Refrigeration and air conditioning principles and applications

2.17.1.1 Refrigeration fundamentals

Evidence shall show an understanding of refrigeration fundamentals to an extent indicated by the following aspects:

a) Principles of heat transfer
b) Temperature scales and measurement
c) Pressure scales and measurement
d) Relationship between pressure and temperature
e) The operation of the vapour compression refrigeration cycle.
f) Refrigeration system components
g) High and low side pressure
h) Saturation, superheat, subcooling and enthalpy
i) Basic pressure, temperature, state and heat cycles
j) Applications of refrigeration

2.17.1.2 Basic refrigeration system operating conditions

Evidence shall show an understanding of basic refrigeration system operating conditions to an extent indicated by the following aspects:

a) Evaporator temperature difference
b) Condenser temperature difference
c) Ambient conditions
d) Low side temperatures and pressures
e) High side temperatures and pressures

2.17.2.1 Refrigerants

Evidence shall show an understanding of refrigerants to an extent indicated by the following aspects:

a) Properties for refrigerants in current use and their alternatives
b) Causes and effects of contamination in refrigeration systems
c) Procedures for working with refrigerants encompassing:
- Reclaiming/recovering refrigerants
- Pressure testing refrigeration systems
- Dealing with contamination in refrigeration systems
- Evacuating refrigeration systems
- Detecting refrigerant leaks
- Charging refrigerant

d) Properties and applications of refrigeration oils in current use

2.17.2.2 Split air conditioning refrigerants

Evidence shall show an understanding of refrigerants commonly used in split air conditioning systems to an extent indicated by the following aspects:

a) Properties for refrigerants in current use

b) Causes of contamination in the system

c) Procedures for working with refrigerants encompassing:

- Reclaiming/recovering refrigerants
- Pressure testing systems
- Evacuating systems
- Detecting refrigerant leaks
- Charging refrigerant

d) Properties of refrigeration oils in current use

2.17.2.3 Appliance refrigerants

Evidence shall show an understanding of refrigerants commonly used in refrigeration and freezer appliances to an extent indicated by the following aspects:

a) Properties for refrigerants in current use

b) Causes of contamination in the systems

c) Procedures for working with refrigerants encompassing:

- Reclaiming/recovering refrigerants
- Pressure testing systems
- Dealing with contamination in refrigeration systems
- Evacuating systems
- Detecting refrigerant leaks
- Charging refrigerant

d) Properties of refrigeration oils in current use

2.17.2.4 High pressure refrigerants

Evidence shall show an understanding of installing high pressure refrigerant to an extent indicated by the following aspects:

- a) The phase out CFC/HCFC refrigerants in favour of environmentally friendly refrigerants and the responsibilities of installers and manufacturers
- b) The chemistry of R22 and its replacement high pressure refrigerants (R407C and R410A), their properties and applications
- c) The function, types, properties, applications, requirements, handling and disposal of refrigerant oils used in the high pressure systems
- d) The essential service tools required to work with high pressure refrigerants
- e) The differences in the materials required for high pressure refrigerant systems
- f) Installation, commissioning and service procedures required for high pressure refrigerant systems
- g) Safety procedures required to work with high pressure refrigerants.

2.17.2.5 Natural refrigerants

Evidence shall show an understanding of natural refrigerants to an extent indicated by the following aspects:

- a) The phase out CFC / HCFC refrigerants in favour of environmentally friendly

refrigerants and the responsibilities of installers and manufacturers

- b) The chemistry natural refrigerants, their properties and applications
- c) The function, types, properties, applications, requirements, handling and disposal of refrigerant oils used in the natural systems
- d) The essential service tools required to work with natural refrigerants
- e) The differences in the materials required for natural refrigerant systems
- f) Installation, commissioning and service procedures required for natural refrigerant systems
- g) Safety procedures required to work with natural refrigerants

2.17.3.1 Refrigeration system capacity control

Evidence shall show an understanding of refrigeration system capacity control to an extent indicated by the following aspects:

a) Methods of system capacity control

Note:
Capacity control includes the role of oil pressure; refrigerant bypass; air flow; water flow; multiple units and compressor speed.

2.17.3.2 Refrigeration systems and compressor operation

Evidence shall show an understanding of the operation of refrigeration systems and compressors to an extent indicated by the following aspects:

a) The vapour-compression cycle

Note:
Vapour-compression cycle includes refrigeration effect; flow rate; specific volume; system capacity; discharge temperature; total heat rejection; heat of compression and refrigerant properties and effects

b) Methods of system capacity control

Note:
Capacity control includes the role of oil pressure; refrigerant bypass; air flow; water flow; multiple units and compressor speed.

c) System efficiency encompassing:

- Compressor parameters

  Note:
  Examples are piston displacement; compressor displacement; compression ratio; compressor efficiency and heat exchange design.

- Compressor drive methods

  Note:
  Examples are belt drives; direct drives; speed vs pulley size and alignment requirements.

2.17.4 Air conditioning fundamentals

Evidence shall show an understanding of air conditioning fundamentals to an extent indicated by the following aspects:

a) Psychrometric terms, basic processes, measurement and charts encompassing:

- Parameter
- Methods

b) Basic air conditioning heat loads sources and effects encompassing:

- Elements of heat load
- Industry check figures
- Basic quick selection heat load tables/graphs

c) Basic air conditioning process, terms, requirements, classifications and applications

d) Basic ventilation terms, requirements, methods and applications

e) Basic air conditioning systems, types, layout and applications

2.17.5 Central plant air conditioning systems

Evidence shall show an understanding of central plant air conditioning systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) Secondary systems and refrigerants

2.17.6 Hydronic systems

Evidence shall show an understanding of hydronic systems applied to refrigeration and/or air conditioning applications to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

2.17.7 Beverage dispensers

Evidence shall show an understanding of beverage dispensers to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components, and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) Pure food act and HACCP

f) Dispensed beverage product knowledge:

> Note:
> Examples are beer, wine, spirits, soft drinks, and the like

2.17.8 Transport refrigeration systems

Evidence shall show an understanding of transport refrigeration systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) External power sources

Note:
Examples are diesel/petrol engines, electrical, dual power supplies

2.17.9 Ultra-low temperature refrigeration systems

Evidence shall show an understanding of ultra-low temperature refrigeration systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) Suitability of refrigerants for each application

2.17.10.1 Post mix refrigeration systems

Evidence shall show an understanding of post mix refrigeration systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) Pure food act and HACCP

f) Dispensed beverage product knowledge:

Note:
Examples are beer, wine, spirits, soft drinks, and the like

2.17.10.2 Dairy refrigeration systems

Evidence shall show an understanding of dairy refrigeration systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.

b) Operating and control principles

c) Maintenance schedules

d) System faults and testing methods

e) Pure food act and HACCP

f) Dispensed beverage product knowledge

2.17.11 Ice making systems

Evidence shall show an understanding of ice making systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and

typical layout arrangements.
b) Operating and control principles
c) Maintenance schedules
d) System faults and testing methods
e) Pure food act and HACCP
f) Dispensed beverage product knowledge

2.17.12 Industrial refrigeration systems

Evidence shall show an understanding of industrial refrigeration systems to an extent indicated by the following aspects:

a) System characteristics, design features, applications, construction, components and typical layout arrangements.
b) Operating and control principles
c) Maintenance schedules
d) System faults and testing methods
e) Secondary refrigerants and systems

2.17.13 Refrigeration system analysis

Evidence shall show an understanding of refrigeration system analysis to an extent indicated by the following aspects:

a) Pressure Enthalpy Definitions
- high pressure & low pressure refrigerants e.g. R124 & R23
- triple point of new refrigerants
- glide of trinary blends
- differential evaporation of refrigerant blends
- variable refrigerant volume

b) Refrigeration cycle
- expansion process
- vaporising process
- compression process
- condensing process
- compression ratio

c) Enthalpy processes
- co-efficient of performance
- effect of suction temperature on cycle efficiency
- effect of condensing temperature on cycle efficiency

d) Actual refrigerating cycles
- effects of superheating suction vapour
- superheating without useful cooling
- superheating that produces useful cooling
- superheating in suction piping outside the refrigerated space
- superheating the vapour inside the refrigerated space
- effects of subcooling the liquid

- liquid - suction heat exchangers
- effects of pressure losses resulting from friction

2.17.14.1 Refrigeration engineering mathematics fundamentals

Evidence shall show an understanding of engineering mathematics fundamentals to an extent indicated by the following aspects:

a) Arithmetic

- Rational and irrational numbers, surds
- SI units, conversion using unity brackets
- Laws of indices (base 10), scientific and engineering notation
- Estimations, errors and approximations, significant figures

b) Algebra

- Substitution
- +, -, x on simple polynomials. Simple indices
- Expanding brackets
- Factorising quadratics. Common factors, difference of two squares
- Simplifying algebraic fractions
- Transposition of engineering formulae
- Solving one variable equations
- Simple algebraic division.

c) Geometry

- Pythagoras Theorem
- Angles: degrees, radians. Parallel lines cut by a transverse
- Triangles: sum of angles, properties of equilateral and isosceles triangles
- Congruent triangles
- Similar triangles: ratio of corresponding sides
- Sin, cos, tan: ratios of a right angled triangle
- Sine and cosine rules
- Circles: circumference, arcs, chords, tangents, circle theorems
- Area and perimeter mensuration on above figures.

d) Coordinate geometry

- 2D plane; *x-y* axes, *s-t* axes
- Graph of linear function, $y = ax + b$. Functional notation, $y = f(x)$
- Straight line given slope and one point or given two points
- Linear equations: solving algebraically and geometrically
- Solving 2 linear functions simultaneously, algebraically and geometrically
- Line segment: length and mid point.

2.17.14.2 Refrigeration engineering advanced mathematics

Evidence shall show an understanding of engineering mathematics to an extent indicated by the following aspects:

a) Matrices

- The operations: addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices.
- Identity matrix, inverse matrix
- Elementary algebraic manipulation of matrices
- Solve up to three equations (linear) in three unknowns using inverse matrices and determinants.

b) Quadratic Functions

- Graphs of quadratic functions represented by parabolas and significance of the leading coefficient
- Zeros represented graphically
- Solve quadratic equations by factoring and quadratic formula
- Solve simultaneously linear and quadratic equations algebraically and geometrically.
- Engineering Mathematics- B

c) Exponential and Logarithmic Functions

- Laws of indices
- Graph of $f(x) = kabx$, emphasising $a = 10$, e
- Definition of the logarithm to any base
- Graph of $f(x) = k \log_a bx$, emphasising $a = 10$, e
- Solve exponential and simple log equations using indices, logs, calculator, graphically
- Change of log base, emphasising 10 and e
- Growth and decay

d) Trigonometric Functions

- The ratios: sin, cos, tan, cosec, sec, cot
- Degrees, radians
- Graphs of $k\,f(ax + b)$ where $f(x) = \sin x$, $\cos x$, $\tan x$, and significance of $k,a,b,$ for example $V = Vm \sin(wt$
- $+ f)$
- Trigonometric identities
- Solve trigonometric equations

2.17.15 Refrigeration science

Evidence shall show an understanding of refrigeration science to an extent indicated by the following aspects:

a) Engineering mechanics

- mass/density
- weight
- forces
- specific gravity
- equilibrium
- momentum
- friction loss

- velocity and speed
- energy in all forms
- mechanical advantage
- efficiency
- pressure/stress

b) Molecular theory

- changes of state
- sublimation
- expansion and contraction
- electron flow
- state of aggregation
- internal potential energy
- phase change diagrams

c) Thermodynamics

- temperature scales
- conservation of energy
- specific heat
- sensible, latent and super heat
- properties of steam
- enthalpy
- heat energy/temperature relationship
- heat balance on a body
- heat transfer
- conductivity
- calorimetry
- Peltier effect
- 1st and 2nd law of thermodynamics

d) Gas laws and liquids

- pressure
- Boyles law
- Charles law
- Volumetric relationship
- psychrometrics
- latent heat of vaporisation
- relative humidity
- air conditioning processes
- dynamic pressure loss
- velocity and static pressure
- bourdon tubes
- density and relative density
- Archimedes principle
- Bernoulli's Equation

- manometers
- absorption refrigeration
- centrifugal compression
- external work of a liquid
- pressure volume diagrams
- isothermal and adiabatic processes
- polytropic processes
- Dalton's law of partial pressure

e) Vapour compression

- pressure/enthalpy relationship
- entropy
- characteristics of the evaporation, condensation,
- compression and pressure drop phases
- co-efficient of performance
- theoretical/practical cycles
- characteristics of refrigerants
- theoretical power input
- pressure losses
- heat exchange
- effects of condensing condition changes
- sub-cooling and super-heating

2.17.16 Heat load estimating of commercial refrigeration

Evidence shall show an understanding of heat load estimating of commercial refrigeration to an extent indicated by the following aspects:

a) Heat transfer

- factors affecting heat transfer
- insulation material characteristics
- vapour barriers (seals)
- ambient conditions
- composite walls (heat flows)
- types of common insulation
- thermal conductivity
- film factors

b) Air change load

- room volumes
- room usage (average, medium, heavy)
- heat removed from cooling air to refrigerated conditions
- air curtains
- temperature differences
- door opening sizes
- Tamm's equation

c) Product load

- sensible heat
- latent heat
- heat of respiration
- storage temperatures
- unit running times
- humidity
- air flows
- stacking of products
- freeze, chill, thaw times

d) Total freezer/cool room loads

- wall load
- air change load
- product load
- miscellaneous
- total load, safety factor and unit running times
- floor loads in cool rooms
- door opening loads (ASHRAE & RADS methods)
- door opening loads (for trucks)

e) Process cooling loads

- cooling chemical reactions
- energy balance methods
- sensible & latent cooling of gases
- sensible & latent cooling of water vapour in gas streams

f) Computer programs

g) Cabinet construction and design

- deep freeze case
- meat case
- dairy case
- fruit and vegetable case
- drink cabinets

2.17.17.1 HVAC load estimating fundamentals

Evidence shall show an understanding of HVAC load estimating fundamentals to an extent indicated by the following aspects:

a) Heat flow in buildings

- conduction
- convection
- radiation
- heat paths

b) Thermal storage

c) Different methods of calculations

- ASHRAE
- Carrier
- finite difference

d) U Values.
e) Film coefficients.
f) Solar heat

- direct
- diffuse
- sol air temperature
- sun position calculations

g) Design conditions

- outdoor
- monthly/daily corrections
- comfort/critical
- indoor
- effective temperature

h) Thermal comfort.
i) Space characteristics.
j) Equipment location.
k) Zoning.
l) Internal loads

- lighting
- equipment
- people
- load profiles
- internal partitions

m) Fresh air/AS 1668
n) Calculation of fabric loads

- walls
- roofs
- floors

o) Windows

- glass types and factors
- shade factors
- internal and external shading
- shading from adjacent structures

p) Air quantity calculation

- psychrometrics
- by-pass factor
- coil load
- VAV air quantities

q) Piping and other losses.
r) Refrigeration plant load.

s) Equipment selection

- coils
- air handling
- chillers/boilers

t) Fresh air preconditioners.

u) Fresh/exhaust air heat exchangers.

v) Computer software

- responsible use

2.17.17.2 HVAC load estimating

Evidence shall show an understanding of HVAC load estimating to an extent indicated by the following aspects:

a) System design parameters

- human comfort
- system requirements in accordance with AS1668
- heat transfer calculations for complex structures and building components
- heat and radiation transfer calculations through complex glass structures including various internal and external shading devices
- indoor air quality
- olfs and decipols

b) Complex shading

- solar data, azimuth and altitude angles
- shading from adjacent structures

c) Computer software

- heat load estimating
- building performance analysis

2.17.18.1 Thermodynamics fundamentals

Evidence shall show an understanding of thermodynamics to an extent indicated by the following aspects:

a) Energy and humanity

- Need for energy and relationship between energy usage and standard of living
- Energy conversion - typical processes and efficiencies
- Sources of energy
- Solar energy - direct heating, photosynthesis, solar cells, power tower, hydrogen for solar energy, ocean thermal energy collector, solar ponds, wind and wave energy, hydro-electric power
- Geothermal energy
- Tidal energy
- Nuclear energy - fission and fusion, burner and breeder reactors
- Stored fuel reserves
- Fuel conservation - reduction in wastage, recycling, greater usage efficiency and use of waste heat

- Thermodynamics

b) Basic Concepts

- Nature of matter - atoms, molecules, inter-molecular forces, molecular motion, states of matter
- Mass and conservation of mass principle
- Volume, density, specific volume, relative density
- Force, weight, pressure (atmospheric, gauge and absolute)
- Temperature (Celsius and Kelvin)
- Systems and black box analysis
- Reciprocating piston and cylinder mechanism – pressure ratio and compression ratio

c) Energy

- Definition and principles
- Potential energy
- Kinetic energy
- Work (linear and rotational), constant and variable force, relationship to pressure and volume change
- Power (linear and rotational)
- Sensible heat - specific heat capacity (constant pressure and constant volume)
- Latent heat
- Chemical energy - energy content of a fuel
- Internal energy

d) Energy transfer in closed and open systems

- Definition of a closed system
- Calorimetry as an example of a closed system (with or without phase change)
- Thermodynamics 1
- Non-flow energy equation - typical applications such as stirring with simultaneous heating or cooling
- Definition of an open system
- Mass and volume flow rate and continuity equation
- Steady flow energy equation (negligible change in kinetic or potential energy) leading to the concept of enthalpy - typical applications such as turbines, compressors, boilers and heat exchangers.

e) Gases

- Definition of a perfect or ideal gas in terms of the molecular model
- General gas equation
- Characteristic gas equation (equation of state)
- Constant pressure process
- Constant volume process
- Isothermal process
- Polytropic process
- Adiabatic process

f) Heat engines

- Definition of a heat engine

- Essentials of a heat engine - heat source, heat sink, working substance, mechanical power output, working cycle
- Energy balance for a heat engine (as a black box) and efficiency
- Maximum possible efficiency (Carnot efficiency)
- Types of heat engines according to working substance, heat source, mechanical arrangement and working cycle
- Typical practical cycles - Stirling, Otto, Diesel, dual, two stroke (spark and compression ignition. Joule cycle.
- Thermodynamics 1

g) Heat engine performance

- Measurement of torque and power output - rope brake, shoe brake, hydraulic dynamometer, electric dynamometer
- Heat supply rate, efficiency, specific fuel consumption
- Measurement of indicated power - mechanical indicator, electric/electronic indicator, Morse test
- Friction power, mechanical efficiency, indicated thermal efficiency
- Volumetric efficiency
- Energy balance
- Performance curves - variable load constant speed, variable speed constant throttle setting.

2.17.18.2 Thermodynamics

Evidence shall show an understanding of thermodynamics to an extent indicated by the following aspects:

a) Heat transfer

- Modes of heat transfer
- Conduction through a flat plate, series flat plates, thick and thin wall pipe, composite pipes (eg lagged pipes and drums)
- Convection at a flat surface or tube
- Radiation from a flat surface or tube for black or grey bodies
- Combined conduction and convection through single or multiple flat plates or thin wall tubes
- Combined convection and radiation
- Combined conduction, convection and radiation such as fluid in a tank (convection to wall), through wall and/or insulation (conduction) to outside air (convection and radiation)
- Heat exchangers - parallel, counterflow and cross flow

b) Combustion and fuels

- The combustion process
- Fuels - desirable and undesirable characteristics, solid, liquid and gaseous types, their relative advantages and disadvantages and common methods of combustion
- Air/fuel ration - stoichiometric excess or insufficient air
- Emissions and pollutants and their control
- Combustion equations - element mass balance
- Combustion products - gravimetric basis

c) Steam

- Importance of steam for heat transfer and power production
- Steam/water properties and the inter-relationship between the various properties for unsaturated or saturated water or steam either superheated, saturated or wet
- Saturation temperature and pressure, specific enthalpy, specific volume, dryness fraction
- Temperature-specific enthalpy diagram for steam/water
- Use of steam table to determine steam/water properties (any condition except supercritical)
- Steam generation - water tube and fire tube boilers, boiler efficiency
- Safety devices and controls used with boilers
- Steam plant - steam traps, economiser, air, pre-heater, superheater, air/water separators, water treatment, feedwater pump, exhaust gas treatment
- Heat transfer rates to or from steam/water (any condition except supercritical)
- Steam throttling and formation of flash steam
- Steam heat exchangers and barrel calorimeters
- Steam plant for process heating
- Steam plant for power production

d) Refrigeration/heat pump

- Basic principles and terminology
- Vapour compression cycle
- Performance criteria
- Types of refrigerant - designation, properties advantages and disadvantages
- Refrigerant properties using the p-h diagram
- Ideal vapour compression cycle on the p-h diagram
- Energy balance and heat transfers in compressor, evaporator and condenser
- Actual vapour compression cycle and variations from the ideal - pressure loss in lines and non-ideal compression
- Superheating and subcooling with or without suction/liquid heat exchanger
- Carnot principle applied to refrigerator and heat pump Principles of evaporative refrigeration, absorption refrigeration, air cycle refrigeration and thermo-electric refrigeration

2.17.18.3 Heater exchanger design

Evidence shall show an understanding of heater exchanger design to an extent indicated by the following aspects:

a) Concepts

b) Design parameters and limitations

c) Construction material and components

d) Testing requirements

2.17.19 Fluid mechanics fundamentals

Evidence shall show an understanding of fluid mechanics fundamentals to an extent indicated by the following aspects:

a) Basic properties of fluids

- Description of a fluid and the difference between solids and fluids, liquids and gases, hydraulics and pneumatics
- Chemical properties, reaction with metals, corrosiveness, flammability, toxicity, pollution and environmental
- effects
- Dissolves gases and particles in liquids (slurries)
- Foaming of liquids. Basic properties and units - mass, volume, density, specific volume, relative density, force and weight, pressure (absolute, atmospheric and gauge), temperature (Celsius and Kelvin), viscosity, surface tension
- Vapour pressure of a liquid - saturation vapour pressure
- Temperature and pressure effects on the basic properties
- Ideal/perfect gases and liquids
- Gas laws for ideal gases
- Fluid Mechanics 1

b) Components

- Pipes, channels, tubes and ducts (rigid and flexible)
- Valves - gate, globe, non-return/foot, needle, ball, plug cock, diaphragm, pressure regulating/reducing, safety
- valves
- Filters and strainers for gases and liquids
- Gauges and instruments - pressure and temperature gauges, liquid level gauges, thermometers, thermocouples, manometers, piezometers
- Pipe fittings - elbows/bends, enlargement/contractions, coupler/unions, tees
- Tanks and vessels - storage tanks, pressure vessels, header and surge tanks, weirs/dams/reservoirs
- Nozzles/spray heads
- Flow measurement instruments - venturi and orifice meters, pitot tube, rotameter, anemometer (fan/hot wire)
- Pumps/compressors, motors/turbines
- Actuators - linear (cylinders) and rotary
- Selection of equipment and instruments considering properties and compatibility

c) Fluid statics

- Pressure at a point, direction of pressure on a surface
- Pressure variation with depth in a liquid
- Pascal's Principle
- Manometer/piezometer calculations (vertical and inclined)
- Forces due to fluid pressure on vertical, horizontal and inclined surfaces
- Centre of pressure
- Archimedes Principle - buoyancy, flotation, apparent weight and centre of buoyancy

d) Fluid flow

- Steady and unsteady flow, streamlines and eddies
- Velocity - average or mean and local

- Mass and volume flow rate
- Conservation of mass leading to the Continuity Equation for fluid flow
- Modification of the Continuity Equation for volume flow of liquids or gases with small changes in density
- Bernoulli Equation for ideal fluids, meaning of pressure, velocity and potential head. Total head
- Causes of head loss and modification of the Bernoulli Equation to include a head loss term for real fluids

e) Fluid power

- Definition and units for work, torque and power
- Relationship between force, velocity and power and torque, angular velocity and power
- Work done by a gas expanding at constant pressure
- Relationship between fluid power, mass flow rate and head
- Relationship between fluid power, volume flow rate and pressure
- Efficiency of a pump or turbine
- Modification of the Bernoulli Equation to include a pump or turbine in the fluid circuit as well as a head loss term

f) Forces developed by flowing fluids

- Impulse-momentum equation for fluid flow
- Force developed by a jet striking a stationary plate - perpendicular, inclined or curved
- Force developed by a jet striking a moving plate or blade
- Force developed by a jet striking a series of moving plates or blades - power developed and efficiency

2.17.20 Materials strength fundamentals

Evidence shall show an understanding of strength of materials to an extent indicated by the following aspects:

a) Stress and strain

- normal stress and strain
- modules of elasticity
- deformation
- Poisson's Ratio
- shear stress and strain
- modulus of rigidity
- yield stress, ultimate stress, proportional limit
- factor of safety
- allowable stress

b) Centrally loaded connections

- bolted connections
- shear, tensile and bearing stresses
- centrally loaded welded connections
- fillet and butt

- method of failure
- size and length
- punching of plates

c) Thin walled pressure vessels

- define thin wall
- longitudinal stress
- hoop stress

d) Properties of plane figures

- first moment of area
- second moment of area

e) Simple beams (point and distribute loads)

- shear force diagrams
- bending moment diagrams
- bending stress
- deflection by formula

f) Torsional stress

- torque diagrams
- angle of twist
- torsional shear stress

g) Thermal stress

- coefficient of linear expansion
- thermal stresses in single members

2.17.21.1 Noise and vibration control fundamentals

Evidence shall show an understanding of noise and vibration control fundamentals to an extent indicated by the following aspects:

a) Fundamentals of sound

- frequency
- decibels
- octave bands
- direct sound
- velocity
- sound pressure level
- sound power level
- sound meters

b) Noise and people

- physical measurement of sound
- weighting networks
- NR curves
- noise damage to hearing
- evaluate daily noise exposures
- peak noise levels

- attenuation for hearing protectors
- excess noise levels permissible
- noise abatement acts

c) Identify and analyse problems

- one-dimensional sound waves
- standing waves
- energy in a sound wave
- sources
- effects of air turbulence
- transmitters
- amplifiers
- absorptivity
- reflectivity
- room characteristics
- acoustic design in buildings
- fan and air noise transmission in ducts

d) Methods of control

- natural attenuation
- sound absorbing materials, placement
- duct lining
- lined plenums
- lined duct splitters
- duct attenuators
- white noise
- vibration isolators

e) Acoustic specifications

- attenuator ratings

2.17.21.2 Advanced noise and vibration control

Evidence shall show an understanding of advance noise and vibration control to an extent indicated by the following aspects:

a) Fundamentals of sound

- Frequency
- Decibels
- Octave bands
- Direct sound
- Velocity
- Sound pressure level
- Sound power level
- Sound meters

b) Noise and people

- Physical measurement of sound

- Weighting networks
- NR curves
- Noise damage to hearing
- Evaluate daily noise exposures
- Peak noise levels
- Attenuation for hearing protectors
- Excess noise levels permissible
- Noise Abatement Act
- Advanced Noise and Vibration Control

c) Sound in confined and unconfined spaces

- Inverse square laws
- Direct and reflective sound
- Define reverberation time
- Sabine's formula
- Absorption coefficients of surfaces
- Types of absorbers and their operation
- Insulation performances of partitions

d) Sound insulation

- Plant room breakout
- Controlling plant room noise

e) Duct borne noise

- Sound power spectra for fans
- Noise attenuation in ducts and fittings
- Reducing fan noise transmission
- Regeneration noise
- Sources of regenerated noise
- Use tables to estimate regenerative noises
- Breakout situations
- Fan noise breakout
- List methods of controlling breakout

f) Controlling the cost

- Economical use of attenuation

g) Vibration

- SHM (Simple Harmonic Motion)
- Period
- Frequency
- Amplitude
- Estimate frequencies for fans, pumps and refrigeration plant
- Estimate transmission of vibration
- Vibration control for building structures
- Use transmissibility graphs to select springs, vibration eliminators and pads
- Types of isolation materials and mounting devices
- Select isolation and mounting devices

- Inertia blocks

h) Noise and vibration analysis computer software packages.

2.17.22 Refrigeration and food storage technology

Evidence shall show an understanding of refrigeration and food storage technology to an extent indicated by the following aspects:

a) Food spoilage and possible causes

- physical damage
- animal activity
- chemical breakdown
- enzyme activity
- micro-organisms
- effects of temperature change
- effects of humidity change
- effects of freezing on fresh produce
- effects of slow freezing time
- effect of refreezing

b) Food preservation

- removing or taking out a reactant
- removing or inactivating the catalyst
- reducing temperature
- changing the reaction system
- irradiation

c) Micro-organisms

- conditions for growth
- potentially hazardous foods
- cross contamination

d) Identification of food spoilage

- recognition and suggest possible cause
- physical damage
- animal activity
- chemical breakdown
- enzyme activity
- micro - organisms

e) Types of heat processing techniques

- heat processing using steam and water
- blanching
- pasteurisation
- sterilisation
- evaporation
- heat processing using hot air
- dehydration

- baking and roasting

f) Types of chilling processing techniques

- chilling and controlled atmosphere storage
- freezing
- freeze drying and freeze concentration
- modified atmosphere combined with low temperature cryovac.

2.17.23.1 Industrial refrigeration systems design fundamentals

Evidence shall show an understanding of industrial refrigeration systems design fundamentals to an extent indicated by the following aspects:

a) Standards and codes

- AS1677, detailed understanding
- AS 3666, overview
- ozone protection regulations
- IIAR Ammonia Data Book
- ANSI/IIAR standards
- ANSI/ASHRAE Mechanical Refrigeration & IIAR bulletins and standards (list will be provided by Rama)

b) Operating characteristics

- pH charts
- refrigerating effect, relate back to air and fluid coolers
- heat of compression, relate back to screw, rotary and reciprocating compressors
- heat rejected high side of the system, relate back to air cooled, evaporative, and water cooled condensers
- variable liquid refrigeration systems & liquid oversee systems
- required mass flow rate of refrigerant and volume flow rate at various points in system
- theoretical compressor power
- required condenser capacity

c) Major system components

- refrigerants, including R717 and R22
- secondary refrigerants
- component lubricant refrigerant compatibility
- evaporators
- condensers, cooling towers
- compressors
- expansion valves
- interconnecting piping and
- isolating valves
- pilot operated valves
- defrost system components for air, water, recycled water, hot gas, electric methods
- refrigerant accumulators and liquid pumps

2.17.23.2 Industrial refrigeration system design

Evidence shall show an understanding of industrial refrigeration system design to an extent indicated by the following aspects:

a) Standards

- AS1677
- ANSI/IIAR Standards
- ANSI/ASHRAE Standards
- IIAR Bulletins

b) Moderate and low temperature industrial refrigeration systems

- revise direct, flooded and pumped liquid recirculation systems
- evaporators
- multi-staged compression
- direct staging
- cascade staging
- compound compressors
- desuperheaters, liquid injection
- direct expansion intercoolers
- open and closed intercoolers
- basic designs of accumulators/intercooler vessels
- oil cooling methods
- oil stabilisation, return and oil recovery in flooded systems

c) Multiple evaporators and multiple compressors

- parallel evaporators
- multiple temperature systems
- evaporator pressure regulators
- temperature control methods
- parallel compressors
- pipework layout
- methods of establishing pressure drop in dry and wet suction lines

d) Indirect refrigeration systems

- classification according to AS1677
- applications
- evaporators
- heat exchangers, types, construction, selection
- secondary refrigerants
- brines
- antifreeze solutions

e) Flooded systems

- applications
- equipment
- accumulators
- level controls

- liquid recirculation pumps
- liquid pressure relief valve

f) Cryogenic systems

- applications and equipment
- system components
- refrigerants
- design safety
- economics
- cascade systems

g) Basic control sequences

- maintaining evaporator conditions
- staging and suction pressure control
- maintaining condenser conditions
- control of intermediate pressure, methods of industrial refrigeration compressor capacity control

2.17.24 Commercial air conditioning systems design

Evidence shall show an understanding of commercial air conditioning systems design to an extent indicated by the following aspects:

a) Design parameters for single-storey buildings (eg offices, restaurants, hotels, bars)

- Customer and objective
- Customer concept of environment desired
- Economics
- Client brief

b) Relevant design criteria

- Building purpose, location, orientation and shape
- External environment ambient conditions
- Internal load diversity
- Thermal capacity behaviour
- Thermal load (full and partial)

c) Zoning and building usage

- Space and building
- Occupancies, single purpose, multi-purpose

d) System selection criteria

- Economics
- Environment
- Control requirements
- Existing structures
- New structures
- System components
- Space for equipment and system
- Selection of appropriate system, equipment, ductwork and components

e) Systems and applications

- Design features, engineering and selection procedures for direct expansion air conditioning systems:
- RAC's, split systems, package units
- Free blow and ducted fan coil units
- Cooling, heat pump and electric heating

2.17.25 Statics

Evidence shall show an understanding of statics to an extent indicated by the following aspects:

a) Force and gravity
- the concept of force
- characteristics of force
- basic principles
- rectangular components of force
- graphical addition of forces
- mathematical addition of forces
- universal gravitation
- variation in gravity
- weight as force
- types of supports

b) Equilibrium of concurrent coplanar forces
- concurrent forces
- conditions of equilibrium
- the equilibrant force
- support reactions
- the three force principle
- two and three force bodies

c) Moment and torque
- moment of force
- addition of moments
- equilibrium of moments
- torque
- equivalent force moment systems

d) Equilibrium of non-concurrent coplanar forces
- conditions of equilibrium
- calculation of beam reactions (simply supported, cantilever, point load, udi, self-weight)
- resultant of non-concurrent forces

e) Friction
- coefficient of frictional resistance
- the laws of dry sliding friction
- the angle of friction
- the angle of repose

- friction on inclined planes
- resultant of normal reaction and friction force
- wedges
- stability - overturning versus sliding

f) Couples

- definition
- applications
- moment of a couple
- replacing a force with a force and a couple

g) Forces in frames

- general principles
- method of joints
- combined force polygon (Maxwell diag)
- method of sections
- method of members

2.17.26 Commercial refrigeration system design

Evidence shall show an understanding of commercial refrigeration system design to an extent indicated by the following aspects:

a) Commercial refrigeration system types

- medium and low temperature applications
- operating conditions
- system operating and service requirements
- refrigerant types
- components
- multiple evaporator systems
- multiple temperature systems
- multiple compressor (rack) systems
- two stage compressors
- multiplex systems
- defrost requirements and methods
- electric defrost systems
- hot gas defrost systems
- cool gas defrost systems

b) Manufacturer's data

- rating tables
- selection tables
- catalogues.

c) Operating characteristics

- Effects of temperature glide with blended
- refrigerants,
- Ph Charts,

- Refrigerating Effect,
- Heat of compression,
- Heat Rejected on High Side of the System,
- Required mass flow rate of refrigerant,
- Volume flow rate at various points in system,
- Theoretical compressor power,
- Required condenser capacity.

d) Review automatic controls

- refrigerant regulating valves
- solenoid valves
- expansion valves
- pressure regulating valves
- cycling controls
- pressure-stats
- thermo-stats
- defrost controls
- monitoring and alarm controls
- energy management systems
- refrigeration automation systems
- control strategies
- control modes

2.17.27 Air conditioning system design

Evidence shall show an understanding of air conditioning system design to an extent indicated by the following aspects:

a) Design parameters for multi-storey building

- customer and objective
- customer concept of environment desired
- economic
- client brief

b) Relevant design criteria

- building purpose, location, orientation and shape
- external environment ambient conditions
- internal load diversity
- thermal capacity behaviour
- thermal load (full and partial)

c) Zoning and building usage

- space and building
- occupancies, single purpose, multi-purpose

d) System selection criteria

- economics
- environment

- control requirements
- existing structures
- new structures
- system components
- space for equipment and system
- selection of appropriate system

e) System and applications

- design features, engineering procedures and controls for:
- direct expansion - self contained room/zone, heat pump, multi-zone fan-coils, central station
- all water - room fan-coil
- all-air - constant volume variable temperature, face and bypass, reheat, constant temp variable volume, constant volume induction, dual-duct, dual-conduit
- air water - induction unit, primary air fan- coil

f) HVAC energy conversation techniques

- heat recovery systems
- night cycle
- optimum stop/start
- purge cycles
- chiller/boiler/cooling tower sequencing
- economy cycles (based on temperature or enthalpy)
- supply air reset
- supply water reset
- condenser water temperature reset
- power demand control
- load limiting
- load shedding
- set point relaxation
- ventilation cycles
- plant - fixed OA to economy, boiler to electric reheat, constant volume to VAV etc.
- cost-benefit (payback)

2.17.28 Psychrometrics - advanced

Evidence shall show an understanding of advanced psychrometrics to an extent indicated by the following aspects:

a) Complex psychrometric processes

- revise sensible cooling and heating and evaporative (adiabatic) cooling
- cooling and dehumidification
- cooling and dehumidification with high latent load
- cooling and dehumidification all out door air
- cooling and dehumidification all out door air with dehumidified air requirements less than supply air
- cooling with evaporative humidification

- cooling with near isothermal humidification
- spray process to include cooling and dehumidification, cooling and humidification with heated spray water, heating and humidification.
- partial load processes
- reheat
- bypass of, RA only and mix of RA & OA
- variable air volume
- variable coil effective surface temperature
- split coil, horizontal, vertical and intertwined.

b) System performance

- saturation efficiency of sprayers
- system capacity calculated from air quantity and enthalpy change

c) Required plant capacity and airflow rates

- effects of coil bypass factor and ADP
- calculation of dehumidified air quantity, using both TSH and ERSH methods.

d) Recap on psychrometrics formulae and charts

- properties of air
- gas constants
- derivation of air constants
- combined gas laws
- Dalton's law of partial pressures
- Carrier's equation
- psychrometric property tables
- psychrometric charts
- air mixing equations
- air quantity equations
- indirect evaporative coolers
- analysis of cooling coil selection and performance
- psychrometric analysis of:
- air conditioning in tropics
- all outdoor air
- LCV/HWF systems
- psychrometric analysis using equations and tables

2.17.29 Exhaust systems design

Evidence shall show an understanding of exhaust systems design to an extent indicated by the following aspects:

a) Relevant codes and regulations

- health and safety
- noise
- smoke
- fire

- hazard identification

b) System types

- applications
- application flow charts
- system requirements
- hazard identification
- effluent types and removal
- relationship with smoke spill systems
- supply air dilution applications
- natural ventilation applications
- fan assisted exhaust applications
- replenishment of exhaust air
- system components

c) Duct design

- static, velocity, total pressure
- pressure drop
- fouling
- transitions
- elbows
- fan position and mounting
- noise and noise attenuation
- requirements for access and maintenance
- system integrity

d) Fan and motor selection

- applications
- suitable fan types
- motor rating and suitability
- balancing the fan duct system
- flame proofing

e) Filters and filter selection

- types and applications
- capture velocity

f) Outlet design and location

- prevailing winds
- position relative to air intakes
- weather and bird proofing

g) Cycling/operation control

- applications
- code/regulation requirements
- monitoring of contaminants
- contaminant detection
- sensors
- variable speed fans

- flame proofing of control equipment

2.17.30 Heating systems design

Evidence shall show an understanding of heating systems design to an extent indicated by the following aspects:

a) Heating techniques:

- electric resistance heaters
- hot water boilers
- steam boilers
- refrigeration heat pump
- heat reclaim
- thermal storage systems
- comparative heating costs
- Australian Standards

b) Heating equipment selection

- double bundle condensers
- heat pumps
- boilers
- coils
- expansion tanks
- pumps, characteristics curves
- control valves, types, flow diagrams,
- air purge points
- water treatment
- pipe anchors and expansion joints

c) Hydronic system configuration

- piping configurations
- single pipe closed circuit
- two pipe closed circuit
- direct return
- three pipe closed circuit with reversed return
- three way diverting valves
- risers and headers
- component location
- evaluation of piping configurations
- capital cost
- owning and operating costs
- noise vibration
- maintenance
- future expansion
- commissioning and balancing
- operating characteristics

- cavitation

d) System pipe sizes

- pipe dynamic and friction losses for different materials
- fitting pressure losses for different materials
- thermal heat losses
- bare, insulated and underground pipes

2.17.31 Hydronic system design

Evidence shall show an understanding of hydronic system design to an extent indicated by the following aspects:

a) Principles of fluid flow

- properties of fluids
- flow of ideal fluids
- fluid flow equipment
- Bernoulli Theorem
- fluid flow in pipes

b) Pressure loss and static head - calculation

- flow throughout system
- pressure throughout system
- friction losses
- pressure loss charts for: copper, steel, UPVC
- dynamic losses
- fitting pressure losses
- fitting interaction
- total losses
- calculating system (static and dynamic) head

c) Pump performance and selection

- pump classification and types
- pump performance terminology, discharge, head, power, efficiency, speed, net positive suction head required
- pump performance curves
- pump laws
- system head and 'K' factor
- balance points
- energy considerations
- pump cavitation
- calculation of net positive suction head available
- Series and parallel operation

d) Pipe sizing

- maximum friction rate
- erosion and equipment life
- industry standards

- recommended system water velocities
- economic balance - first cost and operating cost

2.17.32 Sources of technical development and processes for their adoption

Evidence shall show an understanding of sources of technical development and processes for their adoption to an extent indicated by the following aspects:

- a) Sources of information on alternative or new technologies
- Industry organisations
- Industry technical journals
- Government and private research papers/literature
- Manufacturers' bulletins
- b) Comparison of technical data from different manufacturers
- c) Evaluating performance benefits and limitations of new and developed technologies for given applications, encompassing:
- Capital cost benefits
- Operations efficiency
- Risk hazardous and issues related to environmental and health and safety
- Functionality
- d) Processes to facilitate adoption

  Note:
  Research; analyses; reporting; recommending; and the like, utilising a range of techniques, processes and technologies

2.17.33 Refrigeration systems

Evidence shall show an understanding of introduction to refrigeration to an extent indicated by the following aspects:

a) Major components, type and functions:

- evaporators
- compressors
- expansion devices
- ancillary components
- refrigerants

b) System operation and performance:

- thermodynamic properties of refrigerants
- pressure enthalpy charts
- the refrigerant cycle
- the refrigerant cycle represented on pH charts
- introduction to refrigerating effect, heat of compression, heat rejected on high side, co-efficient of performance, liquid sub-cooling suction superheating
- effects on performance of changing operating pressures, liquid sub-cooling, suction superheating

c) Application of refrigeration:

- introduction to industrial refrigeration, specific system component types and

refrigerants applied.

- scope of commercial refrigeration, specific system component types and refrigerants applied

d) Refrigerated enclosures and cabinets:

- merchandising and display cabinets:
- deep freeze meat
- dairy
- fruit and vegetable
- multi-deck display
- single deck
- well type
- island cases
- glass door
- reach door
- reach in merchandisers
- defrosting methods
- cold rooms and freezer rooms
- types and construction
- insulation
- vapour barrier
- frost heave
- interior fittings
- location of equipment
- defrosting methods
- cold tracking
- trace heating
- storage conditions
- temperature
- relative humidity
- air velocity
- air patterns
- load limits

e) Air conditioning chills & DX coil types and construction

2.17.34 Air conditioning systems

Evidence shall show an understanding of air conditioning to an extent indicated by the following aspects:

a) Occupational health requirements:

- WH&S requirements
- BCA requirements
- AS1668 parts 1 & 2
- AS3666

- noise and vibration
- air quality
- sick building syndrome

b) Operating requirements:

- ventilation
- air distribution
- terminal velocity
- temperature
- relative humidity
- air quality
- noise
- basic psychrometrics

c) Operating modes

- ventilation
- evaporative cooling
- ventilation and cooling
- ventilation and heating
- dehumidification
- dehumidification
- dehumidification and reheat
- humidification

d) Operating terminology/characteristics:

- throw, drop
- primary and secondary air
- coanda effect

e) HVAC system components and functions:

- fans
- ducting
- registers
- dampers
- filters
- cooling coils
- heating coils
- induction units
- fan coil units
- terminal units
- humidifiers, pumps and sprayers
- hydronic systems and components

f) Applications and construction of air conditioning systems:

- applications
- residential, commercial, low and high rise, industrial ventilation and air conditioning
- packaged plant

- RACs, split systems (wall and floor console, ceiling fan coil), wall facia, roof top, reverse cycle option central station plant
- all air systems, constant volume variable temperature, constant temperature variable volume, air/water systems
- all water system, multi-zoning, thermal storage systems
- basic air conditioning system diagrams
- duct layout
- hydronic layout
- unit/conditioner drawings

g) HVAC control systems:

- basic principles
- terminology
- symbols and diagrams
- basic applications

2.17.35 Applied psychrometrics

Evidence shall show an understanding of applied psychrometrics to an extent indicated by the following aspects:

a) Fundamentals and terms

- sensible heat factor (conditioned space and grand total)
- quantity of air
- effective surface temperature
- bypass factor

b) Coil characteristics

- processes
- sensible cooling
- cooling, dehumidification
- sensible heating

c) Spray processes

- saturation efficiency
- processes
- adiabatic/evaporative cooling
- cooling & humidification
- sensible cooling
- cooling and/or humidification
- chemical dehumidification process: dehumidification & heating
- cooling tower characteristics: humidification & cooling
- indirect evaporative cooling process

d) System analysis

- partial load
- reheat control
- bypass control
- volume control

- dump back systems
- low velocity coils

e) Psychrometric formulae and charts

- properties of air
- gas constants
- derivation of air constants
- combined gas laws
- Dalton's law of partial pressures
- Carrier's equation
- psychrometric property tables
- air mixing equations
- air quantity equations

2.17.36 Ventilation systems

Evidence shall show an understanding of ventilation to an extent indicated by the following aspects:

a) Requirements necessary to supply/install/maintain a ventilation/air conditioning system. (not design)

b) Fan classifications and applications.

c) Identification and correct usage of various items of test equipment.

d) Procedures to be followed when conducting an air balance.

e) Filtration applications and service requirements of ventilation - air conditioning systems.

f) Noise and vibration sources in a ventilation – air conditioning system.

g) Site work/architectural drawings.

h) Auxiliary equipment.

i) Layout and zoning of duct work system.

j) Occupational health aspects.

2.17.37 Beverage vending cabinets

Evidence shall show an understanding of beverage vending cabinets to an extent indicated by the following aspects:

a) Types, construction and operation of refrigerated drink vending cabinets encompassing:

- Coin operated mechanism on the refrigerated vending cabinet.
- Electro-mechanical mechanism on the coin operated vending cabinet.
- Electronic mechanism on the coin operated vending cabinet.

b) Specialised components and features required for the operation of a coin operated refrigerated vending cabinet encompassing:

- Electrical / electronic control circuitry.
- Air distribution and air flow curtains.
- Lighting arrangements.

c) Installation requirements for a refrigerated coin operated vending cabinet encompassing:

- Location requirements
- Access requirements and avoidance obstruction

- Power supply and electrical service requirements

d) System operating conditions for a coin operated refrigerated vending cabinet.

e) Commissioning, service and maintenance procedures of a refrigerated coin operated vending cabinet encompassing:

- Electrical / electronic control devices checks and adjustments.
- Air flow checks and adjustments.
- Mechanical checks and adjustments
- Typical faults