Eskom	Guideline	Asset Management

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1. INTRODUCTION

Heating Ventilation and Air Conditioning (HVAC) systems in Eskom power plants and buildings services are a combination of different elements. The HVAC different elements general includes chilled and condenser water pumps, chilled water generators, cooling towers, Air Handling Units (AHU), ductwork, pipework, condensers, evaporators, electrical and control system which are integrated to work together and produce heating, ventilation & air conditioning that cannot be achieved by independent elements or components.

HVAC systems are generally categorized based on the fluid media used for heat rejection as detailed below:

a) Air to Air HVAC systems which are mainly Direct Expansion (DX) systems.
b) Air to Water HVAC systems which mainly comprise of air cooled and water-cooled chilled water generators with their applicable subsystems.
c) Water to Water HVAC systems which mainly comprise fan-coil systems, radiant panel and silent cooling chilled beams to mention few.

HVAC systems are complex systems and no different to other mechanical systems as they have finite life span which require proper design and maintenance during service period to ensure the delivery of conditioned air at right quantity, with acceptable temperatures and relative humidity into the respective spaces.

HVAC systems in power plants and building services are designed and installed to maintain environment conditions for reliable operation of electrical and process control equipment; and for the comfort and safety of plant/building services workforces.

The main objective of HVAC in a power plant and building services in general is as follows however not limited to:

a) That all Server Rooms and Data Centres are equipped with air-conditioning systems that will be able to control the ambient conditions between 20°C±2°C. The relative humidity is to be controlled between 45% ± 5% without condensation, as per the requirements of Eskom Server Rooms and Data Centres Standard (32-894).
b) That all Control & Instrumentation (C&I) equipment rooms, server rooms, and other computer rooms are equipped with air-conditioning systems that will be able to control the ambient conditions to between 22°C±2°C. The relative humidity is to be controlled between 50% ± 10%.
c) That all control rooms and offices are equipped with air-conditioning systems that will be able to control the ambient conditions to between 22°C±2°C. The relative humidity is to be controlled in accordance with the requirements of ASHRAE 55 (Thermal Environmental Conditions for Human Occupancy).
d) All battery rooms, medium and low voltage switch gear rooms, substations be equipped with air-conditioning systems that will be able to control the ambient conditions to 25°C; and the humidity does not necessarily have to be controlled but is to be monitored and recorded.
e) All Variable Speed Drives (VSDs) rooms be equipped with air-conditioning systems that will be able to control the ambient conditions to 30°C maximum and the humidity does not necessarily have to be controlled but is to be monitored and recorded.
f) All other ventilated areas are to be controlled at 6°C above ambient conditions; and
g) All rooms are to be maintained under a positive pressure, to minimise dust ingress.

The HVAC design guide is written with new installations in mind but can also be applied to modifications on existing installations. When applying the design guide to existing installations it is important to understand the design approach used for the existing installations and to select equipment similar to the equipment in the existing installation.

The HVAC design is to progress in four design stages which includes concept, basic, detailed, and integrated design as stated in Heating Ventilation and Air Conditioning System Design Work Instruction (240-143112846).

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers HVAC design guidelines that are related to Eskom Buildings Services, Eskom generating fleet as well as in the distribution and transmission systems. Design Standard for HVAC in Pump Storage Schemes (240-56356363) has since been cancelled and incorporated into this document to have a single HVAC design guideline which covers Eskom wide plants and buildings.

This document has been developed to assist parties involved in HVAC design to determine the most suitable systems to be installed in a specific area within any Eskom Assets (Power plants, confined spaces such as tunnels, and office environment).

The design guide also identifies applicable codes and standards that are to be referred to and referenced when designing HVAC Systems for Eskom Assets.

This document assumes that prospective users of the guideline will have HVAC design experience, however, are not familiar with the specific requirements for Eskom Asset requirements. Cooling and heating load calculations and procedures are not addressed in detailed in this document as they are readily available in many of the references quoted throughout this document and listed under section 2.2

2.1.1 Purpose

HVAC systems are generally designed by different entities either internal or external to Eskom. The intention of this document is to provide a consistent approach to the design of Eskom HVAC system and to ensure the correct design documentation is available when needed.

The purpose of this document is to provide design guidelines to produce an optimized design for Heating, Ventilation and Air-Conditioning (HVAC) at Eskom Buildings Services, Eskom generating fleet as well as in the distribution and transmission systems. An optimized design must meet the following criteria:

a) Provide for legislative requirements.
b) Minimize environmental impact.
c) Provide safe internal environment.
d) Minimize design cost.
e) Minimize plant capital cost.
f) Maximize plant efficiency.
g) Provide energy efficient design.
h) Optimize plant reliability.
i) Optimize plant maintainability; and
j) Simplify operation.

2.1.2 Applicability

This document is to apply throughout Eskom Holdings Limited Divisions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 240-143112846: Heating Ventilation and Air Conditioning System Design Work Instruction.

[2] 240-102547991: General Technical Specification for HVAC Systems Standard.

[3] 240-54937450: Fire Protection and Life Safety Design Standard.

[4] 240-56737448: Fire Detection and Life Safety Design Standard.

[5] 240-53113685: Design Review Procedure.

[6] American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) handbook of fundamentals.

2.2.2 Informative

2.2.2.1 Standards Applicable to VSD's and Battery Rooms

[7] SANS 10108: The classification of hazardous locations and the selection of equipment for use in such locations.

[8] 240-56536505: Hazardous Locations Standard

[9] SANS 60079-15: Explosive atmospheres Part 15: Equipment protection by type of protection "n".

[10] 240-56177186: Design Guide for Power Station Battery Rooms

[11] 240-50237146: Medium Voltage AC Variable Frequency Drives Standard

2.2.2.2 Standards Applicable to Electrical Part of the HVAC works

[12] 240-56227516: LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and Including 1000V AC and 1500V Standard.

[13] SANS 10142-1: The wiring of premises Part 1: Low-voltage installations

2.2.2.3 Standards Applicable to DC and UPS Rooms

[14] 240-53114248: Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard.

2.2.2.4 Standards Applicable to C&I Part of the HVAC works

[15] 240-56355731: Environmental Conditions for Process Control Equipment Used at Power Stations Standard.

2.2.2.5 Standards Applicable to Eskom Server Rooms and Data Centres

[16] 32-894: Eskom Server Rooms and Data Centres Standard

[17] "Data Centre Site Infrastructure Tier Standard: Topology" prepared by Uptime Institute Professional Services, LLC.

2.2.2.6 Standards Specific to HVAC industry

Below are most frequently used standards to HVAC industry. The selection of the standards can be extended as per project requirement.

[18] ASHRAE Standard 62.1: Ventilation for acceptable indoor air quality.

[19] ASHRAE 55: Thermal Environmental Conditions for Human Occupancy.

[20] ASHRAE 90.1: Performance Rating Method Reference Manual.

[21] ISO 9001 Quality Management Systems.
[22] OHS Act: Occupational Health and Safety Act 85 of 1993.
[23] SANS 10400: The application of the National Building Regulations.
[24] SANS 10400: The application of the National Building Regulations Part O: Lighting and Ventilation.
[25] SANS 10400: The application of the National Building Regulations Part T: Fire protection
[26] SANS 204: Energy Efficiency in Buildings.
[27] SANS 10400-XA: Energy Usage in Buildings.
[28] SANS 1424: Filters used in General Air-Conditioning.
[29] SANS 1238: Air Conditioning Ductwork.
[30] SANS 10173: Installation, Testing and Balancing of Air-conditioning Ducting.
[31] SANS 10147: Refrigeration Code.
[32] SANS 1287-1: Ventilation brattices and ducting Part 1: Flexible ducting.
[33] SANS 1287-2: Ventilation brattices and ducting Part 2: Brattices, unsupported.
[34] SANS 10400 Part O: Ventilation and Lighting.
[35] ASHRAE G1: Guideline for Commissioning Air Conditioning Systems.
[36] ASHRAE 62: Ventilation for acceptable indoor quality.
[37] ASHRAE 52/76: Standard Test Method for filters.
[38] ISO 11650: Performance of refrigerant recovery and/or recycling equipment.
[39] CIBSE Commissioning Codes A (Air Distribution), C (Automatic Controls), R (Refrigeration Systems), W (Water Distribution Systems) and or ASHRAE Commissioning Guideline.

2.3 DEFINITIONS

Definition	Description
Arrestance	Percentage of test dust captured
Average Synthetic Dust Weight Arrestance	This test reflects the percent value of weight collected by the test filter when synthetic dirt is fed to it. There are two basic faults with this test: First, the artificial test dusts are quite different from atmospheric dusts and, secondly, even low efficiency filters rate quite high by percentage, not offering a good evaluation between low and high efficiency filters.
Dew point	The temperature at which condensation of moisture begins when air is cooled
Dust holding capacity	The weight of test dust a filter can hold at a specified final pressure drop
Enthalpy	A thermal property indicating the quantity of heat in the air above an arbitrary datum, in kilojoules per kilogram of air. The datum for dry air is 0^0C and, for moisture content, 0^0C water.
Exn or Reduced Risk protection	Exn or Reduced Risk protection is a standard of explosion protection applied to electrical equipment used in hazardous areas. Ex rated equipment refers to equipment that has been classified as safe for use in hazardous areas, which are often referred to as “Ex areas.” Non-Ex equipment may emit small sparks or reach high temperatures that can ignite in hazardous areas, causing explosions or fires. Ex equipment is designed to contain any sparks, flames, or explosions that may be produced by equipment—or to prevent their production altogether.

Definition	Description
Facility	Facility refers to a property or plant controlled by Eskom. Typically, a Power Station, office area such as Megawatt Park or training facility such as the Eskom Academy of Learning
Heating, Ventilating, and Air Conditioning (HVAC)	Relates to systems that perform processes designed to regulate the air conditions within buildings for the comfort and safety of occupants and ensure equipment protection. HVAC systems condition and move air to desired areas of an indoor environment to create and maintain desirable temperature, humidity, ventilation and air purity.
HVAC Building Management System (BMS)	The control system by which the heating, ventilation and air-conditioning system is monitored and controlled. The BMS offers a HMI and GUI for control and monitoring of the System by Operators, Maintenance and Engineering personal.
Minimum Efficiency Reporting Value (MERV)	Lowest efficiency of each range of particle tested during five dust sample feed to test ring.
Initial Atmospheric Dust Spot Efficiency	Discoloration test that measures the discoloration of white target paper disc before and after the air filter when atmospheric air is fed to them. Initial efficiency is performed on a clean filter.
Initial and Final Resistance	The resistance to air flow is measured in inches of water gage before the test (Initial Resistance) and at the end of the test (Final Resistance). These are important to determine if your system can handle the resistance of a filter and to compare the energy consumption between filters.
Interface	Interface means either to hard wired or software interaction between the others design or works
Latent Heat	Refers heat which changes the humidity ratio of air in a room or space it flows into or is generated in that space.
Unit	Refers to main generating units or HVAC units unless otherwise stated.
Particle size efficiency (PSE)	Filter efficiency to remove air borne particle of specific size ranges from 0.3 to 10 microns diameter using aerosol potassium chloride.
Plant	Refers to power generating plants, distribution or transmission assets and HVAC plants unless otherwise stated.
Pressure drop (ASHRAE 52.1 and 52.2)	The filter resistance to air flow.
Psychrometry	Refers to the science dealing with the properties of the atmosphere in relation to the behaviour of the mixture of dry air and water vapour. Air is the medium with which buildings are conditioned (cooled and heated) to ensure that occupants and equipment are made comfortable in both summer and winter seasons.
Relative Humidity	Ratio of the actual water vapour pressure of the air to the saturated water vapour pressure of the air at the same temperature
Refrigerant	Refers to chemical in the refrigerant system that is used to transfer heat.
Sensible Heat	Refers heat which changes the temperature in a room or space it flows into or is generated in that space.
Standard temperature and pressure	$0^{o}C$ and 1.01325 bar at sea level
Standard gravity	$9.80665 m/s^2$
Sound attenuators	Sound attenuators are a proven and effective method for reducing the noise generated by fans and other equipment. Also referred to as duct silencers, sound traps or mufflers, they are designed to reduce the noise transmitted

Definition	Description
	from a source to the receiver.
Variable Refrigerant Flow/ Variable Volume Flow	Refers to the capability of an air conditioning system to control the amount of refrigerant flowing to each of the indoor units/evaporators, enabling the use of multiple evaporators of differing capacities and configurations, individualized comfort control, simultaneous heating and cooling in different zones with heat recovery from one zone to another.
Multiplicity	Many units performing the same function (i.e. several fans in the Turbine roof)

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating current
AHU	Air Handling Units
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BoQ	Bill of Quantities
BMS	Building Management System
BS	British Standards
C&I	Control and Instrumentation
CBMS	Consolidated Building Management System
COP	Coefficient Of Performance
CW	Cooling Water (Aux. Cooling Water closed circuit)
DB	Dry Bulb temperature
DC	Direct Current
DX	Direct Expansion
FD	Forced Draft fan
FAT	Factory Acceptance Test
FIDIC	International Federation of Consulting Engineers
GTE	Group Technology Engineering
Ch/h	Change per hour
HAZLOC	Hazardous location
HMI	Human-Machine Interface
HV	High Voltage
HVAC	Heating, Ventilation and Air-conditioning
I / O	Input/output
LPS	Low Pressure Services
LV	Low Voltage

Abbreviation	Description
MCC	Motor Control Centre
MERV	Minimum Efficiency Reporting Value
m/s	meter per second
MV	Medium Voltage
NEC	New Engineering Contract
NCP	Network Control Panel
NFPA	National Fire Protection Agency (American Fire protection standard)
OHSA	Occupational Health and Safety Act
RH	Relative humidity
S/A, R/A, E/A, F/A	Supply Air, Return Air, Extract Air, Fresh Air
SANS	South African National Standards
SAT	Site Acceptance Test
SC	Study Committee
SCOT	Steering Committee of Technology
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
WTP	Water Treatment plant
VAV	Variable Air Volume system
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
VRV/VRF	Variable Refrigerant Volume/Flow
WB	Wet Bulb Temperature

2.5 ROLES AND RESPONSIBILITIES

Engineering Managers, or their Authorised Delegates, are to be responsible for ensuring that this HVAC Design Guideline is implemented by competent personnel only, as per Eskom Governance and Competency requirements.

A competent person is responsible for performing HVAC designs in accordance with the requirements of Heating Ventilation and Air Conditioning System Design Work Instruction (240-143112846); which provide the steps to be taken in the design of Eskom Power Plants and Buildings Services HVAC systems.

2.6 PROCESS FOR MONITORING

The primary process for monitoring will be governed by Design Review Procedure (240-53113685). The HVAC design guideline is a live document. This document will be reviewed and updated every five years or as maybe required to reflect changes as required, with detail increasing at each time so that this document is continually updated for relevant use and applicability to Eskom.

2.7 RELATED/SUPPORTING DOCUMENTS

Refer to Section 2.2.1 and 2.2.2.

3. HVAC DESIGN PARAMETERS AND SELECTION CRITERIA

HVAC systems include heating, ventilating, cooling, humidification, dehumidification, filtration, and air distribution system to maintain acceptable indoor building or plant environment. The HVAC systems are to satisfy sanitary, hygienic, industrial, fire and emergency requirements and are to comply with established standards for design, construction, installation, performance, energy conservation and safety requirements as detailed by 2.2

3.1 GENERAL DESIGN CRITERIA

The HVAC general design criteria are as follows:

a) Air pressurization and filtration to be implemented to maintain good indoor air quality.
b) Smoke extraction systems for smoke control and removal in the event of fire.
c) Adequate fresh air for normal and emergency ventilation.
d) Avoid refrigerants harmful to the ozone layer.
e) Noise levels of HVAC plant to not exceed background noise levels.
f) Operation of HVAC system is for 24 hours per day, seven days per week for all plant, except for offices which general operate 12 hours per day.
g) Life expectancy of water-cooled chilled water plants air-cooled chilled water plant, Direct Expansion (DX) plants and Split type air conditioning is approximately 25 years, 20 years, 15 years and 8 years respectively; subject to site conditions (i.e. dusty and corrosive environment).
h) Fire dampers are to be selected for two hours fire rating. All dampers and fire dampers to be remotely controlled on automatic or manual.
i) Interface with Fire Detection System
j) All HVAC equipment that services essential areas are to be supplied with electrical, C&I and mechanical redundancy.
k) Emergency ventilation fans to be supplied with emergency power supply.
l) Duct work within all equipment rooms, battery rooms, Low Voltage (LV), Medium Voltage (MV), C&I, Offices and control rooms is to be externally insulated. Air supply outlets to be directed to the electrical panel's ventilation intakes (where possible) and be not directly above the equipment.
m) Ducts are to be designed to low pressure standard. The criteria for duct sizing are pressure drop of 1Pa/m for air flow up to 1m^3/s and the criteria of 6 m/s for higher flow.
n) The supply air flow for air conditioning and ventilation are to be calculated from the required heat removal and applicable temperature difference.
o) The minimum air flow, where no heat load is present is to be 2 air changes per hour.

3.2 COOLING AND HEATING LOAD CALCULATIONS

The load estimation or calculations are the basis of any HVAC system sizing and are to be calculated in accordance with the procedures outlined in the latest edition of American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) handbook of fundamentals.

Design heat transmission coefficients that are used for load estimation or calculations are to be acquired from the building or plant structures and are to reflect the actual materials specified. ASHRAE handbook of fundamentals heat transmission is to be used only for preliminary calculations or concept designs when actual data is not available. The total heat gain to any room or space is the sum of sensible and latent heat, which increases the temperature and humidity ratio of air within the space.

HVAC calculations rely on lengthy, iterative techniques that are very tedious when performed manually, therefore the use of cooling and heating load calculation software packages is recommended to improve accuracy and reduce computation time.

The cooling and heating load calculation software packages generally contain a complete set of ASHRAE weather data and calculations designed for specific air system configuration (constant air volume or variable air volume). Eskom asset projects are hardly placed or positioned at one of the locations specified by ASHRAE weather data, however they can be adjusted to match the local conditions. The designer must study and interpret software data to establish the appropriate local design condition.

The following assumptions are to be made during concept design to compute heat load calculation for selecting cooling equipment, in the absence of actual heat loads generated by the equipment. The actual heat loads to be generated by the selected electrical or electronic equipment are to be used at basic and detailed design phase.

a) Equipment room heat load is equivalent to 200 W/m^2
b) Computer room heat load is equivalent to 250 W/m^2
c) VSD/VFD and Server Room load is equivalent to 550 W/m^2
d) Data Centres to be specified at User Requirements Specification (URS) stage
e) MV_LV room heat load is equivalent to 150 W/m^2
f) Control room heat load is equivalent to 100 W/m^2
g) Battery rooms heat load is equivalent to 50 W/m^2
h) Offices and general workshops such mechanical, electrical and C&I 50 W/m^2
i) Lighting load is equivalent to 20 W/m^2
j) Roof that is being insulated at U value of 0.68 W/m^2 ºC

The heating load estimate is the basis for selecting heating and the humidification equipment. The heating load estimate is to take into account the heating being emitted from the space and heat required to heat the fresh air supply to the space from outdoor temperatures to indoor conditions.

The following factors are to be taken into account when calculating cooling and heating loads:

3.2.1 Design Conditions

3.2.1.1 Indoor Design Conditions

Table 1: Indoor conditions

Description	Indoor Temperatures	Relative Humidity	Pressurisation Requirements
1. Server Rooms and Data Centers	20°C±2°C	45% ± 5%	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
2. C&I Equipment Rooms and Computer Rooms	22°C±2°C	20% to 75%	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
3. Control Rooms	22°C±2°C	50% ± 10%	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
4. Offices	22°C±2°C	The relative humidity is to be controlled in accordance with the requirements of ASHRAE 55: Thermal Environmental	Positive pressure (minimum positive pressure of 5Pa with all doors closed)

Description	Indoor Temperatures	Relative Humidity	Pressurisation Requirements
		Conditions for Human Occupancy (latest edition).	
5. Switchgear Rooms	22°C±2°C	75% max, no condensation	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
6. Battery Rooms	25°C (+3 °C or -5 °C)	75% max, no condensation	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
7. Variable Speed Drives (VSDs)/Variable Frequency Drives (VFDs)	25ºC ± 5ºC	75% max, no condensation	Positive pressure (minimum positive pressure of 5Pa with all doors closed)
8. Other ventilated areas & cable chambers	6°C above ambient	Not Controlled	Negative or positive pressure depending on the area to be ventilated.

3.2.1.2 Outdoor Design Conditions

The design condition for HVAC is based on the Weather bureau data, which is to be sourced from project design data or ASHRAE handbook of fundamentals provided insufficient data is not available.

The mean maximum temperature (DB) for summer and mean minimum temperature for winter is taken as a design condition and is to be determined as explained in the ASHRAE handbook of fundamentals. The weather Bureau does not list temperature and associated relative humidity (RH) as one set of data. The designer must interpret data, study hourly temperatures and hourly humidity to establish the outdoor condition.

3.2.2 Building Thermal Envelope

The following building characteristic are to be considered as the bases for a realistic estimate of cooling and heating loads, however not limited to:
a) Orientation of the building or space to be provided with HVAC.
b) Physical dimensions of the building, plant or space.
c) Lighting load.
d) Electrical and electronic equipment.
e) Miscellaneous heat gains (duct heat gain and leakage, and fan heat loss)

The HVAC designer is to influence the new construction and additions such that the building envelope in compliance with the latest additions of SANS 204 (Energy Efficiency in Buildings), SANS 10400-XA: Energy Usage in Buildings and ASHRAE 90.1 (Performance Rating Method Reference Manual).

The building envelope for renovations and existing buildings is to be based on actual field verification of building construction which can be verified using as built drawings and site conditional assessment.

3.2.3 Occupation

The usage of the building, plant or space varies from application to application or activity; and they are generally specified from user process requirements or user requirements specification or stakeholder requirements specification. The density of occupation in offices depends on whether they are general, private or executive offices, whilst the density of electrical or electronic equipment heat load depends on whether it's a server room, equipment room, electrical switchgear room or other equipment related space.

3.2.4 Ventilation Requirements

The ventilation rates are to be based on the following:

a) Approved latest revision of SANS 10400: The application of the National Building Regulations Part O: Lighting and Ventilation.
b) Approved latest revision of ASHRAE Standard 62.1: Ventilation for acceptable indoor air quality; for areas which are not covered by SANS 10400, Part O.
c) Ventilation rational design for all areas which are not covered by SANS 10400: Part O and ASHRAE Standard 62.1

3.2.4.1 Natural Ventilation

3.2.4.1.1 Buoyancy Driven Natural Ventilation

The buoyancy driven natural ventilation is ventilation which do not rely on wind pressure and provide ventilation based on difference in density of air of lower (inlet) and higher (outlet) temperatures as follows:

a) Relies on temperature differences (inside/outside).
b) Design restrictions (height, location of apertures); and
c) The quality of air it introduces in buildings may be polluted

3.2.4.1.2 Natural Ventilation Design

The system is to be design as follows:

a) The system is to be designed taking into account the wind direction.
b) Inlet openings are not to be obstructed.
c) The greatest flow per unit area is achieved if the inlet and outlet openings sizes are equal.
d) There must be a vertical distance between openings.

3.2.4.1.3 Required Flow for Heat Removal

The required flow for heat removal is calculated as follows:

$Q=Q/C_P D (T_1-T_O)$

Q = required air flow (m^3/s)

Q = heat to be removed (kW)

$c_p =$ specific heat of air (approx. 1 kJ/kgK)

d = density of air at intake temp sea level altitude (approximately 1.2 kg/m^3)

to = outside temperature (°C)

t1 = Indoor temperature (°C)

3.2.4.1.4 Air flow Rate Calculation

The natural ventilation flow rate for buoyancy-driven natural ventilation with vents at two different heights can be estimated with this equation:

$$Q_S = C_d\, A \sqrt{g\; H_d\, \frac{T_I - T_O}{T_I}}$$

where:

Q_S = Buoyancy-driven ventilation airflow rate, m³/s

A = cross-sectional area of opening, m² (assumes equal area for inlet and outlet)

C_d = Discharge coefficient for opening (typical value is 0,62)

g = gravitational acceleration, around 9.81 m/s²

H_d = Height from midpoint of lower opening to midpoint of upper opening, m

T_I = Average indoor temperature between the inlet and outlet, K

T_O = Outdoor temperature, K

3.2.4.2 Mechanical Ventilation

Mechanical ventilation is achieved with usage of fans and blowers. Mechanical ventilation is used where natural ventilation is not sufficiently reliable or where there is no space for large lovers and extract routes, or dilution of contaminants is necessary.

The required flow for heat removal is calculated as follows:

$$Q=q/c_p d\ (t_1-t_o)$$

Q = Required air flow (m³/s)

Q = Heat to be removed (kW)

c_p = Specific heat of air (approx. 1 kJ/kg K)

d = Density of air at intake temp sea level altitude (approximately 1.2 kg/m³)

t_o = Outside temperature (°C)

t_1 = Indoor temperature (°C)

3.2.5 General Heat Load Calculation Inputs

The heat load calculation inputs to HVAC design are based on ASHRAE fundamentals, and Carrier design manual as illustrated by the table below.

Table 2: Heat load calculation inputs to design

Description	Calculate Sensible Heat Gain (W)	Remarks
1. Calculate Room Sensible Heat (RSH)	-	-
1.1. Glass solar at 30° South Latitude separately calculated for each building orientation	Reference glass (W/m²) from tables x correction factor x shading factor	Correction factors for altitude, due point and haze. Find shading factor from glass manufacturer

Description	Calculate Sensible Heat Gain (W)	Remarks
1.2. Glass transmission gain	q= A u (t_o-t_1) Note *) 1 and 2	Find u value from a glass manufacturer For clear glass approximately u = 6.13W/m^{2}K for 6mm thickness.
1.3. Walls transmission gain	q=A u (t_2-t_1) Note *) 1and 2	Find u value for varies type of walling, for metal cladding calculate radiation heat gain-See note 3
1.4. Roof transmission gain	q=Au (t_2-t_1) Note ^) 1 and 2	Find sol-air temperature and calculate u value. The sol-air temperature is defined as the outside air temperature which, in the absence of solar radiation, would give the same temperature distribution and rate of heat transfer through a wall (or roof) as exists due to the combined effects of the actual outdoor temperature distribution plus the incident solar.
1.5. Lighting	90% of power is generated as heat by fluorescent light and dissipated to the room (if return air is ducted). If return air is via ceiling plenum only 40% is dissipated to room	For preliminary assessment allow 20W/m^2. Confirm with lighting designers.
1.6. People	The light factory work to be accepted for heat dissipation purposes which is 110W/per sensible heat and 120W/person latent heat	In air-conditioned space only
1.7. Equipment load	See table below.	-
1.8. Infiltration	For exposed 2 walls to outside add ½ air change per hour to heat load	If air for pressurisation is equal or higher than 2 air changes per hour, infiltration can be assumed as equal zero.
1.9. Supply duct and fan heat gain	Fan and motor in air stream- total motor capacity. Heat gain for insulated ducts can be neglected	-
1.10. Supply duct leakage loss	For low pressure ducting it is approximately 5% and 1% for high pressure ducting construction	-
1.11. Safety factor	Allow 10%	-
SUB-TOTAL 1- RSH (kW)	Summary of items 1.1 to1.11	-
2. Effective Room sensible load (ERSH)	-	-
2.1. Return air load	If return air is ducted allow zero for non-ducted return air, calculate 60% lighting load plus other loads on the return air route	-
2.2. Outside air sensible heat gain	q=m c (t_o-t_1) Note *) 1	-
SUB-TOTAL 2- ERSH (kW)	Summary of items 1.1-1.11 + 2.1+2.2	-
3. Supply air	S/A= Q/mxc (m^3/s)	For air handling equipment sizing

Description	Calculate Sensible Heat Gain (W)	Remarks
calculation		
4. Room latent load (RLH)	-	-
4.1. Latent heat (people)	For light work in air-conditioned space 120W/person	
4.2. Latent heat (equipment)	N/A for electrical rooms	Moisture heat load in open processes
SUB-TOTAL 3	Summary of item 4.1-4.2	
5. Outdoor air load	$q=m*(h_o-h_1)$	Or sum of sensible +latent heat of outdoor air
6. Piping and pumping heat losses	Allow 1.5% added to total heat load for equipment sizing	
TOTAL LOAD	SUB-TOTAL 1 – 6 or $q=m(h_2-h_3)$	For cooling equipment sizing

Note 1 Calculate heat flow (symbols)

q = heat flow (W)
k = thermal conductivity (W/m.K)
u = heat transfer coefficient (W/m^2C)
A = area m^2
t_o = design ambient(^oC)
t_1 = design indoor temperature (^oC)
t_2 = design sol –air temperature
m = mass flow of air kg/s
c = specific heat kW/kg^oK = enthalpy of ambient air (kJ/kg)
h_1 = enthalpy at room temperature (kJ/kg)
h_2 = enthalpy at mixing point
h_3 = enthalpy of the supply air temperature

Note 2: Calculating u value

a) Outdoor air surface (at 7m/s air movement)- $r_1=0{,}03m^2$ K/W
b) Inside air surface (still air $r_2=0{,}12m^2$ K/W
c) Resistance of each layer of the building and insulation materials (ref. ASHRAE fundamentals, Carrier design manual or manufacturers data) r_n…

Total resistance $R=r_1+r_2+r_n$

$$u= 1/R\ (W/m^2K).$$

R,r = resistance (m^2K/W)
U = coefficient of heat transfer (W/m^2K)

Note 3 Calculate radiant heat

Calculating radiant heat of hot surfaces

$$q=5,670*10^{-8}\ (T_1^4 - T_2^4)\ A$$

q = total energy emitted (W)
$5.670*10^{-8} W/m^2K^4$ Stefan Boltzmann constant
T_1^4 = temperature of hot black surface (K)
T_2^4 = temperature of the space (K)
A = Area m^2

3.2.6 Typical Heat Dissipation from Equipment

The figures shown below can only be used for preliminary assessment when no information is available. It is often difficult to establish equipment loss as the resistance of each element of the equipment as well as electrical motors insufficiencies are not known.

Table 3: Heat Dissipation from Equipment

Description	Capacity design criteria	Comments
1. Motor in the space driven equipment out of the space	Q=Power input x (1-motor efficiency)	Efficiency of motors <1.5kw-75%; 2-10kW, 85% 10-30 kW,90% above 30kW 95%
2. Motor out of the space driven equipment in the space	Q=Power input x motor efficiency	
3. Motor in the space, driven equipment in the space	Q=Power Input x motor efficiency + equipment friction losses (approx. 10%)	
4. Pump houses	As per item 1	
5. Compressors and dryers in receivers outside	q=power input*(1-motor efficiency)-heat removed by coolers+ heat gain from auxiliaries	
6. Transformers	12.5% of power output	
7. IT equipment	100% power input including standby equipment if energised	High load floor distribution of supply air is required.
8. LV and MV Electrical equipment room, DC rooms and control rooms	150W/m² of floor area {for concept design only , the heat load shall be obtained from the relevant discipline)	In existing power station radiation from the panels can be measured and calculated
9. Battery room	No heat capacity criteria	Min 10 air changes per hour
10. Toilets	No heat capacity criteria	Min 10 air changes per hour
11. Conveyors	See table below	-
12. Cable tunnels	Minimum flow 2 air changes per hour	Max velocity 2.5 m/s

Description	Capacity design criteria	Comments
13. Cable chambers (cable spreading)	Pressurisation 2 air ch/h	
14. Canteens and kitchens	Cooking equipment capacity from manufacturers alternatively capacity of connected power x diversity of use	Heat from food and food preparation to be considered as well as people movement and hours of operation. Fresh air either from areas surrounding kitchen or from hood make up
15. Offices	Calculate load for building envelope, lights, computers, printers, coffee machines etc.	Auditoriums require a separate system from offices

3.3 PLANT AND BUILDING DESIGN

Small to medium office buildings and plants are generally designed to house most of the heat generating equipment in close proximity to one another. The HVAC for small to medium office buildings and plants is easiest to design due to simplicity of the air distribution system and control; and can be serviced by a central system taking into account the most stringent requirements for various equipment to be air conditioned.

The HVAC for multi-storey buildings and large plants can be complex to design due to difficulty of the air distribution system and control; and is to be serviced by individual central systems. Space of similar environmental room requirements may be serviced by common HVAC system. Multi-storey buildings and large plants include variety of office (open and closed offices), equipment rooms, control rooms, transformer rooms, tunnels, boiler and turbine halls and other areas.

Equipment and control rooms generally have different ambient requirements to office environment and are be serviced by separate Air Handling Units (AHUs) or evaporators to enable ease of control of environmental conditions for both comfort and equipment.

Plants are generally divided into unit bays (auxiliary bays) where each bay is equivalent to the portion of the structure required for each unit. Unit bays maybe serviced simultaneously by central or individual cooling water plants together with unit specific chilled water plants and Air Handling Units (AHUs) depending on the plant layout, cooling and heating loads, and their environmental controls desired. Central HVAC system generally maintains the most uniform temperature conditions throughout the plant and can be designed for general smoke ventilation.

When all unit bays (auxiliary bays) are identical in size and layout, the HVAC system for one bay is to be identical to the next bay, to the maximum extent possible to simplify the HVAC system design and minimise the holding number of spares.

Redundant HVAC systems or equipment are to be considered where loss of conditioned air cannot be tolerated; and they may be fully or partial redundancy subject to the criticality of the space of as recommended by the Reliability, Availability and Maintainability (RAM) studies. Fully redundancy generally consists of equal sized HVAC systems, with each providing a total cooling and heating requirements. Partial redundancy could comprise of main equipment will common piping and ducting system without any mains power backup. The controls for redundant systems are to include automatic and manual switching capabilities to equalise wear on all components to energize backup equipment when primary system fails.

Air intakes are to be located opposite major heat generating equipment such as electronic and electrical equipment, transformers; polluting sources such as engine generators and building or plant exhaust air openings.

3.3.1 Auxiliary Bays

In the new built Coal Fired Power Stations the HVAC design is to be unitised. The preferred cooling system is to be a chilled water system rejecting heat via water-cooled chillers or air-cooled chillers. Cooling water is to be either from the station auxiliary cooling system (preferred) or from the dedicated cooling towers.

The air handling and distribution zoning are to coincide with the fire zones, to minimise requirements for fire dampers.

The air distribution to be via shafts in the structure with insulated supply and extract air ducts. Both supply and return air ducts in the shafts are to be externally insulated to avoid condensation. The supply ducts on the floor do also need to be externally insulated. Where exposed to view ducts are to be cladded with galvanised steel over the vapour sealed insulation and be cladded up to at least 2-meter height.

In general, no floor or ceilings plenums are to be used for chilled air distribution as air leak tightness conditions of those plenum is not achievable during the life of the station

3.3.2 Facility Buildings, Auxiliary Bay Offices, Boardrooms, Lecture Rooms, and Workshops

In these areas all activities are to be analysed to supply an appropriate ventilation system to ensure occupational comfort and safety. Workshop Welding bays are to be provided with dedicated extract air system.

The offices, boardrooms, lecture rooms and workshops are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Heating
c) Humidification
d) Pressurisation
e) Filtration
f) 100% standby plant (where required)
g) Facility for 100% outside air and extraction (where free cooling is feasible)
h) Emergency smoke extraction system

Facility buildings include stand-alone offices (Administration Buildings which do not form part of Auxiliary Bays), canteens, medical centres, security building and other areas. The green building council requirements are to be considered together with the maintainability of the systems in these areas. Variable Air Volume (VAV) system or Variable Refrigerant Flow (VRF) system for standalone offices are to be considered for energy conservation reasons. Make up air treatment is required to achieve required filtration and pressurisation.

3.3.3 Storage Areas

Storage areas is an occupancy where material or equipment is stored. Storage areas are to be natural or mechanical ventilated based on their classification in terms of SANS 10400 (National Building Regulations) and if mechanical ventilation is installed 10 air changes per hour criteria is to apply as minimum.

3.3.4 Turbine Hall

The turbine hall is to be ventilated. The ventilation system design is to ensure heat removal from the power plant equipment and non-insulated structure as well as to remove smoke in a fire condition to make escape areas safe and to protect roof structure from collapsing.

For general ventilation, at the concept and basic design, the heat generated from power plant equipment is to be assumed as 0.25% of the power generated

The ventilation is to ensure heat removal from all areas of the turbine hall such that the temperature at operating level does not exceed 40ºC with the mean monthly maximum ambient air temperature as specified in the weather bureau data.

The ventilation fans are to be thermostatically controlled to switch on/off as required.

All areas below ground pits areas like seal oil area, lubrication oil area, condensate pit area, and feed water pit area to be ventilated with separate 100% redundant ventilation systems.

The fire dampers (where applicable) and fans are to be remotely controlled.

The walk areas to access ventilators are to be established and security of maintenance to be ensured.

Ventilation can be achieved by natural draft, forced mechanical supply and/or extract or natural and mechanical combine system. Natural system uses a combination of inlet louvers and open doors and release air through roof. Mechanical system uses fans, powered roof ventilators to move air. With any ventilation arrangement consideration is to be given to physical separation of inlet and outlet openings to avoid recirculation of air. Because of the low-pressure driving air, natural ventilation requires large inlet louvers and exhaust relief areas. Mechanical ventilation requires fewer openings. Natural ventilation creates negative pressure in the lower portion of the building which may draw dust and fumes into the building from near ground opening. Besides equipment such as transformers tanks etc. block part of the external walls and make some areas unavailable for installation of louvers. Mechanical ventilation can draw air from relatively cleaner higher elevations. Noise can be also better managed via mechanical ventilation.

Before the decision if mechanical (extract air) or natural ventilation is used a HAZLOC study is to be performed taking into account a possible leak of Hydrogen from the Turbine cooling system

3.3.5 Boiler House

Boiler house ventilation is provided by Forced Draft (FD) fan supplying air for combustion to boiler. For this purpose, air is drawn from the top of the Boiler House, to be as warm as possible and to save energy. This design is usually outside HVAC designer's scope and is generally designed as part of the boiler design. However, if the FD fan does not draw air from the top of the boiler house, very careful ventilation design will be needed to avoid heat stress of maintenance personnel as well as overheating of cables in the Boiler House. In this case either natural or mechanical ventilation is to be designed.

3.3.6 Control Rooms

The environmental requirements are described in environmental conditions for process control equipment used at Power Stations standard (240-56355731). The control rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Heating
c) Humidification (where required)
d) Dehumidification (where required)
e) Pressurisation
f) Filtration
g) 100% standby plant
h) Facility for 100% outside air and extraction (where free cooling is feasible)
i) Emergency smoke extract

The control room air conditioning is to be designed separately from other areas of the Power Station. The design main objective in this case is for human comfort, therefore air distribution is important to avoid drafts. Heating is also provided in this area.

3.3.7 Data Centres and Server Rooms

The requirements for server rooms are described in Eskom Server Rooms and Data Centres Standard (32-894). Due to very concentrated equipment heat load in relatively small rooms, and as results they need special attention. A bottom air distribution is recommended to use natural air buoyancy. Attention is to be given to separate equipment area from the accessible area to make heat removal feasible. The floor plenum has to be very well sealed and pressurised. The data centres and server rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Humidification (where required)
c) Dehumidification (where required)
d) Pressurisation
e) Filtration
f) 100% standby plant
g) Facility for 100% outside air and extraction (where free cooling is feasible)
h) Emergency smoke extract

3.3.8 Equipment Rooms, DC Rooms and UPS Rooms

The environmental requirements for these rooms are described in environmental conditions for process control equipment used at Power Stations standard (240-56355731); and Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard (240-53114248).

The Equipment Rooms, DC Rooms and UPS Rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Humidification (where required)
c) Dehumidification (where required)
d) Pressurisation
e) Filtration
f) 100% standby plant
g) Facility for 100% outside air and extraction (where free cooling is feasible)
h) Emergency smoke extract

Air conditioning in these areas is to be designed for heat removal from the equipment and not for human comfort. Heating is not to be provided in these areas. Duct distribution are generally from above as to avoid uncontrolled air drawn during any stage of the plant operation. Air should be directed towards the front of the panel and top entry cables should be avoided.

3.3.9 Outside Substations, LV and MV Rooms

C&I standard for environmental condition is be adopted for this area, where possible as the modern switchgear often include for electronic components which needs to be controlled at 22ºC±2ºC, in order to prolong life of equipment and prevent failures arising from high room temperatures. The maximum temperature in these rooms is not exceed 30ºC and 100% redundancy HVAC system installation is applied.

The LV and MV Rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Pressurisation
c) Filtration
d) 100% standby plant
e) Facility for 100% outside air and extraction (where free cooling is feasible)

f) Emergency smoke extract

If transformers are installed in LV or MV room and air conditioning of total area cannot be installed, the local cooling to the panels will be needed. It is recommended that transformers are separated from the LV and MV rooms and the transformer area is separately ventilated.

3.3.10 VFD/VSD Rooms

The HVAC systems is to be designed for 25ºC (± 5ºC) such that varying ambient temperatures between day/night and summer/winter is not adversely affect the performance of the VFD. The room temperature during the hottest day shall not exceed 30 ºC as detailed by requirements of Medium Voltage AC Variable Frequency Drives Standard (240-50237146).

VFD/VSD Rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Pressurisation
c) Filtration
d) 100% standby plant
e) Facility for 100% outside air and extraction (where free cooling is feasible)
f) Emergency smoke extract

3.3.11 Battery Rooms

The HVAC system for battery rooms is to be designed to meet the requirements of Battery Room Standard (240-56177186), where specified the battery room's temperature is to be maintained at a constant 25°C (+3 °C or -5 °C). The battery rooms are to be provided with HVAC systems as follows, as minimum however not limited to:

a) Cooling
b) Heating
c) Pressurisation
d) Filtration
e) 100% standby plant
f) Facility for 100% outside air
g) Extraction system
h) Emergency smoke extract
i) Interlocking of supply and extract system

3.3.11.1 Lead Acid Battery (Hydrogen Generating) Rooms

The lead acid battery room HVAC design is to comply to the following in addition to the requirements of Battery Room Standard (240-56177186), where hydrogen is generated during boost charging of the batteries:

a) The most critical in the HVAC design of these battery rooms is an extraction system.
b) The extraction system is to have 100% standby.
c) No fire dampers are to be installed in the extract air ducting system, but any ducts passing through fire partitions and occupied areas are to be 2-hour fire rated. The extraction system is to be serviced by 2-hour fire rated fan starter panel, electrical cables, and control cables. The system is to be provided with mains and standby power. The electrical cable is to run through the building in such a way that it is protected in the event of fire.
d) The extract air fans to be eXn. rated (SANS 10108 -Classification of hazardous locations and the selection of apparatus for use in such locations) for motors and fans.
e) The extract air distribution is to ensure that no unventilated air pockets are formed between the beams (if any). No false ceiling is to be installed.
f) No ducts are to run across the battery rooms.

g) The supply air is less critical. It can be via HVAC system. The cooling and heating of outside air to be introduced passively from the surrounding areas (where possible).
h) Recirculation air in this battery room is not permitted and is to be provided with once through 100% filtered fresh air system. Cooling is generally required to prolong life expectancy of the batteries.
i) Heating to be considered for low ambient temperatures as 100% outside air is utilised and is a subject to the batteries manufacturer's requirements, and not for human comfort.

3.3.11.2 Dry Battery Rooms (Nickel/Cadmium Batteries)

The ventilation/air-conditioning of rooms handling dry batteries can be handled in similar manner as C&I rooms and recirculation of air is permitted subject to risk assessment.

3.3.12 Cable Spreading Areas

The accessible cable distribution areas can be ventilated separately or be a part of the same system as the area served by the cables. The area is to be pressurised with air volume of 2 air change per hour. No filtration is required, unless pressurisation is achieved via other system (i.e. air conditioning of the rooms above).

3.3.13 Laboratories

The laboratories room temperature is to be maintained at 22°C±2°C. The relative humidity is to be controlled in accordance with the requirements of ASHRAE 55 (Thermal Environmental Conditions for Human Occupancy).

Fume cupboards extraction system is to be dedicated and make-up air can be supplied from the general areas. Air flow is to be designed such that there is no inflow of air from dirty to clean part of the laboratory.

3.3.14 Steam and Water Analysis room

The area is to be air conditioned. Eskom prefers that the chilled water plant used for process cooling is not used for space cooling even when parameters of chilled water is identical to this required for the samples cooling.

3.3.15 Tunnel Ventilation

The cable tunnels are to be ventilated at 2 air changes per hour. The tunnel ventilation system is to be interfaced to the fire protection system. The extraction fans are to run continuously and facilitate smoke extraction in the event of a fire. The system operation is that when fire is detected in a zone, the relevant fire dampers on the supply side of the tunnel ventilation of that zone are closed. The fire damper to have a 2-hour fire rating and fire sealing to be provided all around the fire damper to ensure that the 2-hour fire rating of the barrier is maintained.

The extraction ventilation fans are to be used as extraction system during normal operation/conditions and is to serve as smoke exhaust fans during fire conditions. The smoke ventilation fans are to be 2-hour fire rated and be equipped with black mild steel ducting for smoke exhaust (where required). The smoke ventilation fan starter panels, electrical and control cables are to be 2-hour fired rated as well.

3.3.16 Compressor Houses and Blower Rooms

The HVAC system for compressor houses is to be designed taking into account the requirements of Compressed Air System Standard (240-105929225). To establish heat dissipation in these areas, it is important to determine the following:
a) Type of compressor used and its efficiency (screw, centrifugal, piston).
b) Type of cooling (water or air cooled).
c) Position of the heat exchangers (outside, ducted inside).

d) Efficiency of heat exchangers (Water cooled compressors are more efficient and remove heat of compression more efficiently than air cooled compressors)
e) Type of dryers (refrigeration or desiccant)
f) Positioning of air receivers (usually outside the room)

The total heat dissipation of the compressor plant is equal to power input (1- efficiency of compressor motor) less heat removed by cooling system plus heat gain from auxiliaries (dryers).

The desiccant dryer releases heat from absorption process. The heat required for regeneration are usually obtained from the bleed off hot compressed air.

Refrigeration dryer usually reject heat into the room, and this heat should be added to heat load. The Coefficient of Performance (COP) of dryer is 1:1 so total power input is to be allowed as a heat rejection to the room.

The extract air from the heat exchanger of the air-cooled compressor must be ducted to outside but non-ducted intake usually provides sufficient air flow for room ventilation.

The compressor houses are naturally or mechanically ventilated, depending on the heat loads and height of the housing building. Compressor efficiency is low (approximately 30%) so large amount of heat is released to the space.

The air intake for compression might be taken from the building or separate air intake louvers must be provided. The taking air from the room is preferred option if reasonably clean room condition can be achieved.

As large amount of air is handled in the compressor room so providing filtered air is often not achievable due to high maintenance impact. However, the filtration is recommended especially if the plant is located in the extremely dirty environment. Minimum filtration level of MERV4 is recommended.

The clean high-level intake should be selected if mechanically driven supply air is designed. The pressurisation is fully dependant on the volume of air supplied.

If both supply and extract air fans are provided the pressurisation level is to be achieved with 2 air changes per hour.

3.3.17 Pump Houses

The pump houses are generally naturally ventilated. Where natural ventilation cannot be achieved due to excessive heat load or underground position of the pump-house the mechanical ventilation without filtration is to be considered.

3.3.18 Coal and Ash Handling Areas

Significant amount of dust is released in these areas. Special ventilation systems consideration is for conveyors, silo feeder, mill, and their transition areas and ash handling areas. The primary concern is dust control, outgassing from the coal, personal access areas and fire protection. Dust has the potential of explosive hazard. Some types of coal may outgas small quantities of methane which could accumulate in the structures.

As part of decision for primary process, dust minimisation should be considered. If dust cannot be handled below the acceptable levels it should be actively supressed. If the suppression does not provide necessary, level of control then additional measures is to be considered. To be incorporated such as filtration/dust extraction using reverse cycle dust collectors.

3.3.18.1 Coal and Ash Conveyor Areas including Transfer Houses

Natural or forced ventilation must remove heat from conveyor motors, other equipment and envelope loads. It will also remove outgassing (if any). Generally, ventilation requirements are 2 to 5 air changes per hour. If a dust collection system is used provision for make-up is to be included in the design. The wet coal can produce acids, so the non-corrosive materials and coatings is to be specified.

Enclosed conveyors are to be ventilated by introduction of air via intake grilles at the bottom of the conveyor structure and let out via continuous ridge ventilators at the top. The fire smoke ventilators are to be incorporated (where required) in accordance with a rational design by a competent fire expert. At each transfer house there must be air admission at the lower level and air outlet at the roof level.

Ash handling equipment usually does not need any attention from HVAC system but can result to ash spillages and fly ash. The fine ash in flue-gas is called fly ash can create problems in any equipment due to its abrasiveness. It should be captured in filters before air enters buildings. It is important that buildings are pressurised to avoid entering air which is not controlled.

3.3.18.2 Silo and Feeder Areas

Ventilation is recommended in any accessible area for life safety dilution of the purge gasses generally 2 air changes per hour criteria is sufficient.

3.3.18.3 Coal Mill Areas

Coal mills require large, powered motors for grinding process. These motors either have their own ventilation or remove heat to the space. The ventilation system is to remove heat without creating high velocities to avoid disturbance of accumulated dust. Although occurrence of ignition dust to air ratio is possible, the area is classified as not hazardous. The maximum velocity in this area is not exceed 1m/s.

3.3.19 Fuel Oil Handling Areas

Fuel oil is used for boiler during cold start up to produce the flame to warm up the boiler furnace to a point where firing can be introduced. It is also used during normal running to stabilise point of firing.

Enclosure for pumps, valves, heat exchangers is to be ventilated to remove access heat and to dilute hydrocarbon fumes. Fuel oil is classified by NFPA 30 as either flammable or combustible dependent on their vapour pressure at the indoor design temperature.

The design of HVAC system for these areas containing combustible fluids involves principle of heat removal and good air mixing. Ventilation rates is to dilute flames expected from evaporation of spilled or leaking fuel. As leaks are expected close to zero low exchange rate of minimum 1 air change per hour is required.

For flammable and combustible liquids, the design is to be arranged to ensure high- and low-level ventilation is provided to clear vapour which are heavier than air as well as those which are lighter than air. The exhaust rate from the area should ensure the concentration of flammable vapours is kept below 25% of the lower explosion limit typically $0.3m^3/min/m^2$. The discharge of the flammable vapours must be removed from the intake point.

The HAZLOC study is recommended for this area.

3.3.20 Hydrogen Generating Plant Areas

The hydrogen system safety requirements are specified in NFPA 2 and NFPA 55 standards.

Where possible, the area is to be naturally ventilated. Due to high buoyancy of hydrogen the attention is to be given to vent hydrogen at highest point of the building and to prevent any accumulation at the structural pockets, so the explosive mixture of air and hydrogen has been avoided. The extractors are not to be constructed with movable parts to avoid potential for sparks. The intake air position is less critical.

The hydrogen generation plant areas are to be naturally ventilated with the extraction air at the highest point. The ridge ventilators are recommended. The intake air louvers approximately 0.5 m above floor level are to be installed. The area of the louvers and ventilators to be calculated based on the heat gain to the building enclosure. The minimum ventilation rate is to be 10 air changes per hour.

3.3.21 Chlorine Plant Areas

SANS 10298 state that Chlorine is a hazardous chemical that, when released into the atmosphere, can cause severe injury or death (i.e. on contact through exposure and respiration). If chlorine is inhaled the victim could become unconscious. Chlorine can cause severe injury to the eyes. Skin contact can result in severe blistering.

Adequate ventilation is required. Exhaust fans should have sufficient rating to changeover the air every minute. Ideal temperature is 6°C above ambient and away from heat sources.

Chlorine gas feed and storage rooms require emergency ventilation. Provision is to be made for ventilation of emergency exhaust fan operation of at least 30 air changes per hour.

3.3.22 Desalination Plant (If Applicable)

This area is a corrosive environment, usually naturally ventilated. Any mechanical equipment used in this area must be corrosion protection by utilising coating and corrosion resistant materials due to corrosive environment.

3.3.23 Lift Shaft and Lift Motor Rooms

The lift shaft is pressurised with fresh air. The air flow is calculated with one door open and velocity through the door of 0.5m/s.

The lift motor room is ventilated with outside air supplied at 10 air changes per hour.

3.3.24 Crane Control Cabin

The intake from outside of the cabin to be ventilated at least 1 air change per hour. The air conditioner to be heat pump type or be fitted with heater.

3.3.25 Pump Storage Schemes

3.3.25.1 Underground Powerhouse and Transformer Hall

The design philosophy is to control the supply of air into the caverns and assist with its extraction via predetermined tunnels or shafts.

Pressurization is chosen to keep all dust and insects out of the caverns. All air is to be filtered prior to being supplied. The internal climate is to be designed to the criteria as provided in the scope of works. The main parameters specified for general accessible areas are for a summer indoor temperature of 28 °C maximum and a winter indoor temperature of 15 °C minimum. Humidity levels are to be controlled by the air-conditioning systems. Close temperature and humidity control are required in the permanently occupied areas such as control room and offices.

The air-conditioning is to be provided to all caverns to maintain the specified internal temperatures. The air-conditioning plant room is to comprise the following plant:

a) Main chilled water generators using water- or air-cooled condensers.
b) A bank of Air Handling Units (AHUs) serving the powerhouse and transformer caverns respectively.
c) Chilled water piping and pumps.
d) Electrical distribution boards and control panels.
e) Supply air distribution system including dampers and fire dampers (where specified by fire department).
f) Fresh air distribution system including dampers and fire dampers (usually via available tunnels).
g) Extract air distribution system (usually via tunnels and shafts).

h) Cooling water pumps (usually a part of common services cooling system).
i) Condenser pipes design for pressure in auxiliary cooling system and water quality.
j) Insulation of ducts and pipes.

The machine and transformer halls and all associated tunnels are to be provided with forced air conditioning and ventilation systems.

The air distribution between various levels is to be achieved via masonry shaft or two-hour fire-rated ducts to limit the number of floors penetrations, and to avoid in-line fire dampers. The airflow requirements are to relate to the load distribution and to include at maximum, minimum and emergency condition.

The outside air delivered to the machine and transformer halls is to pass through the AHUs for cooling, recirculation, and distribution into specific areas of the machine hall and transformer hall. The AHUs are to have the facility to control supply air temperature by modulating fresh and return air dampers, as well as cooling coil mixing or modulating valves.

The fresh air is to be used for pressurization of the escape routes. All levels of the machine and transformer halls are to be connected to the fresh air intake and main extract air shaft.

Cooling is achieved via chilled water plant. Chilled water supply temperature is to be at least 6°C to facilitate dehumidification. Heat rejection from the chilling plant is to be via a common cooling system.

Air is to be extracted via extract air shafts to the surface. The extract air fans are to be used to facilitate extraction both under normal and emergency operation.

In the event of failure of all mechanical systems, ventilation by natural draft is to be initiated by exhausting hot air from the station into the main extract shaft to outdoors.

In the event of fire, the affected area be isolated. The air is to be passively supplied and extracted via the main extract shaft assisted by main extract fans. The ventilation capacity is to be designed to meet the requirements of both emergency and normal ventilation.

The cable tunnels are to be ventilated with the station air to outside, using extract air fans.

All air conditioning plant rooms are to be provided with a drainage system.

The ventilation system is to be provided with a reliable power source supplied from two independent electrical panels, so that ventilation is not disrupted during maintenance of electrical equipment. Ventilation with 100% standby capacity is preferably in this environment. Where space is a problem, lower standby capacity may be accepted.

Due to the constant make-up of fresh air in both caverns, the excess air is to be directed to the main access tunnel to assist with keeping the vehicle fumes out of the caverns and the main tunnel.

The smoke evacuation philosophy for the powerhouse and transformer caverns would be to use vertical chimney shafts directly to the surface, because this is the best solution regarding hot airflow and stack effect. To further ensure negative pressure in these vertical shafts, exhaust fans are also required. It is required that the vertical smoke chimneys/shafts be extended to the surface.

3.3.25.2 Underground Control Room

The control rooms are to be air conditioned and ventilated separately from the caverns via their own independent air conditioning units and ventilation fans. The ventilation and cooling equipment are to have 100% redundancy. The control room is to be designed with the independent fresh air intake from the rest of the station or from the area where contaminations is unlikely. The extraction to be linked to the main extraction routes.

The air handling equipment is to be positioned outside the control room to limit access by maintenance personnel to this area as well as to eliminate possibility of condensation water in the control room.

3.3.25.3 Underground Battery Rooms

The battery room to be ventilated to dilute a hydrogen generated during battery charging processes and to remove it to outside without danger of accumulating it in other underground areas.

The extract system is to be designed for 24 hours operation with two 100% redundant eXn rated fans. The makeup air is to be supplied by passive intake from underground caverns or supply via HVAC system. The extract is to be connected to the extract air routes.

No fire dampers are to be installed in the extract air system, but the ducting is to be 2hr fire rated.

The fans are to be interlocked with the battery chargers such that no boost charge will be possible if ventilation system is not operational from whatever reason.

The cooling of the battery room is optional and reason for it is to increase life expectancy of the batteries. If cooling is introduced, it is to be designed on once through bases without recirculation.

3.3.25.4 Fresh and Extract Air Routes

The fresh and extract air routes to be designed in such a way that every part of the underground work have the connection to intake and extract air streams.

The fresh air is to be brought into the caverns via dedicated fresh air routes, shafts or tunnels. The air is to flow freely inside those routes, such that all tunnels are ventilated.

The extract air routes are to clearly allow for up-flow. No ducting running up and down between levels is allowed.

3.3.26 Diesel Generator Area

Diesel generator areas are to be ventilated at design outdoor ambient temperature plus 6°C, the room ventilation rate is to be 30 air changes per hour. The air changes listed are for estimating purposes only, and when heat gain data are available, the following equation is to be used:

$$Q=q/c_p d\ (t_1-t_o)$$

3.3.27 HVAC Plant Rooms

HVAC plant rooms are to be ventilated and maintained under a positive pressure, to minimise dust ingress.

Refrigerant gases are considered to be toxic gases although they have low toxicity, however at high concentrations they can displace oxygen. ASHRAE 15 "Safety Standard for Refrigeration Systems" states that gas detection is to be considered when the refrigerant charge is greater than the practical limit as follows:

a) Each machinery room is to contain a detector located where a refrigerant leak would concentrate.
b) The detector is to trigger an audible and visual alarm both inside and outside the mechanical room and activate mechanical ventilation.

For economic reasons refrigerant leak detection is required due to costs associated with refrigerant leaks. The chiller plant room are to be equipped with gas detection system to monitor refrigeration leaks. The gas detection system is to be interfaced with the HVAC BMS (where specified) and be able to start mechanical ventilation (where required), initiate visual alarms, initiate auditable alarms, and deactivate machinery. Chillers are to be equipped with refrigerant relief vent line discharging to the atmosphere.

3.3.28 Smoke Control in the Event of Fire

3.3.28.1 General Requirements for Smoke Control

In addition to normal HVAC system, smoke control system is required to reduce concentration of smoke in fire incident, to prevent migration of smoke to adjacent areas and clear smoke after fire has been extinguished.

SANS 10400-T: States that any room of which the floor area is more than 500 m^2 is to be provided with mechanical ventilation or natural smoke ventilation.

The complete HVAC system is to be interfaced to the fire detection system. In the event of a fire break out, the fire detection system is to send a signal to the HVAC controllers to indicate that there is a fire in a specific zone; the HVAC controllers are to automatically stop the HVAC system serving the respective areas. After the fire has been extinguished, smoke evacuates by a manually operated switch in a break glass box positioned on each zone which re-opens fire dampers, re-starts extract fans and over-ride damper control, closing return air dampers and opening exhaust dampers in the air conditioning plant rooms. The HVAC system is to automatically return to normal operation once the fire alarm signal to the air conditioning switchboard is cleared.

The fire dampers are to be provided on the respective fire zones. The various floors are divided into fire zones. The system operation is that when fire is detected in a zone, the relevant fire dampers on the supply and return ducts feeding that zone are closed as well as the supply air handling.

3.3.28.2 Lift Lobbies and Enclosed Stairways Pressurisation

SANS10400 (National Building Regulations) states that any enclosed area which is a component of an emergency route in any building exceeding a height of 30 meters or basement more than 10 meters in depth is to be provided with an approved pressurisation system which is to be capable of pressurising the enclosed area to not less than 25 Pa with any three (3) doors open & not more than 50 Pa with all doors closed and is either to run continuously or come into operation automatically in the event of fire.

Fresh air for such pressurisation is not to be drawn from the inside of the building. The pressurisation system is to be provided with an approved emergency power supply system independent of the normal mains supply, which is to be capable of operating safely for a minimum period of two hours (120 minutes) after activation of the pressurisation system.

Lift lobbies and stairways pressurisation system is to be serviced by 2-hour fire rated fan starter panel, electrical cables, and control cables. The system is to be provided with mains and standby power as recommended by SANS 10400 (National Building Regulations). The electrical cable is to run through the building in such a way that it is protected in the event of fire.

Fire relays and interlocks are to be provided to activate the pressurization system. The lift Lobby and stairways pressurization system is to be interfaced with fire detection system (by others) such that the pressurization fan runs upon receiving a fire signal from fire detection system.

3.4 DESIGN AND SELECTION OF EQUIPMENT

The heat loads and airflow analysis are to be used to determine the size of the HVAC plant required to service the space or plant. The supplier technical data sheets are to be used for the design and selection of HVAC units required to service the heat loads. HVAC systems are generally categorized based on the fluid media used for heat rejection as detailed below:

a) Air to Air HVAC systems which are mainly Direct Expansion (DX) systems.
b) Air to Water HVAC systems which mainly comprise of air-cooled and water-cooled chilled water generators with their applicable subsystems.
c) Water to Water HVAC systems which mainly comprise fan-coil systems, radiant panel and silent cooling chilled beams to mention few.

3.4.1 Cooling and Heating Equipment

The cooling HVAC equipment consists of air handling units, chilled water generators, pumps, cooling towers, valves, and piping system as well as various types of the air-cooled direct expansion equipment including heat pumps. The basic air conditioning water system consists of two circuits of water, chilled water circuit and condenser water circuit that are linked to water make up (usually potable water) and drainage system.

It must be noted that South Africa is a scarce water country (in fact, it was pronounced in year 2018 that it is 30th driest country in the world) and many local bylaws have restriction or forbidden the use of potable water for HVAC heat rejection equipment such as cooling towers and condensers. Therefore, water cooled systems via potable water are to be justified by means of cost and environmental benefit analysis over other technologies.

The heating equipment usually consists of electrical heating systems, steam systems, hydronic hot water systems, glycol systems, gas heating systems and heat pumps (reverse cycle air-conditioning units). Heating is used in the permanently occupied areas or in the 100% fresh air ventilation systems where temperatures control is required.

The equipment is to be supplied by reputable suppliers which have an established maintenance department in South Africa, preferably in the vicinity, but not more than 500 km from the site

The preferred supplier is usually not specified with the exception that it is for standardisation purposes (i.e., the same supplier is already established on the site).

The equipment is selected for their reliability record, energy efficiency and maintainability.

3.4.2 Chilled Water Circuit

The chilled water system is a close loop type system which consists of chiller unit’s heat exchanger (chiller), piping, pumping and air handling unit’s heat exchangers (cooling coils) network.

With multiple chillers arrangement a two pumping cycle is designed with the primary, constant flow cycle, pumping water through chillers and secondary, & variable flow cycle, pumping water through the system.

The chilled water temperature is usually designed at 7ºC supply and 12ºC return. The velocity in piping system is designed below 3.0m/s. The water flow requirements are calculated at temperature difference of between 5ºC to 6ºC.

The system static pressure is controlled by open or pressurised feed and expansion tank (head tank). The preferred expansion tank is an open tank positioned at least 1m above highest positioned heat exchanger. The tank controls system pressure and serve as air purging, make up water tank and chemical dosing point. Closed pressurised tank is used when open tank position cannot be found. It has to provide for separate dosing system, in line make up system and separate purging system in addition to neutral gas pressurisation system to maintain system pressure.

Water quality for this system is usually potable water type. The chemical dosing controlling the system can be introduced via the head tank or as a connection to the piping system.

3.4.3 Condenser Water Circuit

The condenser water circuit consists of chiller’s heat exchanger (condenser), piping, pumping and cooling tower (dedicated or connected to auxiliary cooling system).

The condenser water system may be either opened or closed type, depending on the type of cooling tower circuit.

When closed system is used, the system pressure is kept by open or pressurised feed and expansion tank (head tank). A tank is controlling the static pressure of the system. The open tank is preferred, as a low maintenance solution. The tank shall include for level control, drain and overflow connection in addition to the expansion line connection. It also needs to include for a make-up line connection.

If the condenser water circuit is part of the closed circuit of the auxiliary cooling water system at power plant. The pressure of this system is usually sufficient, and no additional tank or pumps need to be specified. It should be analysed if the system providing water is available for 24hrs operation. Common system and not unitised system should be used.

The condenser water temperature is usually designed at 29ºC supply and 35ºC return. The velocity in piping system is designed below 3.0m/s. The water flow requirements are calculated at temperature difference of between 5ºC to 6ºC.

3.4.4 Chilled Water Generators

Eskom HVAC designs are generally based on the chiller equipment using fluorocarbon refrigerants as working fluid. The chiller equipment using the fluorocarbon refrigerants as a working fluid is usually a self-controlled unit that consist of the following main components:

a) Compressor.
b) Chilled water heat exchanger.
c) Condenser water heat exchanger.
d) Expansion valve.
e) Oil pumping system, and
f) Control panel, but not limited to

The chillers are classified from the point of heat rejection (air cooled or water cooled), from the point of type of the compressors used which included reciprocating, screw, scroll, centrifugal (single or multi-compressor arrangement) and from the point of type of working fluid (refrigerant) use.

The compressor type used in the chiller equipment depends on the equipment capacity. The most frequently used compressor in Eskom plants is screw type for higher capacity and scroll type for low-capacity equipment.

The recommended refrigerant is R134a or equivalent, a single chemical refrigerant which is environmentally acceptable.

The R134a refrigerant is however not used in smaller equipment, which uses mixture of chemicals as a refrigerant. The most suitable of all available is R410a refrigerant or equivalent which uses the components of similar evaporating temperatures, so in the case of a leak the refrigerant does not need to be fully replaced but can be filled with the missing quantities.

The chiller control panel utilises the open protocol controls, BACnet, LonWorks or Modbus being most commonly used protocol controls. For chiller electrical panel Eskom specifies type of starter.

The other less frequently used chiller equipment is a lithium bromide-based absorption system (which uses water as a refrigerant and lithium bromide as an absorber) or ammonia chiller (which uses ammonia as a refrigerant and water as an absorber). This equipment is energy efficient if a waste heat of suitable parameters is available for re-generation purposes. The investigation was performed to use this equipment at power plants, however it was found to be very difficult to capture any waste heat without affecting operation of the critical systems at power plants, so it is not currently recommended at power generation plants. Ammonia chillers are not preferred for safety reasons but can be considered taking into account cost benefit analysis and safety risks assessments.

3.4.5 Cooling Water System (Condenser Water)

The cooling towers are classified as open or closed, induce or force draft. The closed tower has a built-in heat exchanger, cooled with spray water over the heat exchanger coil. The open tower sprays the water directly over the tower filament.

The closed-circuit cooling tower is a preferred option for the air conditioning system in power generating plants and building services facilities. The make-up water for the closed circuit is to be potable water.

The cooling tower is sized considering range of water temperature (temperature of water less temperature of water out), approach temperature (supply water temperature less design wet bulb ambient temperature) as well as the chiller's heat rejection (chiller's delivery capacity plus capacity of the compressor motors plus pumping losses).

The most typical design parameters are 29ºC/35ºC with 20ºC ambient WB temperature. The water temperature is controlled by modulating the variable speed fans.

The cooling tower make up flow is a function of evaporative rate plus drift. The water quality is usually potable water for both closed and open circuits

The frequency of the blow down of the open circuit is a function of water quality, cooling tower evaporation rate and the materials of construction of the cooling tower. The release point (for example the dirty system) of the blow down water is to be determined by taking cognisance of the chemicals dosed into the system viz. biocides, scale inhibitors etc.

Where heat is rejected via the power plant cooling water system the design parameters of this system are to apply to the air conditioning condenser water system.

3.4.6 Direct Expansion Equipment

The direct expansion equipment can be used for an equipment cooling capacity from 3 kW to 200 kW, or even higher heat load capacities provided they can be justified from cost benefit analysis, reliability, availability and maintainability point of view.

For smaller capacities equipment, the air handling units are suitable for installation in the occupied areas and are connected with copper piping with the condensing units placed outside. These systems are to be avoided in power generating plants application as the available filtration is of very low efficiency. If these systems are utilised, the outside air is to be filtered and supplied separate fresh air system.

For higher capacity equipment a purpose-built air handling unit with a two stage of filtration can be connected to the condensing unit and be used at power generating plants environment.

The unitary equipment is available in many supporting configurations such a single zone constant volume, multiple zone constant volume, single zone variable volume or multiple zone variable volume. The following are the industry nomenclature for those systems:

a) Split systems.
b) Variable Refrigerant Flow (VRF) or Variable Refrigerant Volume (VRV).
c) Single package units.
d) Roof top units.
e) Heat pumps (reverse cycle cooling/heating units).
f) Condensing units (connected to DX cooling coil in Air handling units); and
g) Condensers (connected to condenser-less package air-conditioning unit)

3.5 PIPING SYSTEM DESIGN CRITERIA

3.5.1 Pumps

In HVAC systems the low-pressure centrifugal pumps are used. The pumps configuration is an axial suction nozzle and vertical discharge nozzle. Pumps are direct driven by a 3-phase 400V or single phase 230V electrical motors. Pumps are selected such that the system characteristics and pump performance achieve at least 75% efficiency. In the closed loop systems Net Positive Suction Head (NPSH) pressure of the pump is achieved by positioning of the head tank over the highest located heat exchanger. In the open loop system, the open tank of cooling tower should be positioned above the pump suction intake.

3.5.2 Water Piping

Pipe size selection is to satisfy the limiting parameters of maximum water velocity and maximum fluid pressure drop as listed by the table below. The pipe sizing is based on ASHRAE handbook fundamentals which state that pipe selection is not to exceed maximum fluid velocity or maximum pressure drop.

ASHRAE fundamentals recommend a velocity of 0.75 to 2.1 m/s for clean water piping systems, a velocity limit of 1.2 m/s for 50 mm pipe & smaller and a pressure drop limit for 400 Pa/m of piping over 50 mm.

Table 4: Hydronic Pipe Sizing Criteria

Pipe Type and Size	Maximum Fluid Velocity (m/s)	Maximum Pressure Drop (Pa/m)
1. Chilled and hot water pipe, 50 mm and below	1.2	400
2. Chilled and hot water pipe, above 50 mm	3.0	400
3. Condenser water of any size	3.0	400

All diameters quoted or referred to for pipes, valves or fittings are to be considered as inside bore measurements unless specifically stated to be outside diameters.

Pipes are to be designed according to SANS 62 and 719. Condenser cooling water open circuit pipes are heavy duty class piping to SANS 62 and galvanised according to SANS 719 for type B articles heavy duty.

Close circuit chilled and condenser water pipes to be middle class black piping to SANS 62 and 719; painted and coated as specified prior to application of insulation.

3.5.3 Refrigerant Piping

The refrigeration piping is to be designed according to SANS 1453. Copper tubing sizes are to be as specified in SANS 460 class 2. Pipe sizing is to ensure the following:

a) Lubrication oil return to compressor and minimising oil trap in the system.
b) Prevent liquid refrigerant returning to compressor during operation and shut down.
c) Ensure no excessive pressure drop when entering evaporator.

3.6 DUCTING SYSTEM DESIGN CRITERIA

The ducting system is to be designed in accordance with the requirements of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) and ASHRAE handbook fundamentals. The following design considerations are to be taken into account when designing duct systems:

a) Minimise the number of fittings to reduce pressure loss in the duct run.
b) Use semi-extended plenums as far as possible to reduce the number of transition fittings and facilitate balancing.
c) Sealing of ductwork.
d) Use of round ductwork is preferred over rectangular ductwork as the offer lower friction loss.
e) Duct aspect ratio is not to exceed of 1:4 maximum.

For duct construction (as per SMACNA) the following information is required:

a) A comprehensive duct layout indicating sizes, design air flows, pressure drop/m and routing of duct system, pressure class.
b) Location of fittings, use of turning vanes, location of access doors, location and types of diffusers, location of flow control dampers and location and type fire dampers.
c) Requirement for duct insulation and vapour barrier.
d) Fire rating (rated/not rated).
e) Location of control sensors.
f) Variable volume ducts have minimum 500Pa basis of compliance to leakage integrity; and
g) The low pressure, constant flow ducting has a minimum 250Pa of compliance to leakage integrity

Air distribution equipment consists of fans, sound attenuators, ducts, dampers, fire dampers, outlet grilles and diffusers. Selection of the type of fans (centrifugal or axial) depends on the required operating pressure.

The duct material for general areas to be galvanised steel folded construction as per SMACNA (Sheet Metal and Air-conditioning Contractors National Association) standard.

The fire rated ducts to be welded construction with a minimum steel thickness of 1.6 mm.

Ducting handling abrasive fumes should be stainless steel 304L as minimum.

Where condensation on the outside surface of the duct is probable, ducts have to be insulated. External insulation and vapour seal is preferred. Ducts exposed to view to be aesthetically finished. The air outlets should not be positioned over the electrical equipment and can be selected as constant or variable flow depends on system requirement.

The following table indicates the minimum ventilation rates for industrial processes:

Table 5: Minimum ventilation rates for industrial processes

Area	Process	Design Criteria	Transport velocity (m/s)	Comments
1. Workshop-Welding	Local hood with flange	Velocity 0.5m/s at hood face 0.4m^3/s/ machine	10m/s	Welding booth
2. Smoke extraction system	Emergency extraction	Air flow to be calculated at 10 air changes/hr minimum	7,5m/s	Separate system or via all air conditioning system return air ducting and release dampers
3. Belt conveyors speed above 1m/s	Hood at transfer point	Velocity 1m/s through open area 1.5 m^3/s per meter of belt with	17.5m/s	Cold process
4. Abrasive blast cabinets	Tight enclosure with access openings	Velocity 2.5m/s through opening	17.5 m/s	Cold process
5. Kitchen	Canopy (hot process)	Velocity 0.5m/s at hood face	7.5m/s	Hot process
6. Laboratory	Fume booth with door	Velocity 0.5 m/s via door opening	7.5m/s	Hot or cold process
7. Pressurisation of enclosures	Enclosure with access openings	Velocity0.5m/s at openings	10m/s	i.e Maintenance enclosure in Turbine Hall

The following table indicates the approximate conveying velocities which are to be used as input to the duct design.:

Table 6: Approximate conveying velocities (input to duct design)

Material conveyed	Design velocity (m/s)	Comments
1. Clean air (supply air, return air, and fresh air)	6m/s above 1m^3/s or 1 Pa/m below 1m^3/s	Duct design at equal friction method. Constructed to SMACNA low pressure standard
2. Vapour, gasses, fumes, and very fine dust	10m/s	Duct design at static regain method constructed to SMACNA middle pressure stand and. The volume to be calculated on the vapour dilution requirement
3. Fine dry dust	15m/s	Duct design at static regain method only round ducts permitted branches enter at 30-degree, bends
4. Average industrial dust	17.5m/s	Duct design at static regains. Ducts are of welded construction. Branches at 30-degree connect at top or site of main Access openings every 3m or at connection.
5. Coarse particles	17.5-22 m/s	Ducts of welded construction no branches or elbows. Access every 3m

The design and sizing of ducting system is to be accomplished by any of the following methods:

3.6.1 Equal Friction Duct Design Method

The equal friction method is the most widely used to design and size ducting due to the fact that it is easier to calculate the total pressure drop and velocities in the duct run are reduced automatically. The equal friction method utilises duct slide rule, duct calculator or friction rate chart to determine the relationship between duct size and air flow.

The low-pressure ducts are designed at equal friction method at pressure drop of 1 Pa/m (ASHRAE) or velocity 6 m/s. This ducting conveying air volumes below 1 m^3/s is to be designed for friction loss of 1 Pa/m and velocity below 6 m/s.

The ducting conveying flow from 1 m^3/s to 10m^3/s is to be designed at velocity of 6 m/s with lower pressure drop. The pressure drops at the fittings to be designed at k*vp where k is a local loss coefficient and vp is velocity pressure.

3.6.2 Velocity Reduction Duct Design Method

The velocity reduction method can be used for simple ducting layouts and splitter dampers are to be included into the ducting system for balancing purposes.

3.6.3 Static Regain Duct Design Method

The ducts conveying more than 10 m^3/s and higher velocities than 8m/s are to be designed using static regain method.

The static regain method is an excellent method for the design of variable air volume systems due to the fact that the duct system will stay in balance because the losses and gains are proportional to a function of the velocities.

3.7 FILTRATION SYSTEM DESIGN

HVAC Filtration is the primary process of ensuring the cleanliness of conditioned air. The complete HVAC filtration has to be designed based on the recommendations of ASHRAE Standard 52.2, which uses 16-20 Minimum Efficiency Reporting Values (MERVs) to select air filters based on particle size composite efficiency.

Filter efficiencies for control and electrical rooms are to be as listed below:

a) ASHRAE 52.1 – 85% dust spot efficiency.
b) ASHRAE 52.2- MERV 13.
c) EN 779-2011- class F7

The standard Minimum Efficiency Reporting Value (MERV) chart is as detailed by the table below:

Table 7: Minimum Efficiency Reporting Value (MERV) chart

MERV	Composite average size Efficiency %			Average arrestance%	Minimum final resistance	
	Range 0.3-1um	Range 1-3um	Range 3-10um	By Standard 52.1 method	Pa	Inch of water
1	n/a	n/a	<20	65	75	0.3
2	n/a	n/a	<20	65-70	75	0.3
3	n/a	n/a	<20	70-75	75	0.3
4	n/a	n/a	<20	>75	75	0.3
5	n/a	n/a	20-35	n/a	75	0.3
6	n/a	n/a	35-50	n/a	75	0.3
7	n/a	n/a	50-70	n/a	150	0.6
8	n/a	n/a	>70	n/a	150	0.6
9	n/a	50	>85	n/a	250	1
10	n/a	50-65	>85	n/a	250	1
11	n/a	65-80	>85	n/a	350	1.4
12	n/a	>80	>90	n/a	350	1.4
13	75	>90	>90	n/a	350	1.4
14	75-85	>90	>90	n/a	350	1.4
15	85-85	>90	>90	n/a	350	1.4
16	>95	>95	>95	n/a	350	1.4

The ASHRAE 52.2 standard does not completely replace ASHRAE52.1 standard. Both standards are applicable. The table below illustrate the filter ratings in accordance with EN779-2012.

Table 8: Filter ratings in accordance with EN779-2012

Classification	*[1])Average Arrestance	Average efficiency	Filter group	Pressure drop Initial	Pressure drop Final	Pressure limit
G1 (EU1)	65%	-	Coarse (G)	1mm	15mm	dp=250 Pa
G2 (EU2)	65-80%	-	Coarse (G)	1mm	15mm	-
G3 (EU3)	80-90%	-	Coarse (G)	4mm	20mm	-
G4 (EU4)	90-95%	-	Coarse (G)	4mm	20mm	-

Classification	*[1])Average Arrestance	Average efficiency	Filter group	Pressure drop Initial	Pressure drop Final	Pressure limit
F5 (EU5)	95-97%	40-60%	Fine (F)	6mm	25mm	dp=450Pa
F6 (EU6)	97-98%	60-80%	Fine (F)	7mm	25mm	-
F7 (EU7)	98-99%	80-90%	Fine (F)	7mm	25mm	-
F8 (EU8)	Semi HEPA	90-95%	Fine (F)	6-10mm	40mm	-
F9 (EU9)	Super Semi-HEPA	95-98%	Fine (F)	6-10mm	40mm	-

3.8 ATTENUATION AND NOISE CONTROL

Noise and vibration control for HVAC equipment, piping and ducting is to be implemented in accordance with equipment manufacture's recommendations including applicable standards. Poorly designed HVAC system can result to major noise and vibration; the following recommendations are to be considered to reduce noise and vibration but not limited to:

a) Acoustic louvres are to be provided on plant room air intakes and exhaust opening where the need for engineered sound attenuation cannot be avoided.
b) Sound attenuators which are designed to reduce noise transmitted from HVAC equipment are to be provided at intake and discharge side of the equipment where required.
c) Flexible collars have been provided between the HVAC units and ductwork to eliminate control vibration between the subsystems.
d) Duct system lining is to be considered where the need for engineered sound attenuation cannot be avoided.
e) Floor mounted HVAC equipment are be mounted onto concrete plinth, which protrudes at least 50mm above finished floor level. Vibration elimination rubbers are to be provided between HVAC equipment and the concrete plinth.
f) All wall mounted HVAC equipment will be mounted onto cantilever bracket with vibration elimination rubbers provided between the units and the brackets.

4. HVAC CONTROL SYSTEMS

4.1 HVAC CONTROLLERS

The control system for HVAC is to be a stand-alone system and be capable of interfacing with HVAC Building Management System (BMS) and Central Building Management System (CBMS). The system is to be designed to utilise standard sensors, transducers and actuators for the industry which have been field tested for the last two years. The control system must have capability to communicate with the standard HVAC equipment supplied, so that the sub-system can be tested, logged, stopped, started, load-shed, reset temperature and commanded at the central operator's terminal and locally, so as to manage the relevant sub-systems in terms of operation, energy and maintenance.

The monitoring (including control and operation when required) of the air conditioning and ventilation system is to be managed by means of HVAC controllers. Field controllers are to operate independently of the Human Machine Interface (HMI) system. The communication bus is to be BACnet, LonWorks or Modbus.

The HVAC controllers and associated instruments, if not contained within temperature and humidity-controlled environments, are to be suitable for the environmental conditions prevailing at respective site locations, without any negative impact on the performance, reliability, availability or life expectancy of the equipment.

The HVAC controllers is to have a capability to communicate with the standard equipment supplied such as fans etc to enable monitoring of performance of the components and allow for subsystems to be tested, logged and commanded at the central operator's terminal.

HVAC panel controllers to have sufficient space for the HVAC BMS controllers which will:

a) Switch units on/off.
b) Interlock between running and standby units.
c) Drive and control all the normal motorized dampers.

4.2 HVAC BMS AND CBMS INTERFACE

4.2.1 HVAC BMS General Requirements

The Building Management System (BMS) is the central point of information for the HVAC System which includes data from various HVAC plants field devices, instrumentation, and controllers. The HVAC BMS Human-Machine Interface (HMI) is used primarily for supervisory monitoring and control of the HVAC system and sub-systems; and is capable of controlling all field control elements and controller set points.

The Human Machine Interface (HMI) supervisory monitoring and control functions are to be provided via a common Graphical User Interface (GUI). The GUI including all mimics, alarms, logic and diagnostics are to be suitable for the screen size and resolution in accordance with 240-56355728 Human Machine Interface Design Requirements Standard.

The HMI logs all user logins and actions. The system provides for individual user profiles with associated security levels allowing or denying various user actions. All user profiles are password protected. The following minimum-security levels are to be available for linking to user profiles:

a) Level 1: View Only – Able to generate, view and print all data, trends, reports, logic and alarms etc.
b) Level 2: Operate – Level 1 plus able to provide input to plant set points etc. enabling control and monitoring of the system; and be capable of defining new trends and data logging functions.
c) Level 3: Maintenance – Level 1 & 2 plus the ability to modify and edit plant mimics, control logic and parameters to improve plant performance.
d) Level 4: Administrator/engineer – Level 1-3 plus full control of the system for maintenance and administration.

Communication between HVAC controllers and HVAC BMS is implemented by networked communication, utilising industry standard protocols such as BACnet, LonWorks, or Modbus. Networked communications are redundant preventing any single fault from disrupting communication between the HVAC BMS, HVAC controllers and field controllers.

The HVAC BMS system design is to have the following spare capacity requirements:

a) 10% spare capacity on the system for additional points.
b) 10% spare digital and analogue input and output for the field.
c) 10% spare capacity for multi-core cables.
d) 20% spare hardware and software capacity for operating workstations.

The HVAC BMS and HVAC systems are supported by the OEM for a minimum of 25 years inclusive of all components forming part of the system

The HVAC BMS is to be capable of supporting data storage. Archiving of signals is required on the HVAC BMS. Archiving, trending, logs and reports are defined during the detailed design phase. The typical HVAC BMS function legend is described by the following tables however not limited to:

Table 9: Typical HVAC BMS Function Legend for Chilled Water System

HVAC Signal	BMS Function	Interface to DCS for Monitoring
1. Chilled Water Generator Units (Chiller Units)		
1.1. Leaving Chilled Water Set-point	Control	
1.2. Remote Stop/Start	Start/Stop	
1.3. Chilled Water Supply Temperature	Monitor	
1.4. Chilled Water Supply Pressure Probe	Monitor	
1.5. Chilled Water Return Temperature	Monitor	
1.6. Chilled Water Return Pressure Probe	Monitor	
1.7. Evaporator Pressure Sensor	Monitor	
1.8. Oil Pressure Differential	Monitor	
1.9. Red Phase Current	Monitor	
1.10. White Phase Current	Monitor	
1.11. Blue Phase Current	Monitor	
1.12. Red Phase Voltage	Monitor	
1.13. White Phase Voltage	Monitor	
1.14. Filter Pressure Differential	Monitor	
1.15. Chiller Operating Hours	Monitor	
1.16. Chiller Water Flow Switch	Monitor	
1.17. Chiller Unit Trip	Alarm	Yes (Hardwired)
1.18. Chilled Water System/Common Fault/General Alarm	Alarm	Yes (Hardwired)
1.19. Condenser Fan Status	Monitor	
1.20. Condenser Fan Trip	Alarm	
1.21. Liquid Temperature Sensor	Monitor	
1.22. Condenser Pressure Sensor	Monitor	
1.23. Compressor Status	Monitor	
1.24. Low Pressure Switch	Monitor	
1.25. Suction Temperature Probe	Monitor	
1.26. High Pressure Switch	Monitor	
1.27. Discharge Temperature Probe	Monitor	
2. Chilled Water Pumps		
2.1. Pump Stop/Start	Start/Stop	
2.2. Pump Status	Monitor	
2.3. Pump Flow	Monitor	
2.4. Pump Trip	Alarm	
2.5. Pump Discharge Pressure Probe	Monitor	
2.6. Pump Suction Pressure Probe	Monitor	
2.7. Pump System/Common Fault/General Alarm	Alarm	Yes (hardwired)

HVAC Signal	**BMS Function**	**Interface to DCS for Monitoring**
3. Chilled Water System Plant Room Electrical Panel		
3.1. 1 off Energy Meters on Chilled Water System Electrical Panel	Monitor	
3.2. Supply A AC Failure (Power lost)	Alarm	Yes (hardwired)
3.3. Supply B AC Failure (Power lost)	Alarm	Yes (hardwired)
4. Chilled Water Air Handling Units (AHU)		
4.1. Fresh Air Inlet Temperature	Monitor	
4.2. Fresh Air Supply Fan	Monitor	
4.3. Fresh Air Supply Flow	Monitor	
4.4. Fresh Air Fan Trip	Alarm	
4.5. Economy Cycle Set Point	Set Point	
4.6. Return Air & Fresh Air Economy Dampers	Control	
4.7. AHU Primary Filter Dirty Status (Clogged filter)	Status/Alarm	
4.8. AHU Secondary Filter Dirty Status (Clogged filter)	Status/Alarm	
4.9. AHU Supply Air Fan	Start/Stop	
4.10. AHU Supply Air Flow	Monitor	
4.11. AHU Supply Air Fan Trip	Alarm	Yes (hardwired)
4.12. Supply Air Temperature Set Point	Control	
4.13. AHU Common Supply Air Temperature Sensor	Monitor	
4.14. Supply Air Humidity Set Point	Control	
4.15. Supply Air Humidity Sensor	Monitor	
4.16. Humidifier Status	Monitor	
4.17. AHU Supply Air Fire Damper Open	Monitor	
4.18. AHU Supply Air Fire Damper Closed	Monitor	
4.19. AHU Extract Fan	Start/Stop	
4.20. AHU Extract Air Flow	Monitor	
4.21. AHU Extract Air Fan Trip	Alarm	Yes (hardwired)
4.22. AHU Common Return Air Temperature Sensor	Monitor	
4.23. Return Air Humidity Sensor	Monitor	
4.24. AHU Return Air Fire Damper Open	Monitor	
4.25. AHU Return Air Fire Damper Closed	Monitor	
4.26. Room Temperature Sensor (high/low humidity)	Monitor/Alarm	
4.27. Room Humidity Sensor (high/low humidity)	Monitor/Alarm	
4.28. Chilled Water Control Valve	Control	

HVAC Signal	BMS Function	Interface to DCS for Monitoring
4.29. Chilled Water Supply Temperature	Monitor	
4.30. Chilled Water Supply Pressure Probe	Monitor	
4.31. Chilled Water Return Temperature	Monitor	
4.32. Chilled Water Return Pressure Probe	Monitor	
4.33. Chilled Water Flow Measuring Device	Monitor	
4.34. AHU System/Common Fault/General Alarm	Alarm	Yes (hardwired)
4.35. Fire Signal from Fire Detection System	Monitor/Alarm	
4.36. Water leak under unit (down-blow or under-ceiling units located on equipment rooms)	Alarm	
5. Air Handling Units (AHU) Plant Room Ventilation		
5.1. Plant Room Ventilation Fan	Start/Stop	
5.2. Plant Room Ventilation Flow	Monitor	
5.3. Plant Room Ventilation Trip	Alarm	Yes (hardwired)
6. Air Handling Units (AHU) Plant Room Electrical Panel		
6.1. 1 off Energy Meters on AHU Electrical Panel		
6.2. Supply A AC Failure (Power lost)	Alarm	Yes (hardwired)
6.3. Supply B AC Failure (Power lost)	Alarm	Yes (hardwired)

Table 10: Typical HVAC BMS Function Legend for Direct Expansion System

HVAC Signal	BMS Function	Interface to DCS for Monitoring
1. Air Cooled Condensing Unit		
1.1. Remote Stop/Start	Start/Stop	
1.2. Condensing Unit Control	Control	
1.3. Condenser Fan Status	Monitor	
1.4. Condenser Fan Trip	Alarm	
1.5. Liquid Temperature Sensor	Monitor	
1.6. Condenser Pressure Sensor	Monitor	
1.7. Compressor Status	Monitor	
1.8. Compressor Trip	Monitor	
1.9. Low Pressure Switch	Monitor	
1.10. Suction Temperature Probe	Monitor	
1.11. High Pressure Switch	Monitor	
1.12. Discharge Temperature Probe	Monitor	
2. DX Air Handling Units (AHU) or Evaporators		
2.1. Fresh Air Inlet Temperature	Monitor	

HVAC Signal	BMS Function	Interface to DCS for Monitoring
2.2. Fresh Air Supply Fan	Monitor	
2.3. Fresh Air Supply Flow	Monitor	
2.4. Fresh Air Fan Trip	Alarm	
2.5. Economy Cycle Set Point	Set Point	
2.6. Return Air & Fresh Air Economy Dampers	Control	
2.7. AHU Primary Filter Dirty Status (Clogged filter)	Status/Alarm	
2.8. AHU Secondary Filter Dirty Status (Clogged filter)	Status/Alarm	
2.9. AHU Supply Air Fan	Start/Stop	
2.10. AHU Supply Air Flow	Monitor	
2.11. AHU Supply Air Fan Trip	Alarm	Yes (hardwired)
2.12. Supply Air Temperature Set Point	Control	
2.13. AHU Common Supply Air Temperature Sensor	Monitor	
2.14. Supply Air Humidity Set Point	Control	
2.15. Supply Air Humidity Sensor	Monitor	
2.16. Humidifier Status	Monitor	
2.17. AHU Supply Air Fire Damper Open	Monitor	
2.18. AHU Supply Air Fire Damper Closed	Monitor	
2.19. AHU Extract Fan	Start/Stop	
2.20. AHU Extract Air Flow	Monitor	
2.21. AHU Extract Air Fan Trip	Alarm	Yes (hardwired)
2.22. AHU Common Return Air Temperature Sensor	Monitor	
2.23. Return Air Humidity Sensor	Monitor	
2.24. AHU Return Air Fire Damper Open	Monitor	
2.25. AHU Return Air Fire Damper Closed	Monitor	
2.26. Room Temperature Sensor (high/low humidity)	Monitor/Alarm	
2.27. Room Humidity Sensor (high/low humidity)	Monitor/Alarm	
2.28. Electronic Expansion Valve	Monitor	
2.29. Evaporator Pressure Probe	Monitor	
2.30. AHU System/Common Fault/General Alarm	Alarm	Yes (hardwired)
2.31. Fire Signal from Fire Detection System	Monitor/Alarm	
2.32. Water leak under unit (down-blow or under-ceiling units located on equipment rooms)	Alarm	

HVAC Signal	**BMS Function**	**Interface to DCS for Monitoring**
3. Air Handling Units (AHU) Plant Room Ventilation		
3.1. Plant Room Ventilation Fan	Start/Stop	
3.2. Plant Room Ventilation Flow	Monitor	
3.3. Plant Room Ventilation Trip	Alarm	Yes (hardwired)
4. Air Handling Units (AHU) Plant Room Electrical Panel		
4.1. 1 off Energy Meters on AHU Electrical Panel		
4.2. Supply A AC Failure (Power lost)	Alarm	Yes (hardwired)
4.3. Supply B AC Failure (Power lost)	Alarm	Yes (hardwired)

4.2.2 HVAC Building Management System (BMS) Workstation

The HVAC BMS is to be designed complete with Engineering Workstation, Supervisory Workstation, and Maintenance Workstation.

Engineering Workstation is to be provided to administer, engineer, maintain and configure the HVAC BMS system and sub-systems which includes the following but not limited to:
a) Programming and configuring the system.
b) Control logic and interlocking.
c) Plant and system diagnostics.
d) Scheduling and coordination.
e) Maintenance functions.
f) Alarm and event management.
g) Pre-defined and user-defined reporting, trending and log generating through retrieval of stored or archived date.
h) System and user administration

Supervisory Workstation is to be provided to monitor and control including:
a) Plant and system diagnostics,
b) Scheduling and coordination,
c) Alarm and event management,
d) Pre-defined and user-defined reporting, trending and log generating through retrieval of stored or archived date.

Maintenance Workstation is to be provided to monitor and maintain the BMS system and sub-systems including:
a) All maintenance functions as follows but not limited to:
    i. Monitor condition of filters
    ii. Monitor condenser and evaporator coils
    iii. Monitor drain lines for proper flow and clear clogs
    iv. Monitor drain pans of any standing water to avoid overflows
    v. Monitor conditions of pulleys and belts. Check fan motor
    vi. Inspect ducts for mold, dust, and debris
    vii. Observe humidity levels
    viii. Check refrigerant charge and for leaks
    ix. Test thermostats and controls to make sure temperatures and timer functions are correctly
    x. Check electrical system and connections
    xi. Examine heat exchanger or heating elements
b) Alarm and event management.

4.2.3 HVAC BMS Storage, Reporting and Alarming

The HVAC BMS server stores facility/plant process and system data for a minimum period of 1 year with due consideration to the amount of system signals and object properties associated with each plant. All object properties are stored.

The HVAC BMS is to be capable of transferring stored data to removable non-volatile media such as compact disk or external hard drive for long term storage.

The HVAC BMS is to be capable of transferring configuration backups for system recovery to removable non-volatile media such as compact disk or external hard drive for long term storage.

The HVAC BMS is to be capable of producing trends, reports and system logs with time stamping. User-defined and preconfigured trends, reports and logs are possible through HMI configuration. All information residing on the HVAC server is reportable per user configuration.

An alarm is to be displayed when system storage has reached capacity limits and advices transfer of archived data to removable storage media. Retrieval of archived data from removable storage media is possible whereby trends, reports and logs are generated on the system from the attached removable storage media.

Alarming is in accordance with 240-56355466 Alarm Management System Guideline. A comprehensive and integrated alarm handling system is provided which clearly distinguishes when alarm types and provides selective filtering functionality. Alarms screens are dynamic and real-time in presenting alarms to the User.

4.2.4 HVAC BMS Time Synchronisation

The HVAC BMS is time synchronised through the Stations’ existing central time server (GPS Clock) and is to be in accordance with applicable cyber security and interface standards. The HVAC BMS is to provide time synchronisation to the HVAC system controllers. All alarms, events and trends are time stamped at the HVAC controllers and transferred with the time stamp to the HVAC BMS Server

4.2.5 HVAC BMS Interface with CBMS

The HVAC BMS system is to be capable of fully integrating into a CBMS system installed at site. Industry standard protocols such as BACnet, LONWorks and Modbus may be used with BACnet being the preferred communication protocol. Network communication is to be dual redundant to support availability of the system in line with plant requirements.

4.3 DISTRIBUTED CONTROL SYSTEM (DCS) INTERFACE

The Generation fleet underlying DCS technology will remain unchanged. As, far as possible spare I/O modules is to be used when interfacing with DCS. Where spares are not available modules will be added to cater for additional signals. The existing HMI mimics will be updated to cater for the new signals and their associated alarms.

The HVAC control system is to be able to generate alarms that will be routed to the DCS for monitoring purposes. The alarms which will be monitored are specified on project-by-project basis.

4.4 FIRE DETECTION SYSTEM (FDS) INTERFACE

The interface between the fire detection and HVAC systems is to be implemented at the controller level between the Fire Detection Control Panel (FDCP) and the HVAC Controllers. The HVAC controller interface with the fire system is to be via potential free normally closed contacts, receiving signal from fire panels via hard wired links. The interface between the FDS and the HVAC controller complies with 240-56737448 Fire Detection and Life Safety Design Standard.

5. HVAC ELECTRICAL SYSTEMS

HVAC electrical system scope of works is to comprise the following as minimum:

a) 400 V AC HVAC Electrical Distribution Panels
b) Power cabling including control cable, cable racks, earthing, circuit components etc.

The HVAC electrical system scope is to be designed and executed in line with the specified standards as follows:

5.1 400 V AC HVAC ELECTRICAL DISTRIBUTION PANELS

The designs and installation of HVAC Electrical Distribution Panels is to be in accordance with the requirements of 240-56227516 (LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and Including 1000V AC and 1500V) and SANS 10142-1 (The wiring of premises Part 1: Low-voltage installations).

The electrical supply for the HVAC electrical installation is to be fully redundant with A, B & C sections (where specified). The supply cables are to be terminated by into three main sections of the HVAC Panel situated in the HVAC plant room. The HVAC electrical distribution panels are to comprise of the following:

- Section A (to supply power HVAC system A which includes the AHU fans, extract fans, fresh air fans, heater banks, chillers, etc).
- Section B (to supply power HVAC system B which includes the AHU fans, extract fans, fresh air fans, heater banks, chillers, etc).
- Section C (to supply power to common equipment such fresh air system, other non-redundant equipment and all the fire dampers)

HVAC Electrical Distribution Panels which have A, B & C sections are to be configured as depicted in Figure 1. Section A and B are to be designed to have a bus-section such that either section can be fed via the second section. Section A and B are to be designed to have 2 feeders for Section C. These feeders are to have mechanical interlocking mechanism for selection between Section A supply and Section B supply, such that if one section is unavailable the second section can still supply Section C.

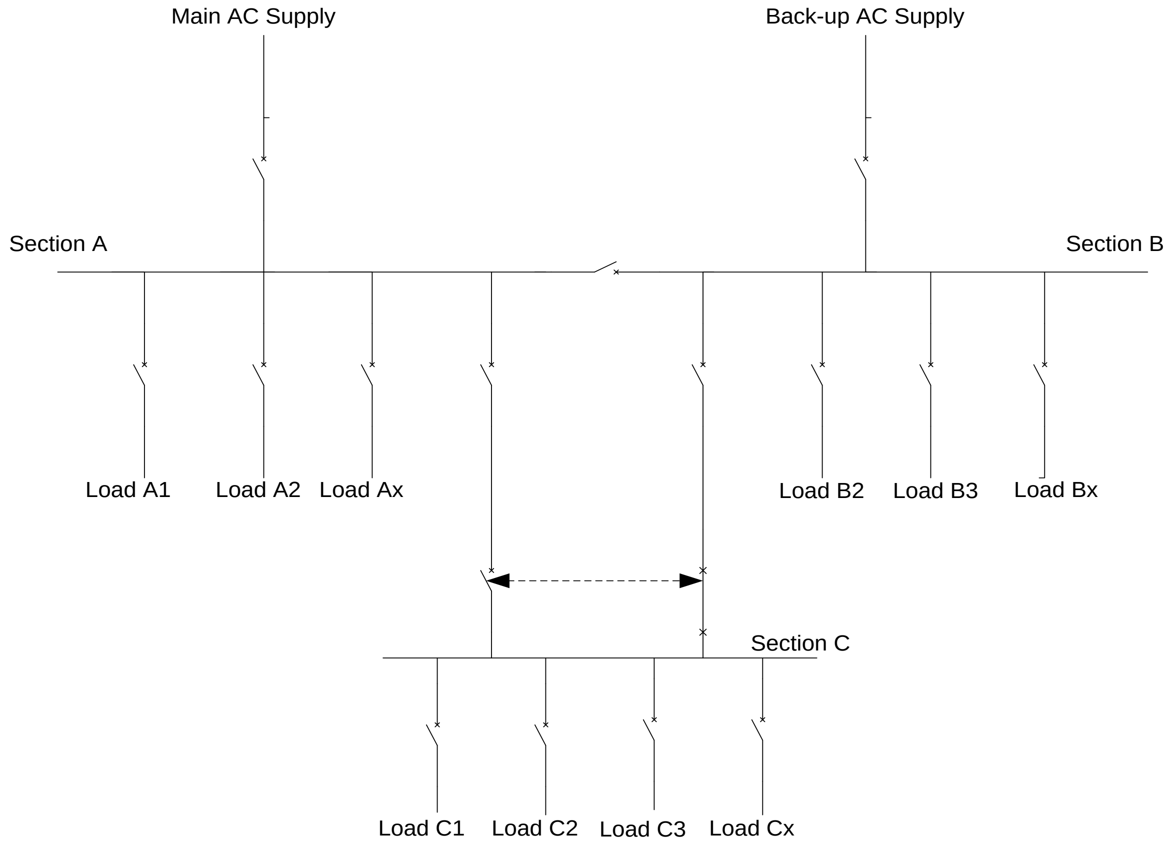

Figure 1: Typical HVAC Electrical Distribution Panel with Section A, B and C

HVAC Electrical Distribution Panels which have one section (where specified) are to be designed as per the single line diagram in Figure 2. These are different from Figure 1 configuration as they only require one power supply.

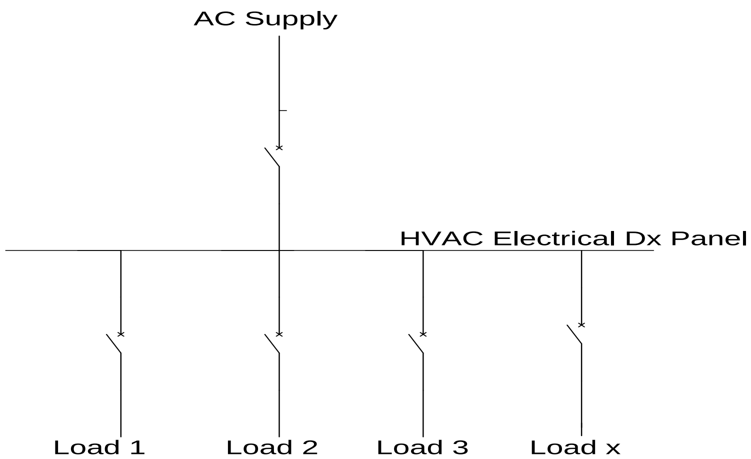

Figure 2: Typical HVAC Electrical Distribution Panel with one section

5.2 CABLING

The complete power and control cabling is to be designed, installed, and commissioned in accordance with the requirements of Eskom Standard 240-56227443 (Requirements for Control and Power Cables for Power Stations Standard). Power cabling includes incoming power cable from electrical switchgear supply source supplying the 400 V HVAC Electrical Distribution Panels; and further includes power cables from HVAC Electrical Distribution Panels feeding HVAC plant equipment.

Cable schedules are to be developed to include the circuit descriptions, cable sizes and lengths, cable numbers, cable types etc. as per Electrical Cable Schedule template 240-56176097.

The load list and load schedules are to be populated as per the following templates:
a) 240-56176097: Electrical Cable Schedule Template
b) 240-56227927: Electrical Load List Template
c) 240-56356421: Electrical LV Switchgear Schedule Template
d) 240-56356465: Electrical LV List of Switchboards Template
e) 240-77301384: Electrical LV Load Schedule Template
f) 240-77302094: Electrical Termination Schedule Template

The bonding and earthing are to be carried out in accordance with the requirements of 240-56356396 (Earthing and Lightning Protection Standard).

6. HVAC BUILDING RELATED WORKS

Indoor HVAC plant rooms that is lockable are preferred to house HVAC equipment and protect them against vandalism and unauthorized. However, dedicated HVAC equipment may be located in close proximity to the conditioned space where indoor HVAC plant rooms are not feasible.

ASHRAE handbook of fundamentals (HVAC Systems and Equipment) recommends the following:
a) The floor space required for HVAC plant rooms varies from 4 to 9 percent of the gross building area.
b) Ceiling height generally varies from 3800 to 6000 mm depending on the amount of overheard ducting system to be installed.
c) The interior shafts for ducting system are to have an aspect ratio ranging from 2:1 to 4:1 to facilitate installation of ductwork between the HVAC plant rooms and shafts. Shafts are to be sized at 10 to 15 percent larger than the initial design requirement to facilitate future growth. Where feasible, separate supply and return/exhaust shafts are to be provided to enable the use of return/exhaust chase as a plenum.

The interface with civil and building's discipline is to be as follows:
a) Allocation and sizes of plant rooms, establishing a ceiling space requirement as well as shafts for ducts and pipes distribution.
b) The building is to be insulated (especially roofs) where heating or/and cooling is requested. Insulation level shall be lower than $1 W/m^2 K$.
c) Any glazing is to be externally shaded via louvers, overhangs or shaded glass. Low U-values and double glazing to be considered for office type buildings.
d) Intake and extract louvers are preferably to be on different facades of the building.
e) Plant rooms are to be centrally located with direct access to outside.
f) All plant rooms are to have drainage, electrical power and water supply connection.
g) Lifting and accesses to the equipment are to be established.

7. HVAC SYSTEMS MOST FREQUENTLY USED IN ESKOM ENVIRONMENT

General Technical Specification for HVAC Systems Standard (240-102547991) describes the equipment and recommends installation requirements which are preferred in Eskom environment.

8. HVAC SYSTEM DESIGN INTERFACES WITH OTHER PLANTS

8.1 INTERFACE WITH AUXILIARY COOLING (CW) SYSTEM

HVAC system uses Auxiliary Cooling for heat rejection from the chillers. The interfaces are as follows:

a) The design parameters of water into chiller condenser should be the same as CW closed circuit supply water (temperature, system pressure).
b) Flow requirements to be an input to CW design.
c) Utilising available pressure or provide booster pumps.
d) Design piping system to the same standard as the auxiliary cooling system standard.
e) Be aware of water quality (i.e. demineralised water) and specify chillers heat exchangers accordingly.
f) Utilise common system of CW.
g) Design termination points and codification

8.2 INTERFACE WITH WATER SYSTEMS

a) Make up water for closed loop chilled water system (preferable potable water).
b) Water supply to humidifiers is to be potable water
c) System drainage from the chiller plant room and condensation from the air handling units to the nearest wastewater system.
d) Termination points design and codification

8.3 INTERFACE WITH CHEMICAL SYSTEMS

Request required quality and quantity of water. Where no required water quality can be received a dedicated water treatment (for example treatment via chemical dosing, desalination etc.) system will Interface with electrical systems.

9. AUTHORISATION

This document has been seen and accepted by:

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10. REVISIONS

Date	Rev.	Compiler	Remarks
September 2013	0.1	D. Kubyane	First Draft for Comment
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September 2015	0.3	C.B. Zdziarski	Draft Document for Comments Review
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February 2022	1.1	N Ndika	Draft Document issued for Comments Review
March 2022	1.2	N Ndika	Draft Document updated to incorporate comments and inputs from Eskom wide reviewers. Draft Document issued to Auxiliary Study Committee Members for Comments Review
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May 2022	2	N Ndika	Final Rev 2 Document for Authorisation and Publication

11. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Dithole Kubyane
- Prenolan Gangan

12. ACKNOWLEDGEMENTS

All team members to as listed under section 9 above.