

Engineering Standard

SAES-K-001

31 May, 2004

Heating, Ventilating and
Air Conditioning (HVAC)

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Saudi Aramco DeskTop Standards

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Revised paragraphs are indicated in the right margin

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1 Scope

- 1.1 This Standard defines the minimum mandatory requirements governing the design and installation of Heating, Ventilation and Air Conditioning (HVAC) systems for all Saudi Aramco buildings and facilities.
- 1.2 Additional HVAC requirements for critical services are covered in:
 - [SAES-K-002](#) *Air Conditioning Systems for Essential Operating Facilities*
 - [SAES-K-003](#) *Air Conditioning Systems for Communication Buildings*
- 1.3 Other mandatory requirements for the installation and maintenance of HVAC systems are covered in:
 - [SAES-K-100](#) *Saudi Aramco Mechanical (HVAC) Code*
- 1.4 For the design and installation requirements of refrigeration systems refer to the Refrigeration Volume of ASHRAE Handbooks.

2 Conflicts and Deviations

- 2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Industry Standards, Codes, Forms, and Saudi Aramco Standard Drawings (SASDs) shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department, Dhahran.
- 2.2 All requests to deviate from this standard shall be directed to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department, Dhahran.

3 References

All referenced Specifications, Standards, Codes, Forms, Drawings and similar material shall be of the latest issue (including all revisions, addenda and supplements) unless stated otherwise.

- 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

<u>SAEP-302</u>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
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Saudi Aramco Engineering Standards

<u>SAES-A-102</u>	<i>Air Pollutant Emission Source Control</i>
<u>SAES-A-104</u>	<i>Wastewater Treatment, Reuse and Disposal</i>
<u>SAES-A-105</u>	<i>Noise Control</i>
<u>SAES-A-112</u>	<i>Environmental and Seismic Design Criteria</i>
<u>SAES-G-005</u>	<i>Centrifugal Pumps</i>
<u>SAES-J-700</u>	<i>Control Valves</i>
<u>SAES-K-002</u>	<i>Air Conditioning Systems for Essential Operating Facilities</i>
<u>SAES-K-003</u>	<i>Air Conditioning Systems for Communications Buildings</i>
<u>SAES-K-100</u>	<i>Saudi Aramco Mechanical (HVAC) Code</i>
<u>SAES-L-005</u>	<i>Limitations on Piping Components</i>
<u>SAES-M-100</u>	<i>Saudi Aramco Building Code</i>
<u>SAES-P-103</u>	<i>Batteries and UPS Systems</i>
<u>SAES-P-113</u>	<i>Motors and Generators</i>
<u>SAES-S-060</u>	<i>Saudi Aramco Plumbing Code</i>

Saudi Aramco Materials System Specifications

<u>27-SAMSS-001</u>	<i>Packaged Water Cooled Centrifugal Chillers for Utility Service</i>
<u>27-SAMSS-002</u>	<i>Direct Expansion Air Conditioning Systems for Offshore Facilities</i>
<u>32-SAMSS-012</u>	<i>Manufacture of Water Cooling Towers</i>
<u>34-SAMSS-611</u>	<i>Safety Relief Valves</i>
<u>34-SAMSS-821</u>	<i>Instrument Control Panel-Outdoors</i>

Saudi Aramco Inspection Procedure

<u>27-SAIP-01</u>	<i>HVAC Inspection Requirements</i>
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Saudi Aramco Standard Drawing

AA-036913 Insulation for Cold Lines

Saudi Aramco Drafting Manual

General Instructions

*GI-0002.710 Mechanical Completion & Performance
Acceptance of Facilities*

GI-0425.000 Refrigerant Management

3.2 Industry Codes and Standards

Air Movement and Control Association International

AMCA 99 Standards Handbook

AMCA 210 Laboratory Methods of Testing Fans for Rating

American Conference of Government Industrial Hygienists

ACGIH Industrial Ventilation Manual

American National Standards Institute

ANSI B31.5 Refrigeration Piping

ANSI B31.9 Building Services Piping

*ANSI B73.1 Specification for Horizontal End Suction
Centrifugal Pumps for Chemical Process*

American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc.

ASHRAE STD 15 Safety Code for Mechanical Refrigeration

ASHRAE STD 52 Filters, Testing Air-Cleaning Devices

*ASHRAE STD 55 Thermal Environmental Conditions for Human
Comfort*

ASHRAE STD 62 Ventilation for Acceptable Indoor Air Quality

*ASHRAE STD 110 Method of Testing Performance of Laboratory
Fume Hoods*

*ASHRAE STD 111 Practice for Measurement, Testing, Adjusting and
Balancing of HVAC Systems*

ASHRAE Handbook HVAC Applications

ASHRAE Handbook Systems and Equipment

ASHRAE Handbook Fundamentals

ASHRAE Handbook Refrigeration

American Society for Testing and Materials

ASTM C552 Specification for Cellular Glass Thermal Insulation

ASTM C930 Classification of Potential Health and Safety Concerns Associated with Thermal Insulation Materials and Accessories

ASTM E84 Test Method for Surface Burning Characteristics of Building Materials

American Water Works Association

AWWA C511 Reduced-Pressure Principle Backflow-Prevention Assembly

Associated Air Balance Council

AABC National Standards for Field Measurement and Instrumentation, Total System Balance, Vol. 1

Joint Commission International Accreditation (JCIA)

National Air Duct Cleaners Association

NADCA Standard 1992-01 Mechanical Cleaning of Non-Porous Air Conveyance System Components

NADCA General Specifications for the Cleaning of Commercial Heating, Ventilating and Air Conditioning Systems

National Environmental Balancing Bureau

NEBB Testing, Adjusting and Balancing of Environmental Systems

National Fire Protection Association

NFPA 1 National Fire Prevention Code

NFPA 45 Fire Protection for Laboratories Using Chemicals

NFPA 70 National Electrical Code

NFPA 90A Installation of Air Conditioning and Ventilating Systems

NFPA 99 *Health Care Facilities*

NFPA 101 *Life Safety Code*

Sheet Metal and Air Conditioning Contractors' National Association, Inc.

SMACNA 1993 *HVAC Systems-Testing, Adjusting and Balancing,*
2nd edition

SMACNA 1995 *HVAC Duct Construction Standards-Metal and*
Flexible, 2nd edition

SMACNA 1992 *Fire, Smoke and Radiation Damper Installation*
Guide for HVAC Systems, 4th edition

Uniform Building Code

UBC STD 43-7 *Test Standard for Fire Dampers and Ceiling*
Dampers

Uniform Mechanical Code (UMC)

4 Design Basis

4.1 Definitions

AIR, AMBIENT: The air surrounding an object.

AIR, OUTSIDE: External air, atmosphere exterior to conditioned space.

AIR, RE-CIRCULATED: Return air passed through the air-conditioning unit before being re-supplied to the conditioned space.

AIR, SATURATED: Moist air in which the partial pressure of water vapor equals the vapor pressure of water at the existing temperature.

AIR, STANDARD: Dry air at a pressure of 101.35 kPa (29.92 in Hg.) at 20°C (68°F) temperature.

AIR, CHANGES: A method of expressing the amount of outside air introduced into a space in terms of the number of space volumes per unit time.

AIR-CONDITIONING, COMFORT: The process of treating air to control its temperature, humidity, cleanliness, and distribution to meet the comfort requirements of the occupants of the conditioned space.

AIR-CONDITIONING UNIT, PACKAGED: An air-conditioning unit having the means of air cooling, air heating, air circulation, air cleaning, and the controls thereof, in the same cabinet with the condensing unit.

AIR CONDITIONING, SPLIT: Air Conditioning system consisting of equipment provided in more than one enclosure, usually with supply air distribution equipment housed separately from the refrigeration equipment.

AIR- HANDLING UNIT: Device, usually connected to ductwork, to move air, which also may clean and temper the air.

AIR INLET OR OUTLET: An opening through which air is delivered into or drawn from a space.

BRITISH THERMAL UNIT (BTU): A BTU is a unit of heat energy. It is defined as 252.9957 calories (777.65 Ft – Lb) and it is the heat required to raise the temperature of one pound of water from 59°F to 60°F.

BLOCK LOAD: Is the sum of cooling loads of zone(s) with various load profiles at the same time, resulting in the maximum space cooling load.

CAPACITY, CONDENSING UNIT: Refrigerating effect produced by the difference in total enthalpy between the refrigerant liquid leaving the condenser coil and the total enthalpy of the refrigerant vapor entering the condenser coil.

CAPACITY, REFRIGERATING: The term used to define the rate of heat removal from a medium or space to be cooled at stated conditions.

CAPACITY, REFRIGERATING, GROSS: The total rate of heat removal from all sources by the evaporator of a refrigeration system at stated conditions.

CEILING OUTLET: A round, square, rectangular, or linear air diffuser in the ceiling which provides a horizontal distribution pattern of primary and secondary air over the occupied zone and induces low velocity secondary air motion through it.

CHILLED WATER: Water used as a cooling medium at below ambient temperature.

CIRCUIT, REFRIGERATING: Assembly of refrigerant-conditioning parts and their connections used in a refrigerating cycle.

COEFFICIENT OF PERFORMANCE (refrigerating): Ratio of the rate of heat removal to the rate of energy input, in consistent units.

COEFFICIENT OF DISCHARGE: The ratio of area at vena contracta to the total free area of an air outlet device.

COIL: A cooling or heating element made of pipe or tubing.

COIL, DIRECT EXPANSION (DX): Coil using the direct refrigeration method.

CONDENSER (refrigerant): A heat exchanger in which the refrigerant, compressed to a suitable pressure, is condensed by rejecting heat to an appropriate external cooling medium.

CONDUCTANCE, SURFACE FILM: Time rate of heat flow per unit area under steady conditions between a surface and a fluid per unit temperature difference between the surface and fluid.

CONDUCTANCE, THERMAL: Time rate of heat flow through a body from one of its bounding surfaces to the other per unit temperature difference between the two surfaces, under steady conditions.

CONDUCTIVITY, THERMAL: Time rate of heat flow through unit area and unit thickness of a homogeneous material under steady conditions when a unit temperature gradient is maintained in the direction perpendicular to area.

CONDUCTION HEAT GAIN (or loss): The heat gain (or loss) caused by difference in outdoor and indoor temperatures.

CONSTANT VOLUME SYSTEM: Operates on the principal of supplying a constant volume of air to a single zone of conditioned space. Capacity control of this type of system is achieved by varying the amount of heat removal from (or addition to) the air stream.

CONVECTION: Heat transfer by the movement of a fluid.

COOLING CAPACITY, SENSIBLE: Available capacity of an air-conditioning system for removing sensible heat from the conditioned space.

COOLING CAPACITY, LATENT: Available capacity of an air-conditioning system for removing latent heat from the conditioned space.

COOLING CAPACITY, TOTAL: Available capacity of an air-conditioning unit for removing sensible and latent heat from the conditioned space.

COOLING COIL LOAD: The rate at which energy is removed at the cooling coil that serves one or more conditioned space in a central air-conditioning system.

COOLING, EVAPORATIVE: Sensible cooling obtained by latent heat exchange from water sprays.

COOLING LOAD: The rate at which heat must be removed from the space to maintain the room air temperature.

COOLING WATER: Water used for the condensation of a refrigerant; condenser water.

CORE AREA: The total plane area of that portion of a grills, included within lines tangent to the outer edges of the outer openings, through which air can pass.

CYCLE, REFRIGERATING: A sequence of thermodynamic processes through which a refrigerant passes, in a closed or open system to absorb heat at a relatively low temperature level and reject heat at a relatively higher temperature level.

DAMPER: A device used to vary the volume of air passing through a confined cross section by varying the cross sectional area.

DECIBEL: See SOUND POWER LEVEL.

DEHUMIDIFICATION: 1) Condensation of water vapor from air by cooling below the dew point temperature; 2) Removal of water vapor from air by chemical or physical methods.

DEW POINT TEMPERATURE: The temperature at which water has reached the saturation point (i.e.: 100% relative humidity).

DIFFUSER: An outlet discharging supply air in various directions and planes.

DUCT: A passageway made of sheet metal or other suitable material, not necessarily leak tight, used for conveying air or other gas at low pressures.

EFFECTIVE AREA: The net area of an outlet or inlet device through which air can pass, equal to the free area times the coefficient of discharge.

ENTHALPY: A thermodynamic property of a substance defined as the sum of its internal energy plus the quantity Pv/J ; where P =pressure of the substance, v =its volume, and J =the mechanical equivalent of heat.

EVAPORATION: Change of state from liquid to vapor.

EVAPORATOR (refrigerant): A heat exchanger in which liquid refrigerant, after reducing its pressure (through expansion), is evaporated by absorbing heat from a medium to be cooled.

EXCEEDANCE TEMPERATURE: Represents the temperature that is exceeded on average by the indicated percentage of the total number of hours in a year.

EXFILTRATION: Airflow outward through a wall, leak membrane, etc.

ENTRAINMENT: The secondary air motion of room air generated by the primary air stream discharged from an outlet.

FAN COIL UNIT: Fan and a heat exchanger for cooling and/or heating, assembled within a common casing.

FENESTRATION: Any opening transmitting light in a building's wall or roof.

FINS PER INCH(FPI): The number of fins in a coil per 25.4 mm (1 inch).

FREE AREA: The total minimum area of the openings in the air inlet or outlet through which air can pass.

GRILL: A covering for any opening through which air passes.

HEAT EXTRACTION RATE: The rate at which heat is removed from a conditioned space.

HEAT TRANSMISSION: Heat flow rate; usually refers to conduction, convection, and radiation combined.

HEAT TRANSMISSION COEFFICIENT: Coefficients used in calculating heat transmission by conduction, convection, and radiation, through various materials and structures.

HUMIDITY: Water vapor within a given space.

HUMIDITY, ABSOLUTE: The weight of water vapor per unit volume.

HUMIDITY, RELATIVE: The ratio of the mole fraction of water vapor present in the air to the mole fraction of water vapor present in saturated air at the same temperature and barometric pressure.

INDUCTION: The movement of room air drawn into an outlet by a primary air stream.

INFILTRATION: Air flowing inward as through a wall, leak, etc.

LOAD PROFILE: Is a chart showing the variation of space load over a certain time period, such as a 24-hour cycle.

LOUVER: Device comprising multiple blades which, when mounted in an opening, permits the flow of air but inhibits entrance of other elements in a reverse direction.

OUTLET VELOCITY: The average velocity of air emerging from an air outlet, measured in the plane of opening.

PRESSURE, ABSOLUTE: Pressure above a perfect vacuum. It is the sum of gauge pressure and atmospheric pressure.

PRESSURE GAUGE: Pressure above atmospheric.

PRESSURE, VELOCITY: In a moving fluid, the pressure capable of causing an equivalent velocity, if applied to move the same fluid through an orifice, such that all pressure energy expended is converted into kinetic energy.

PRESSURE DROP: Static pressure loss in fluid pressure, as from one end of a duct to the other, due to friction, fittings, etc.

PRIMARY AIR: The air delivered to the air outlet by the supply duct.

PSYCHROMETRY: The branch of physics relating to the measurement or determination of atmospheric conditions, particularly regarding the moisture mixed with the air.

RADIATION, THERMAL: Transmission of heat through space by wave motion; passage of heat from one object to another without warming the air in between.

REFRIGERANT: The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid.

REGISTER: A grille equipped with a damper or control valve.

ROOM VELOCITY: The residual air velocity level in the occupied zone of the conditioned space.

SHADING COEFFICIENT: The ratio of solar heat gain through a glazing system under a specific set of conditions to solar gain of the reference glass under the same conditions.

SOLAR HEAT GAIN: The heat gain caused by transmitted and absorbed solar energy.

SOLAR HEAT GAIN FACTORS: Heat gain values through sunlit glass calculated for daylight hours of the twenty-first day of each month.

SOUND ATTENUATION: The reduction in sound power. For a duct it is expressed in units of decibels per meter (dB/m) indicating the average reduction of sound power level for each meter of duct length.

SOUND BAND PRESSURE LEVEL: The sound pressure level for the sound contained within the restricted band, based on a reference pressure.

SOUND POWER LEVEL: Ten times the logarithm (base 10) of the ratio of a given sound power to a reference power.

SPREAD: The divergence of an air stream in a horizontal or vertical plane after it leaves the outlet.

SUCTION LINE: A tube or pipe that carries refrigerant vapor from the outlet of the evaporator to the compressor inlet.

SYSTEM, DIRECT EXPANSION: A refrigerating system in which the evaporator is in direct contact with refrigerated material or space, or is located in air circulating passages communicating with such space.

TEMPERATURE, DRY BULB: The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

TEMPERATURE, WET BULB: Thermodynamic wet bulb temperature is the temperature at which liquid or solid water, by evaporating into air, can bring the air to saturation adiabatically at the same temperature.

TEMPERATURE VARIATION of the conditioned space: The temperature difference between different points of the same space.

THERMAL CONDUCTANCE: The thermal transmission through a unit area of a body or assembly with defined surfaces when a unit average temperature difference is established between the surfaces.

THERMAL CONDUCTIVITY: The thermal transmission through a unit area of a thermally homogeneous and isotropic material in a direction perpendicular to the surfaces, with a temperature gradient of unity between the surfaces.

THERMAL RESISTANCE: The reciprocal of thermal conductance.

THERMAL TRANSMISSION: The quantity of heat flow in unit time under the conditions prevailing at that time.

THERMAL TRANSMITTANCE: The thermal transmission through unit areas of a body or assembly where the difference between the fluid temperatures on either side of the body or assembly is unity.

THROW: The horizontal or vertical axial distance an air stream travels after leaving an air outlet before the stream velocity is reduced to a specified terminal level.

TON OF REFRIGERATION: The refrigerating effect equal to 3516 watts (12,000 Btu/hr).

TOTAL AIR DISCHARGE: The mixture of discharged air and entrained air.

TRANSMITTANCE, THERMAL (U factor): The time rate of heat flow per unit area under steady conditions from the fluid on the warm side of a barrier to the fluid on the cold side, per unit temperature difference between the two fluids.

VANE: A thin plate in the opening of a grille.

VAPOR BARRIER: A moisture impervious layer applied to the enclosing a humid space to prevent moisture travel to a point where it may condense due to lower temperature.

VAV: Operates on the principal of constant supply air temperature at varying supply airflow rate.

VENTILATION: The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

ZONE: Is a space having the same orientation, exposure and similar internal load characteristics.

ZONE PEAK LOAD: Is the maximum space cooling load for a particular zone.

4.2 Environmental Conditions

4.2.1 Climatic Conditions

- 4.2.1.1 The 2.5 % exceedance temperature values given in [SAES-A-112](#); shall be used as the minimum ambient design criteria for HVAC system design, equipment selection and equipment specification purposes for the geographic areas listed for all Saudi Aramco facilities.

Exception:

The sizing and selection criteria listed in paragraphs 4.2.1.6 and 4.2.1.7 below.

- 4.2.1.2 The 1% exceedance values or other stricter design criteria shall only be used for facilities with unusually stringent environmental control requirements and with the concurrence of the HVAC Standards Committee Chairman.
- 4.2.1.3 Design data for locations, not listed in [SAES-A-112](#) shall be determined by the Project Team with the concurrence of the Environmental Protection Department.
- 4.2.1.4 For all HVAC Systems: Cooling load shall be calculated with the Summer Design Dry Bulb and Mean Coincident Wet Bulb temperatures, and the supply air requirements shall be determined at these temperatures.
- 4.2.1.5 For HVAC systems of 5 Tons and larger: In addition to the calculations performed in paragraph 4.1.1.4 above, cooling load shall also be calculated at the Design Wet Bulb and coincident Dry Bulb temperatures to determine which set of conditions results in larger HVAC system capacity. This will determine the cooling capacity of the refrigeration system, while the air-side capacity would have been determined from paragraph 4.1.1.4.
- 4.2.1.6 For sizing evaporative coolers, the Summer Design Wet Bulb temperature at 1% exceedance + 2°F shall be used.
- 4.2.1.7 For the selection of air cooled packaged units, air cooled condensers and air cooled chillers, the following shall be used:
1. The Summer Design Dry Bulb temperature at 1% exceedance + 10°F for facilities located within plant areas.
 2. The Summer Design Dry Bulb temperature at 1% exceedance + 5°F for facilities located in areas other than plant areas.
- 4.2.1.8 WIND: The prevailing wind direction in the eastern province is 15 degrees West of North. A wind velocity of
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24 kilometers per hour (15 mph) shall be used for outdoor air film resistances for both summer and winter conditions.

4.2.2 Indoor Design Conditions

4.2.2.1 Table 1 contains the minimum indoor conditions to be used for the design of HVAC systems in selected Saudi Aramco facilities.

4.2.2.2 Design conditions for occupancies other than those listed in Table 1 shall comply with the recommendations of the ASHRAE Handbooks; ASHRAE STD 55; applicable health and safety codes and equipment manufacturers' requirements. The concurrence of the HVAC Standards Committee Chairman is required for these different occupancies.

4.2.2.3 HVAC systems shall be capable of maintaining dry bulb temperature and relative humidity (if applicable) within the performance range given in Table 1 unless stricter indoor design conditions are required.

4.2.3 Ambient Air Quality

HVAC Systems shall be designed for the ambient air quality defined in [SAES-A-102](#), Air Pollutant Emission Source Control.

4.3 Load Calculation

4.3.1 General Requirements

4.3.1.1 HVAC load calculations shall be in accordance with ASHRAE Handbook methods.

4.3.1.2 Design softwares used to perform HVAC load calculations shall be as per the ASHRAE method. Upon request documentation from the originator confirming this shall be provided.

4.3.1.3 Loading factors for people, equipment and lighting shall be considered in the cooling load calculations.

4.3.1.4 The HVAC load calculations shall include an overall excess capacity in the range of 5%-10%, due to safety factors or reserve capacity requirements.

4.3.1.5 Residential HVAC load calculation method shall only be used for residential applications.

Table 1 – Inside Design Conditions

Facility	DB C (°F)	Percent Relative Humidity	Tolerance	
			Air Motion m/s(fps)	DB C (°F) (% RH)
Offices, schools, theaters	24 (75)	50%	0.075-0.25 (0.25-0.82)	+ 2 (+ 3.6) + 20%
Shops, houses, apartments, trailers, dining halls and stores	24 (75)	50%	0.075-0.25 (0.25-0.82)	+ 2 (+ 3.6) + 20%
Computer rooms, control rooms, communication facilities, process, interface buildings, analyzer houses	22 (72)	50%	0.075-0.25 (0.25-0.82)	+ 2 (+ 3.6) + 10%
Unattended equipment rooms (excluding communication rooms)	29 (85) (Unless otherwise required by equipment manufacturers)			
Unattended electrical substations	35 (95)	-	-	-
Hospitals and clinics (various rooms)	Refer to ASHRAE Applications Handbook & JCIA			
Laboratories	Refer to ASHRAE Applications Handbook			

4.3.1.6 Overall building cooling and heating loads shall be calculated. Zoning, exposure, and building mass shall be considered in heating and cooling load calculations.

4.3.1.7 The air conditioning system shall provide comfort conditions in all rooms throughout the operating period.

4.3.1.8 Each zone, room and portion of a room with a different load profile, orientation or sensible load shall be calculated.

4.3.1.9 A separate block load for each air handling system shall be calculated.

4.3.1.10 HVAC units re-circulating or recycling indoor air within a room (such as through the wall window units, fan coil units or mini-split direct expansion units) shall not be used within communication rooms, battery rooms and rooms housing sensitive electronic equipment.

4.3.2 Cooling Loads

4.3.2.1 During load calculations all sensible and latent heat sources shall be considered.

4.3.2.2 Sensible cooling load shall be calculated for building envelope, people, lights, equipment and for outside air that is introduced into the system by air make-up or by infiltration.

4.3.2.3 Latent cooling load shall be calculated for people, outside air and any process in which moisture is given up to the air.

4.3.3 Heating Loads

Loads shall include heat losses from outside surfaces (roofs, walls, windows, raised floors); interior non-conditioned spaces (partitions, ceilings, floors); make up air and infiltration; duct and plenum losses.

4.3.4 Psychrometric Charts

A psychrometric analysis and chart shall be provided for each air handler with the cooling/heating load calculations. This analysis shall include, but not necessarily be limited to:

- a) mixing temperature of outside and return air streams
- b) entering air condition at coil
- c) leaving air condition at coil
- d) room design conditions
- e) outside design condition
- f) entering air enthalpy at coil
- g) leaving air enthalpy at coil

4.4 System Considerations

4.4.1 Zoning

In buildings which have separate interior and perimeter rooms, each room or group of rooms with a distinctive load profile shall have individual temperature control.

Exemption:

Residential buildings and unoccupied rooms.

4.4.2 Air System Design

4.4.2.1 Air Distribution Systems shall be designed in accordance with ASHRAE Fundamentals Handbook, Duct Design section.

- 4.4.2.2 Air outlets and inlets shall be shown on HVAC drawings and indicated in schedules, as specified in Section 4.6, Design Documentation Requirements. Manufacturer's standard diffusers, registers and grilles shall be used.
 - 4.4.2.3 Fresh air intakes shall be designed and located to minimize intrusion of contaminants and dust.
 - 4.4.2.4 Return air shall be drawn through the ceiling plenum, whenever practical. The material within ceiling plenums shall meet the requirements of paragraph 4.5.12.11 of this standard.
 - 4.4.2.5 In all HVAC systems the return air and fresh air shall be ducted to the air handling unit within the A/C equipment room.
 - 4.4.2.6 The A/C Equipment Room shall not be used as a return or fresh air plenum.
- 4.4.3 Cooling Source
- 4.4.3.1 The selection of a cooling source requires an analysis of the various alternatives. If chilled water from an existing central plant is available in sufficient quantities and in close proximity, it shall be considered the first choice for a cooling source.
 - 4.4.3.2 Design parameters for existing central chilled water supply are:
 - 1) Supply temperature 9°C (48°F)
 - 2) Maximum pressure drop through system 140 kPa (20 psi)
 - 3) Chilled water demand: 0.05 L/S per kW (3 GPM/Ton)
 - 4) Temperature rise of 4.5°C (8°F).

If the above design parameters are not suitable for a specific application, the responsible utility organization shall be contacted for more detailed information on a specific location. Concurrence of the HVAC Standards Committee Chairman is required for any variation to the above design parameters.

4.4.3.3 Condenser Water

4.4.3.3.1 Dedicated refrigeration equipment shall use air cooled condensers, except where an analysis of a project specific conditions, or site utilities, or cooling load characteristics justify condenser water (sea water or cooling towers).

4.4.3.3.2 Use of water cooled condensers requires an evaluation of the condenser water fouling characteristics and it's availability.

4.4.3.4 In remote locations, the use of water chillers is restricted to locations where adequate water supply for system make-up is available.

4.4.4 Control Systems

4.4.4.1 HVAC systems shall be designed and installed using commercially available equipment and techniques to control temperature, and when required, humidity, pressure and odors.

4.4.4.2 All thermostats shall be manually adjustable over the operating range.

4.4.4.3 HVAC units shall automatically shut down when fire alarm system is activated, in accordance with [SAES-M-100](#), NFPA 90A and NFPA 101.

4.4.4.4 Chilled water pump control panel located outdoors shall be weatherproof and dustproof in accordance with [34-SAMSS-821](#).

4.4.4.5 For all electric resistance heaters airflow switches shall be provided.

4.4.4.6 All Building Management Systems (BMSs) shall be BAC net compatible.

4.4.5 Piping, Coils and Appurtenances

4.4.5.1 Location of air conditioning equipment components shall be selected to minimize piping and equipment pressure drop.

- 4.4.5.2 Adequate access space shall be provided for the removal of any coil or other equipment component, as per equipment manufacturer's recommendation.
- 4.4.5.3 Multiple compressor refrigerant piping shall be interconnected in accordance with manufacturer's recommendations.
- 4.4.5.4 The refrigerant lines of split condenser/compressor or compressor/evaporator units, separated by more than 3 m (9.84 feet), shall be sized in accordance with ASHRAE Fundamentals Handbook, Refrigerant Line Sizing section or as per HVAC equipment manufacturer recommendation
- 4.4.5.5 Strainers Serviceable strainers and discharge check valves shall be provided immediately before the following:
- Control valves
 - Flow meters
 - Pumps(strainer location as per manufacturer recommendations)
- 4.4.5.6 All chilled water piping systems shall include a valved, potable water make-up connection. In addition to the shut-off valve, the make-up water connection shall include a reduced pressure type backflow preventer, manufactured to AWWA C511 standard.
- 4.4.5.7 Dissimilar metal piping connections, shall comply with the following:
- 1) Be exposed and accessible, this shall include valved connections.
 - 2) Provided with insulating unions or insulating flange sets.
- 4.4.5.8 Hydronic piping shall be fabricated and installed in accordance with [SAES-K-100](#), "Saudi Aramco Mechanical (HVAC) Code". Piping and valves shall be identified.
- 4.4.5.9 Minimum design pressure for all chilled water system components shall be 1035 kPa, gauge (150 psig).
- 4.4.5.10 Chilled water pumps shall be upstream of chillers.
-

- 4.4.5.11 Expansion tank shall be connected to the chilled water pump suction line.
- 4.4.5.12 Chilled water expansion tanks shall be equipped with sightglass to provide indication of system water level.
- 4.4.5.13 Packaged equipment shall come complete with all internal piping, controls, electrical wiring, valves, pumps, fans, etc.
- 4.4.5.14 Automatic air-vents shall be provided at the, or close to the highest elevation within a chilled water system.

4.4.6 Valves

4.4.6.1 Control Valves

- 2-way control valves are to be used in water coils with variable flow.
- 3-way control valves are to be used in water coils with constant flow.
- Control valves shall be selected as per [SAES-J-700](#).
- 2-way control valves shall be located on the discharge of each water coil as shown in Figure1.
- 3-way control valves shall be located on the discharge of each water coil as shown in Figure2.
- The pressure drop in a control valve at the full open position shall not be less than one-half the pressure drop across branches A-B shown in Figures 1 and 2.

4.4.6.2 Balancing Valves

4.4.6.2.1 "Circuit Setter", or equivalent:

4.4.6.2.1.1 Location

On the discharge side of the water coil, downstream of the control valve, as shown in Figures 1 and 2.

4.4.6.2.1.2 Requirements

- Differential pressure readout ports, with built-in check

valves, across balancing valve seat area.

- Provision to allow control valve to be closed and re-opened to set point without disturbing balance position.
- Control Valve to be bronze body and brass ball construction with glass and carbon filled TFE seat rings for ½" to 3" pipe size.

4.4.6.2.2 Globe Valve:

Location

- Around 2-way and 3-way control valves, as shown in Figures 1 and 2.
- On the by-pass piping between the supply piping and the third port of a 3-way control valve, as per Figure 2. The pressure drop in this valve shall be as close as possible to the pressure drop through the coil.

4.4.6.3 By-Pass Valves

By-pass valves shall be located around the following:

- Control valves
- Flow meters

4.4.6.4 Flush Valves

Flush valves shall be provided at the following locations:

- On the supply pipe of a water coil after the isolation valve, as shown in Figures 1 and 2.
- On the return pipe of a water coil before the isolation valve, as shown in Figures 1 and 2.

4.4.6.5 Isolation Valves

Isolation valves shall be provided at the following locations:

- On the supply pipe of a water coil up-stream of the flush valve, as shown in Figures 1 and 2.
- On the return pipe of a water coil down-stream of the flush valve, as shown in Figures 1 and 2.
- On the suction and discharge branch piping of chilled water pumps and suction strainers, without disturbing chilled water system operation.

4.4.7 Pressure measurement

4.4.7.1 Pressure gauges or combination pressure/temperature insertion plugs, such as Pete's Plug, shall be installed on water coils, at the following locations:

- On the supply pipe, down-stream of the isolation valve, as shown in Figures 1 and 2.
- On the return pipe, up-stream of the isolation valve, as shown in Figures 1 and 2.
- On the suction and discharge branch piping of chilled water pumps.

4.4.7.2 Pressure gauges shall be installed on direct expansion air cooled condensing units at the following locations:

- On the suction side of positive displacement compressors, complying with manufacturer's recommendations.
- On the discharge side of positive displacement compressors, complying with manufacturer's recommendations.
- On the oil side capable of measuring oil pump discharge pressure, complying with manufacturer's recommendations.

4.4.8 Temperature Measurement

Thermometer wells or combination pressure/temperature insertion plugs, such as Pete's Plug, shall be installed at the following locations:

- On the supply pipe of a water coil down-stream of the isolation valve, as shown in Figures 1 and 2.
- On the return pipe of a water coil up-stream of the isolation valve, as shown in Figures 1 and 2.

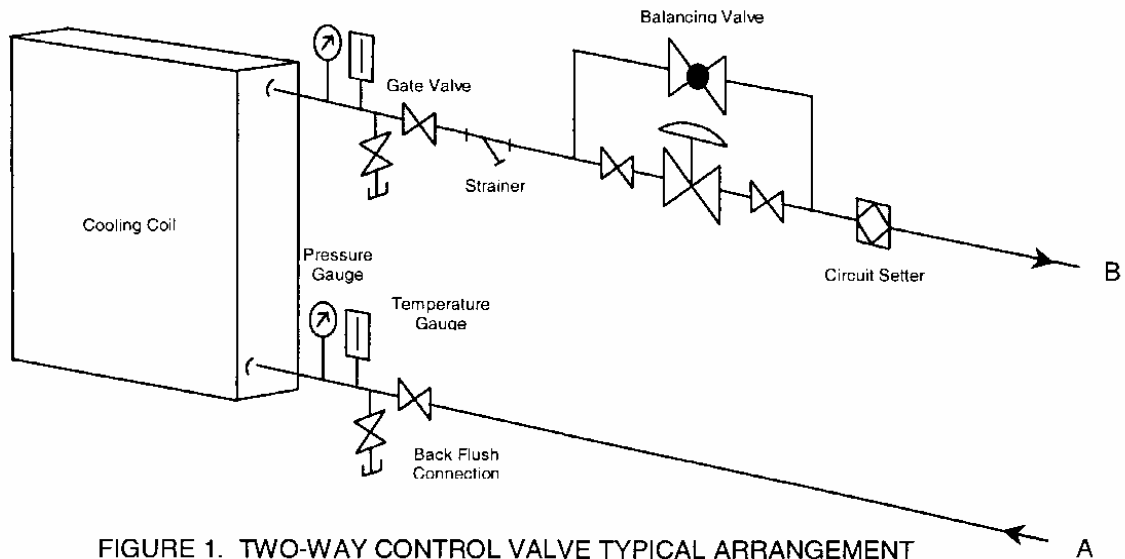


FIGURE 1. TWO-WAY CONTROL VALVE TYPICAL ARRANGEMENT

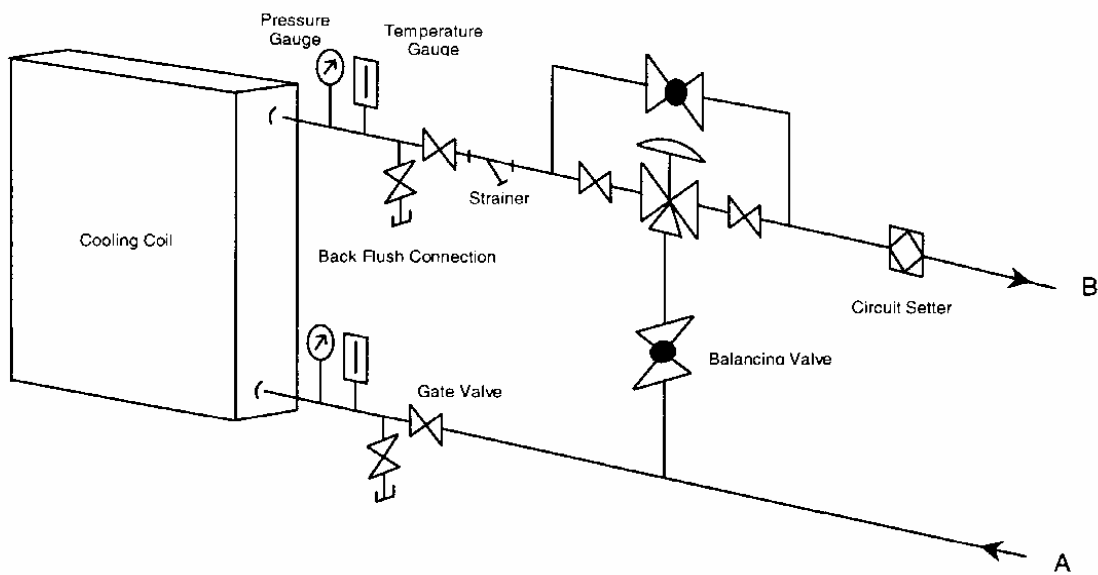


FIGURE 2. THREE-WAY CONTROL VALVE TYPICAL ARRANGEMENT

4.4.9 Humidity Control

To provide humidity control the following is required:

- 1) Water blowdown for all humidifiers. This is to minimize solids build up in the humidifier.
- 2) Duct humidistat with high-limit setting capability. This is so as to limit moisture carry over and condensation in the duct.
- 3) Under normal operation the humidifier shall be controlled by a return air or space humidistat sensor.

4.4.10 Ventilation and Exhaust

4.4.10.1 All enclosed portions of buildings, customarily used by occupants, shall be provided with fresh ventilation air.

4.4.10.2 The minimum amount of outside air shall equal the greater of the following:

- a) 5% of supply air plus all exhaust air.
- b) The ventilation air requirements listed in Table 2 of ASHRAE STD 62.

Exception:

No outside/make-up air is required for residences. However, infiltration load shall be accounted for at a minimum rate of 0.5 air change per hour in heating/cooling load calculations.

4.4.10.3 Toilet rooms exhausts require the following:

- a) A mechanically operated exhaust system capable of providing a minimum of four (4) air changes per hour.
- b) Exhaust shall be directly to the outside with a point of discharge of at least 1.5 m away from any openable window or door, and a minimum of 1m above and 3 m away from any air intake.
- c) Re-circulation of air from toilet rooms, janitor closets, locker rooms and such are not allowed.

4.4.10.4 Occupied non-air conditioned enclosed spaces shall require the following:

- a) A mechanically operated forced ventilation system.
-

- b) Ventilation airflow rate shall be chosen to ensure that space temperature does not exceed the ambient outdoor temperature by more than 10°F.
 - c) Ventilation air intakes shall be designed and located to minimize sand and dust intrusion.
- 4.4.10.5 Ventilation of flammable or toxic materials:
- a) All buildings or portions thereof where flammable or toxic materials are used, shall be analyzed by an Industrial Hygienist for the required fresh air ventilation rate.
 - b) Exhaust ventilation shall be taken from a point at or near the floor level for gases heavier than air, and from the ceiling or near to the ceiling level for gases lighter than air.
- 4.4.10.6 All building exhausts shall be separated by at least that listed in paragraph 4.3.10.3.b, above.
- 4.4.10.7 Battery room ventilation rate shall be in accordance with [SAES-P-103](#) and [SAES-K-002](#).
- 4.4.10.8 For ventilation requirements of wastewater treatment facilities see [SAES-A-104](#), "Wastewater Reuse and Land Development".
- 4.4.10.9 Every automotive type garage, where vehicles operate under their own power, shall either have mechanical exhaust system, or have permanent openings to the outside.
- 4.4.10.10 Refer to [SAES-M-100](#), "Saudi Aramco Building Code" for general ventilation and exhaust requirements. In case of conflict between this Standard and [SAES-M-100](#), the stricter of the two shall govern.
- 4.4.10.11 Hospital ventilation and exhaust shall be designed in accordance with Joint Commission International Accreditation (JCIA).

4.5 Noise

Noise shall comply with [SAES-A-105](#), "Noise Control". ASHRAE Systems Handbook recommended indoor design goals shall be used for air-conditioning system sound control.

4.6 Water Treatment

4.6.1 Condenser water shall have the following:

- 1) Condenser water treatment, including scale inhibitors, corrosion inhibitors, dispersants/antifoulants and biocide as a minimum. Condenser water treatment shall comply with the ASHRAE Applications Handbook, Chapter on Water Treatment.
- 2) Blow down shall be automatic, and controlled by a conductivity controller set at the maximum allowable concentration of Total Dissolved Solids (TDS).

4.6.2 Closed chilled or hot water systems shall be treated with a corrosion inhibitor. This corrosion inhibitor shall be a buffered, nitrite based product, with sodium nitrite residual in the range of 700 to 1200 ppm or molybdate in the range of 250-350 ppm; and with a pH of 7 or higher.

4.7 Special Applications

4.7.1 Health Care Facilities

4.7.1.1 Health care facilities including hospitals, clinics, medical facilities, outpatient healthcare facilities, dental care facilities and medical laboratories shall have HVAC systems designed in accordance with the latest edition of the following:

<i>JCIA</i>	<i>Joint Commission International Accreditation</i>
<i>ASHRAE</i>	<i>HVAC Applications Handbook, Chapter on Health Care Facilities</i>
<i>ASHRAE STD 62</i>	<i>Ventilation for Acceptable Indoor Air Quality</i>
<i>ACGIH</i>	<i>Industrial Ventilation Handbook</i>
<i>NFPA 99</i>	<i>Health Care Facilities</i>

4.7.1.2 Indoor air conditions including temperature, humidity, air change rates and air quality of each area of a health care facility shall be as per recommendations of ASHRAE, HVAC Applications Handbook Chapter on Health Care Facilities.

- 4.7.1.3 Filtering efficiencies of each area shall be in accordance with ASHRAE STD 52 and ASHRAE HVAC Applications handbook, Chapter on Health Care Facilities.
 - 4.7.1.4 Recirculating of air is permitted only from the areas recommended in ASHRAE HVAC Applications Handbook, Chapter on Health Care Facilities.
 - 4.7.1.5 Outdoor air requirements for ventilation shall be in accordance with ASHRAE STD 62 and ASHRAE HVAC Applications Handbook, Chapter on Health Care Facilities. In case of conflict, the stricter requirements shall govern.
 - 4.7.1.6 Pressure relationships to adjacent areas (indicated as positive or negative) shall be as per ASHRAE HVAC Applications Handbook, Chapter on Health Care Facilities.
 - 4.7.1.7 Air from health care laboratories shall be continuously discharged to the outdoors and the area shall be maintained at a negative pressure relative to the pressure of other adjacent areas.
 - 4.7.1.8 Air from health care laboratories shall not be recirculated.
 - 4.7.1.9 Exhaust air from fume hoods or safety cabinets of infectious disease and virus laboratories shall be sterilized before being exhausted to the outdoors, and meet the requirements of ASHRAE HVAC Applications Handbook, Chapter on Health Care Facilities.
 - 4.7.2 Chemical Laboratories
 - 4.7.2.1 Chemical laboratories shall have HVAC Systems designed and operated in accordance with the latest edition of the following:

<i>ASHRAE STD 62</i>	<i>Ventilation for Acceptable Indoor Air Quality</i>
<i>ASHRAE</i>	<i>HVAC Applications Handbook, Chapter on Laboratories</i>
<i>ACGIH</i>	<i>Industrial Ventilation Manual</i>
<i>NFPA 45</i>	<i>Fire Protection for Laboratories Using Chemicals</i>
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*ASHRAE STD 110 Method of Testing Performance
of Laboratory Fume Hoods*

- 4.7.2.2 Indoor air conditions including temperatures, humidity, air change rates and air quality shall be as per ASHRAE, HVAC Applications Handbook, Chapter on Laboratories.
- 4.7.2.3 Outdoor air requirements for ventilation shall be in accordance with ASHRAE STD 62.
- 4.7.2.4 Filtering efficiencies shall be in accordance with ASHRAE STD 52 and ASHRAE HVAC Applications Handbook, Chapter on Laboratories.
- 4.7.2.5 Air from chemical laboratory work areas shall be continuously discharged to the outdoors and the area shall be maintained at a negative pressure relative to adjacent areas.
- 4.7.2.6 Air from chemical laboratories shall not be recirculated.
- 4.7.2.7 Ductwork, hoods, fans, drives and other system components shall be designed and selected to meet the specific requirements of chemical laboratories such as fire, explosion, corrosion and acid resistant.
- 4.7.2.8 Automatic fire dampers shall not be used in laboratory hood exhaust systems.
- 4.7.2.9 Fire detection and alarm systems shall not be interlocked to automatically shut down laboratory hood exhaust fans.
- 4.7.2.10 Fume hood exhaust shall be designed in accordance with the latest edition of Uniform Mechanical Code (UMC), and the Industrial Ventilation Manual of the American Conference of Governmental Industrial Hygienists (ACGIH).
- 4.7.2.11 Airflow indicators shall be installed on all new laboratory hoods, in accordance with the requirements of NFPA 45. If existing laboratory hoods are modified then airflow indicators shall also be installed.
- 4.7.2.12 When installed or modified, and at least annually thereafter, laboratory hoods, laboratory hood exhaust systems, and

laboratory special exhaust systems shall be inspected and tested, as described in section 6-14.1 of NFPA 45.

4.8 Equipment and System Component Requirements

4.8.1 Equipment Identification and Documentation

4.8.1.1 All HVAC equipment shall be identified by mark/tag numbers and shall be listed with such identification on the HVAC Equipment Schedule of drawings.

4.8.1.2 Name Plate

4.8.1.2.1 An identification tag or name plate made of 316 stainless steel or better, and shall be attached to each equipment unit, securely with stainless steel or Monel fasteners.

4.8.1.2.2 The tag or name plate shall be marked by raised letters or die-stamping with at least the following information:

- a) Purchase Order Number
- b) Manufacturer
- c) Part/Model No.
- d) Serial No.
- e) Date of Manufacture
- f) Mark/Tag No., etc.

Exception:

Window units and other consumer type equipment under 7000 W (2 tons).

4.8.1.2.3 The tag or name plate shall be located such that the information is visible and can be read after equipment installation.

4.8.1.3 Each water chilling package, chilled water pump package, and air handling unit shall be provided with installation, operating, and maintenance manuals and all other required documentation. These manuals shall include all detailed technical information necessary for the initial installation,

startup, operation, and maintenance of all furnished equipment.

4.8.2 Saudi Aramco Materials System Specifications (SAMSSs)

4.8.2.1 Equipment shall be selected from Class 27 of the Saudi Aramco Material Catalog, whenever possible. Manufacturer's name and model number with the required capacity, performance data and name plate information shall be given in the design documents.

4.8.2.2 Equipment not listed in the SAMSS catalog shall be specified in design documents in accordance with all applicable Saudi Aramco and Industry Standards.

4.8.3 Mechanical Refrigeration

4.8.3.1 Mechanical Refrigeration systems and equipment shall conform to the requirements of [SAES-K-100](#), "Saudi Aramco Mechanical (HVAC) Code."

4.8.3.2 Packaged, air cooled, reciprocating condensing units shall require only refrigerant piping and electrical connections in order to be placed in operation.

4.8.3.3 The compressor capacity of packaged, air cooled, reciprocating water chillers shall not exceed 50 tons.

4.8.3.4 Each condensing unit shall be complete with all operational equipment, including solenoid valve, sight glass with cover, and cartridge type filter on liquid lines. It shall be mounted on a base frame.

4.8.4 Coils

4.8.4.1 The velocity of liquid in water coils shall be between 0.7 and 2 m/s (2 and 6 fps).

4.8.4.2 Water pressure drop through coils, water chillers or condensers shall not exceed 100 kPa (35 ft w.c., 15 psi). This value applies to chillers, condensers, and cooling coils at their rated fouling factor, unless a lower pressure drop is specified in the design documents.

4.8.4.3 Insert type turbulence promoters, not integral to the coil tubing, (turbulators) shall not be used.

- 4.8.4.4 The air velocity through coils shall not exceed 3 m/s (600 fpm).
 - 4.8.4.5 Wet coil pressure drop shall not exceed 38 Pa (0.15 in. w.c.) per row of coil.
 - 4.8.4.6 Dry coil pressure drop shall not exceed 25 Pa (0.10 in. w.c) per row of coil.
 - 4.8.4.7 Number of rows per coil shall not exceed 10 rows.
 - 4.8.4.8 Coil Fin Spacing:

Fin spacing of evaporator and condenser coils shall not be closer than 15 fins per inch.
 - 4.8.4.9 Copper fins on copper tubes shall be used for all condenser coils within ½ km of sea. Evaporator coils shall also have copper fins on copper tubes when introducing 20% or more outside air within ½ km of sea or within an industrial area.
 - 4.8.4.10 Coil return bends shall have flux removed and be protected from corrosion.
 - 4.8.5 Piping
 - 4.8.5.1 Refrigeration piping shall meet the requirements of ANSI B31.5. Piping materials and installation shall comply with SAES-L-005 and [SAES-K-100](#) Standards.
 - 4.8.5.2 Chilled water and condenser cooling water piping shall meet the requirements of ANSI B31.9. Piping materials and installation shall comply with SAES-L-005 and [SAES-K-100](#).
 - 4.8.6 Condensers

Water cooled condensers shall have wall thicknesses and fouling factors as required by [27-SAMSS-001](#) and [27-SAMSS-002](#).
 - 4.8.7 Cooling Towers
 - 4.8.7.1 Cooling towers shall have provisions for automatic blow down based on cooling water conductivity or total dissolved solids. Feed tank and pumps shall be provided for chemical treatment.
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- 4.8.7.2 Cooling towers shall be designed in accordance with the requirements of 32-SAMSS-012; Manufacture of Water Cooling Towers.
 - 4.8.7.3 Cooling towers shall be located downwind of any adjacent facility or building. Cooling towers shall also be separated by not less than 15 m (49.5 ft.) from adjacent facilities.
 - 4.8.7.4 Make-up water line for cooling towers shall have an air gap between the termination of the make-up line and the maximum water level of the cooling tower reservoir. This air gap shall be a minimum of two times the diameter of the make-up line.
 - 4.8.8 Air Handling Units (AHUs)
 - 4.8.8.1 Packaged central-station AHUs shall be a factory-encased assembly of sections and modular construction.
 - 4.8.8.2 AHUs shall consist of filters, cooling/dehumidifying coil, fan and the following, as required:
 - a) mixing box
 - b) humidifier
 - c) electric heater
 - d) face and bypass dampers
 - 4.8.8.3 AHUs casings shall be manufactured, pre-painted backed enamel finish, 18 gauge minimum galvanized steel with structural steel frame and bracing. Casing panels shall be insulated with 25 mm (1 inch) minimum thickness of fire, rot, rodent and water resistant material with a density of not less than 48 kg/m³ (3.0 lb/ft³).
 - 4.8.8.4 Outside air/return air mixing plenum shall include opposed blade dampers for both the return and outside air streams. Automatic proportioning dampers shall be provided between the outside air and return air. Mixing plenum shall include baffles or other provisions to insure complete mixing of outside and return air streams at all flow rates.
 - 4.8.8.5 Casings shall include doors to provide maintenance and removal access for all fans, motors, coils, filters, and humidifiers. Access doors or frames shall have resilient
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gasketing material to prevent air leakage. Access doors shall have corrosion-resistant hinges and positive latches.

4.8.8.6 Casing filter mounts or filters shall have seals to prevent air bypass.

4.8.8.7 AHUs with total supply air equal to or greater than 5,000 ft³/min shall, in addition to the above requirements, have the following:

- a) The structural frame and bracing shall be constructed of steel or extruded aluminum and structurally reinforced for rigidity.
 - b) The entire AHU shall be minimum two inch, double wall construction. Casing panels shall be fabricated with a minimum of G-90 galvanized steel or aluminum with all necessary reinforcements to prevent pulsation and bulging.
 - c) The AHU casing shall be designed and constructed to withstand pressures required by the system, but not less than ± 12 inches static pressure.
 - d) AHU panels shall have galvanized steel with pre-painted backed enamel finish or aluminum exterior skin and a solid aluminum inner lining. Insulation shall be sandwiched within the AHU panels with a minimum of 2" glass fiber insulation having a density not less than 48 kg/m³ (3.0 lb/ft³). Casing panels shall be airtight without caulking. Insulation shall be secured with 100% coverage of waterproof adhesive. All insulation products shall meet the requirements of ASTM C552, ASTM C930 and ASTM E84. Insulation shall be adequate to prevent condensation on the outside of the casing at 1% design wet bulb and mean coincident dry bulb conditions. Mount panels to the frame using neoprene gaskets, rubber washers and cadmium plated screws.
 - e) Casing shall completely enclose all AHU components.
 - f) The AHU shall have a structural steel base with cross members adequate to support all AHU components. The unit floor shall consist of a minimum 18 gauge
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galvanized steel or 0.040" aluminum outer panel, three inches of glass fiber insulation and a 0.063" aluminum inner panel.

- g) Drain pans shall extend completely under the coil sections and shall have minimum 1-¼ inch threaded drain connections. Drain pans shall be sealed, double wall steel construction with rigid glass fiber insulation and Type 316 stainless steel inner pan. Slope drain pans toward drain connection. Drain pans shall drain completely.

4.8.9 Fans

4.8.9.1 Fans shall be air-foil, backward-inclined, backward curved, or forward-curved and shall conform to AMCA 99 and AMCA 210 requirements. In variable air volume (VAV) systems a variable speed fan shall be provided. Propeller fans may be used for exhaust services.

4.8.9.2 Fans installed in parallel within a common system shall have back draft dampers, which open when the fan motor is energized. All exhaust fans shall have back draft dampers which shall close when fan is off.

4.8.9.3 Fans shall be V-belt driven with drive rated at 150% of fan rated power.

Exception:

Exhaust fans can be direct drive type.

4.8.10 Motors

4.8.10.1 Motors in conditioned space, shall be open, drip-proof, with Class B insulation in compliance with [SAES-P-113](#), unless there are more stringent requirements.

4.8.10.2 Compressor motors, 10 tons and larger, shall have a separate overload relay protection, as described in Article 440 of the National Electric Code (NEC). This protection shall be in addition to other built-in compressor motor protection devices.

4.8.10.3 Condenser fan motors, 25 tons and larger units, shall have a separate overload relay protection, as described in Article

440 of the National Electric Code (NEC). This protection shall be in addition to other built-in compressor motor protection devices.

4.8.11 Heating Equipment

Heating equipment shall be selected for the type of service required. Through the wall, room type air conditioning units shall have an electric resistance coil, with heating cycle.

4.8.12 Ducts

4.8.12.1 Duct design and construction shall comply with the requirements of Saudi Aramco Mechanical (HVAC) Code, [SAES-K-100](#).

4.8.12.2 Ducting shall be sized based on the following maximum duct air velocities:

Main Duct		Branch Duct	
Supply (Ft/min)	Return (Ft/min)	Supply (Ft/min)	Return (Ft/min)
2,000	1,500	1,500	1,000

NOTE: In no way shall the velocities shown in the above table result in noise exceeding that listed in [SAES-A-105](#).

EXEMPTION: Residential and noise sensitive applications, such as auditoriums and theaters are exempted from the maximum duct air velocities listed in the above table. The ducting shall be sized to meet the specific noise requirements for such applications.

4.8.12.3 Supply, return and exhaust duct systems shall be designed for duct transitions and change in duct sizes to divide airflow.

4.8.12.4 Use of orifice, duct splitters or extractors to provide pressure drop in duct systems is not allowed.

4.8.12.5 The air ducts of all HVAC systems, including new construction, modification and/or retrofitting of any existing systems, shall be constructed of only sheet metal in accordance with the requirements of Uniform Mechanical Code ([SAES-K-100](#)) and SMACNA Standards.

- 4.8.12.6 Pre-insulated double wall flexible ducts may be used at the connection of air diffusing devices, in accordance with the requirements of NFPA 90A. Flexible ducts shall not exceed 5 feet in overall length and shall not have bends greater than 45°.
 - 4.8.12.7 Splitter dampers shall not be used for duct branch take-offs. Only fittings fabricated in accordance with the latest issue of the SMACNA HVAC Duct Construction Standards shall be installed.
 - 4.8.12.8 Turning vanes, as per SMACNA HVAC Duct Construction Standards, shall be provided in all rectangular elbows of low velocity systems.
 - 4.8.12.9 Diffusers, registers, grilles and other similar air terminal devices shall not be installed directly on to main ducts. Branch ducts shall be provided to these air terminal devices, having a minimum length of two duct sizes.
 - 4.8.12.10 Troffer light diffusers, perimeter slot diffusers or similar shall not be located on the same duct branch with standard type diffusers.
 - 4.8.12.11 All materials in return air plenums shall be noncombustible or limited combustible and shall meet the requirements of Section 2.3.10 of NFPA 90A.
 - 4.8.13 Insulation
 - 4.8.13.1 Ducts shall be insulated in accordance with Table 10-D of the Uniform Mechanical Code ([SAES-K-100](#)) and the following:
 - All supply and return air ducts, located outdoors or exposed to unconditioned air, shall be insulated.
 - Insulation is not required for return air ducts which are located in a ceiling space, where both sides of the ceiling space are exposed to conditioned air and the ceiling space is not used as a return air plenum.
 - Supply air ducts located in return air plenums shall be insulated.
 - Return air ducts located in conditioned space and in return air plenums do not have to be insulated.
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4.8.13.2 Internal duct lining shall not be used, except in acoustically sensitive areas, with the prior approval of Chairman, HVAC Standards Committee.

Exception:

Internal lining, that includes protective coating to prevent erosion, is permitted for terminal boxes and air handling units.

4.8.13.3 Refrigerant suction lines shall be insulated from the evaporator to the compressor.

4.8.13.4 PVC nitrile rubber insulation (such as Armaflex) shall not be used exposed to sunlight. Chilled water lines shall be insulated in accordance with Standard Drawing AA-036913.

4.8.13.5 Insulation installed outdoors shall be protected from moisture and sunlight degradation by an approved and acceptable method.

4.8.14 Vibration Isolation

4.8.14.1 Provisions shall be made to control equipment induced vibration. The use of vibration isolators between equipment and foundations and/or building structures is required to minimize transmitted vibration. Fan casing and air handling units shall be attached to ducts with flexible connectors.

4.8.14.2 Reciprocating compressors shall be vibration isolated from the unit, and frame shall have vibration isolation (such as a vibration pad) between equipment and equipment base.

4.8.14.3 All fans shall be isolated from their ducts by flexible connections.

4.8.14.4 All spring isolators shall be selected according to ASHRAE recommendations. Air handling units or rotating equipment within the housing of units, shall be mounted on vibration isolators.

4.8.15 Filters

4.8.15.1 Built-up central HVAC systems shall be provided with pre-filters and final filters.

The filtering efficiency of these systems shall conform to the requirements of ASHRAE HVAC Applications Handbook, latest issue.

4.8.15.2 Filters of packaged air handling units and filters of any residential HVAC system shall be replaceable media or washable material with a minimum 70% weight arrestance rating as per ASHRAE STD 52.

4.8.15.3 The air velocity through filters shall not exceed 3 m/s.

4.8.15.4 Dirty pre-filter pressure drop shall not be greater than 125 Pa (0.50 in WC) or final filter pressure drop greater than 250 Pa (1.00 in WC).

4.8.15.5 Pre-filters and final-filters shall be upstream of coils and fans.

4.8.16 Pumps

4.8.16.1 Pumps shall be selected so that 10% increased capacity can be obtained by a larger impeller.

4.8.16.2 Pump capacity at peak efficiency, with impeller furnished, shall be equal to or greater than the design capacity.

4.8.16.3 Pumps shall meet the requirements of [SAES-G-005](#), Centrifugal Pumps.

4.8.16.4 "Low-flow" switches shall be installed on the pump suction line.

4.8.16.5 Chilled water systems shall be provided with standby chilled water pump(s). The number of standby chilled water pumps shall be as follows:

- a) For chilled water systems with only one normally operating pump, an identical 100% capacity standby pump with all accessories shall be provided.
- b) For chilled water systems with two or more normally operating pumps, the total capacity of the standby pump(s) shall be at least 50% of the total capacity of the normally operating pumps.

4.8.16.6 Chilled water pumps shall comply with the requirements of ANSI B73.1.

- 4.8.16.7 Chilled water pumps shall be furnished with mechanical contact face seals.
 - 4.8.16.8 Chilled water pump drive couplings shall be non-lubricated type.
 - 4.8.17 Dampers
 - 4.8.17.1 Each supply or return branch duct serving a separate zone or room shall have a volume damper.
 - 4.8.17.2 Branch duct dampers shall be sheetmetal butterfly type, using pivot and rod, with locking quadrant damper.
 - 4.8.17.3 Volume dampers shall be located a minimum of two duct sizes away from fittings.
 - 4.8.17.4 Fire dampers shall bear a label from a recognized (by Saudi Aramco) testing laboratory (such as UL) or be tested in accordance with the requirements of Uniform Building Code, UBC STD 43-7.
 - 4.8.17.5 Fire dampers shall be securely mounted in rated fire separation wall, ceiling or floor, such that ducts can break away without lessening fire separation rating.
 - 4.8.17.6 Fire and smoke dampers shall be manufactured and installed in accordance with the latest issue of SMACNA, "Fire, Smoke and Radiation Damper Installation Guide".
 - 4.8.17.7 Inspection doors shall be provided to allow access to all fire dampers.
 - 4.8.17.8 Combination Smoke/Fire Dampers shall meet all the requirements for smoke damper fire alarm closure and fire damper latching.
 - 4.9 Design Documentation Requirements
 - 4.9.1 Specifications
 - 4.9.1.1 Design Execution Specifications and Design Drawings shall be prepared for each project. These Specifications shall include all mechanical design requirements for air conditioning and refrigeration (HVAC).
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- 4.9.1.2 All applicable Saudi Aramco Engineering Standard requirements shall be covered in the design documentation.
 - 4.9.1.3 Specifications shall be complete and include work description, references to drawings, standards, and description of construction materials.
 - 4.9.2 Drawings
 - 4.9.2.1 HVAC drawings shall be provided with sufficient details to permit the construction of a complete facility.
 - 4.9.2.2 Drawings shall include a list of drafting symbols / abbreviations used, and equipment schedules.
 - 4.9.2.3 All symbols and abbreviations on HVAC drawings shall be consistent with SMACNA, ASHRAE and the Saudi Aramco Drafting Manual.
 - 4.9.2.4 All construction drawings shall be revised to show "as built" conditions.
 - 4.9.2.5 On one of the drawings of each HVAC system, Design Data, including the following items, shall be shown:
 - a) Outside air conditions used for load calculations;
 - b) Indoor design conditions;
 - c) Total sensible cooling load with a breakdown to its components, i.e., external heat gain, heat from lights, people, etc.;
 - d) Total latent cooling load, with breakdown;
 - e) Grand total cooling load;
 - f) Heating load;
 - g) Outside air intake;
 - h) Chilled water (if any) flow rate, temperature rise and pressure drop;
 - i) Entering and leaving air conditions at cooling coil; and
 - j) Total pressure drop of air handling system with a breakdown to components, i.e., pressure drop through supply/return ducting, coils, filters, etc.
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4.9.2.6 Psychrometric charts shall be shown on one of the HVAC drawings for each HVAC system of 10 tons and larger. This psychrometric chart shall include, as a minimum, the data required by paragraph 4.3.4 of this standard.

Exemption: Residential buildings.

4.9.2.7 System curves superimposed with fan curves shall be shown on one of the HVAC drawings, for each HVAC system of 10 tons and larger.

Exemption: Residential buildings.

4.9.2.8 Drawings shall be assigned numbers by the Chief Draftsman and shall be of standard size, compatible with Saudi Aramco drawing system in accordance with Saudi Aramco Drafting Manual.

4.9.2.9 As built drawings: The original drawings shall be up-dated to "as built" conditions, when the construction of a project is completed.

4.9.2.10 Vendor drawings shall be specified by the originator of the material requisition, and shall conform to the requirements of Saudi Aramco Drafting Manual.

4.9.2.11 Original drawings: At the completion of the project, all original project drawings shall be submitted to the Chief Draftsman, Saudi Aramco, Dhahran, Saudi Arabia.

4.9.2.12 HVAC sequence of operation shall be shown on one of the HVAC drawings, for each HVAC system of 10 tons and larger.

Exemption: Residential buildings.

4.9.3 Equipment Schedules

4.9.3.1 Equipment schedules shall be included on one of the HVAC drawings with information necessary for bidding, purchasing, and installation of all HVAC equipment. Schedules shall contain all required data, such as type of equipment, quantity, temperature, medium handled, pressure and pressure drop, design conditions, etc. Area served and location shall be shown on the drawing plans. Each item of equipment schedule shall have the following:

- a) Equipment number.
- b) Air (water) quantities, from each source.
- c) Equipment rpm.
- d) Total pressure drops, across each portion of equipment.
- e) Unit type.
- f) Manufacturer and model number.
- g) Motor type, size, rpm, kW (hp), volts/phase/hertz.

4.9.3.2 And in addition, the following specific data shall be given:

- Filter:* type, efficiency, number, size, pressure drop (clean/dirty).
- Coil:* sen. heat, total heat, EAT (DB/WB), LAT (DB/WB)
- Chillers:* capacity, compressor input, EWT, LWT, water flow pressure drop, cond. ambient temp., cond. fans No. and motor size, (or condenser supply, condenser return), refrigerant.
- Pumps:* capacity, total head, type, duty.
- Fans:* type, capacity, static press., wheel diam., drive, interlocks, accessories.
- Duct Htr:* airflow, capacity, stages, power and control voltages.
- Air Distr.:* size, symbol, duty, air pattern, accessories.

4.9.4 Calculations

Detailed HVAC calculations shall be provided for each HVAC system. This shall include the cooling load, heating load and psychrometric analysis described in paragraphs 4.3.2, 4.3.3 and 4.3.4.

5 Installation

5.1 General Requirements

- 5.1.1 Any air handlers, refrigeration condenser units, pumps, or any equipment mounted outside, shall be mounted on a concrete

housekeeping pad, at a minimum of 100 mm (4") above the floor or a minimum of 150 mm (6") above unpaved ground.

- 5.1.2 Roof mounting of HVAC equipment, other than in penthouse equipment room is prohibited, unless there is no practical alternative.

Exception:

Packaged rooftop units, especially manufactured for rooftop installation, may be used for other than residential HVAC systems.

- 5.1.3 Access doors shall be provided to every valve, coil, filter, damper or mechanical device for inspection and/or adjustment and be within reachable distance. Access doors for fire dampers shall be positioned so that dampers can be reset and fusible links replaced, if necessary.

- 5.1.4 Equipment clearance shall be provided with a minimum of 1 m clearance on each side of equipment with openable panel or controls, unless equipment manufacturer requires greater clearances. Adequate space shall be provided for coil removal.

- 5.1.5 Inspection requirements of HVAC systems shall include the following:

- a) No work shall be covered or otherwise concealed without approval by Saudi Aramco inspection.
- b) Any duct work, piping, or components so covered shall be uncovered for inspection.
- c) Preinsulated pipes and ducts may be installed only with the prior approval of Saudi Aramco inspection.

- 5.1.6 Any interference between ducts, piping and/or equipment, shall be resolved by Project Engineering and Inspection. All necessary design corrections shall be made prior to installation of HVAC system.

- 5.1.7 Each equipment unit shall be installed at the location indicated on the drawings and in accordance with details of mounting, with vibration isolation as required by the Design Specifications.

- 5.1.8 All HVAC Equipment shall be properly grounded in accordance with NFPA 70, National Electrical Code.

- 5.1.9 A raw water hose bib with vacuum breaker shall be provided within close proximity (not to exceed 10 feet) of HVAC equipment that require periodic washing.

5.2 Air Systems

- 5.2.1 Air System equipment and duct work shall be installed according to the Construction Drawings and Specifications, and Manufacturer's Installation Manual.
- 5.2.2 All air system supply and return grilles shall be furnished in accordance with drawings and specifications, and mounted at locations shown on drawings.
- 5.2.3 Ducts shall be installed in accordance with Uniform Mechanical Code (UMC) or [SAES-K-100](#).

5.3 Refrigeration Systems

5.3.1 Factory Tests

- 5.3.1.1 All refrigerant containing parts of the air conditioning equipment shall be pressure tested in accordance with ASHRAE STD 15.
- 5.3.1.2 Each completely assembled refrigerant system shall be leak tested to confirm that no joint, seal, or connection leaks.
- 5.3.1.3 All leak tests shall be performed prior to any final painting or insulation.
- 5.3.1.4 Leak test shall be performed in accordance with the "Factory Dehydrating, Charging and Testing" chapter of the ASHRAE Refrigeration Handbook.

5.3.2 Field Tests

- 5.3.2.1 After installation, purge all refrigerant lines with 7 kPa gage (1.0 psig) dry nitrogen while soldering, brazing or welding connections.
 - 5.3.2.2 Blow out all lines with dry nitrogen prior to testing and charging.
 - 5.3.2.3 After installation, all field-erected refrigerant piping, regardless of the quantity of refrigerant charge, shall be pressure-tested in accordance with the requirements of the Uniform Mechanical Code (UMC) and ASHRAE STD 15. The required test pressure shall be maintained for a minimum of 10 minutes.
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Exemption:

Factory charged and sealed refrigerant tubing.

5.3.2.4 After installation, dehydrate system by placing a vacuum of 1.7 kPa (0.5 in. Hg) absolute pressure. Hold vacuum for 24 hours or cycle vacuum and dry nitrogen purge according to manufacturer's recommendations. Charge system with quantity and type of refrigerant as per manufacturers' requirements.

5.3.2.5 Leak testing of existing HVAC refrigeration systems shall be performed as follows:

- a) A mixture of a trace quantity of non-CFC refrigerant with dry nitrogen shall be injected into the refrigeration system.
- b) At 350 kPa (50 psig) all joints, seals, or connections shall be checked for leakage by an approved method.

5.3.3 Condensers

Air cooled condenser unit shall be mounted level. Vertical air-cooled condensers shall be provided with wind deflectors.

5.3.4 Evaporator Sections

5.3.4.1 Evaporators of air handling units shall be mounted a minimum of 150 mm (6 inch) off the floor, to allow room for condensate trap.

5.3.4.2 Drain pan

- a) A corrosion resistant drain pan shall be provided under each evaporator coil.
 - b) The evaporator drain pan shall have a trapped drain pipe, attached to the bottom or to the side of the drain pan, flush with the bottom plate.
 - c) The drain pan shall slope towards the drain outlet.
 - d) The drain pipe trap shall have a water seal height equal to or larger than the fan's External Static Pressure (ESP) but not less than 50 mm (2").
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- e) The drain pipe shall discharge to the nearest floor drain, in accordance with the requirements of ASHRAE Equipment Handbook.

Exception:

HVAC units installed outside of buildings may discharge condensate onto the ground or roof, but not onto walkways.

5.4 Hydrostatic Testing of Chilled Water and Cooling Water Piping

Chilled water and cooling water piping shall be subjected to a hydrostatic test at a minimum test pressure of 1.5 times the design pressure, in accordance with the procedures described in section 937.3 of ANSI B31.9; Building Services Piping.

5.5 Pre-Start Up and Commissioning

5.5.1 Commissioning shall comply with "Mechanical Completion and Performance Acceptance" of each air conditioning system or component, of General Instruction GI-0002.710. This document covers the acceptance and turning over of plants and equipment.

5.5.2 In addition, each HVAC system shall be inspected in accordance with the requirements of [27-SAIP-01](#), "HVAC Inspection Requirements" prior to start-up.

6 Testing, Adjusting and Balancing

6.1 General Requirements

6.1.1 All building environmental systems and components shall be checked and adjusted to produce the design objectives. It shall include:

- a) the balance of air and water distribution
- b) adjustment of total system to provide design quantities
- c) electrical measurement
- d) verification of performance of all equipment and automatic controls, and
- e) sound and vibration measurement, when required.

6.1.2 The above tests shall be accomplished by:

- a) checking installations for conformity to design
 - b) measurement and establishment of the fluid quantities
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- c) recording and reporting the results.

6.1.3 A complete system test report shall be provided on air and water movement systems, including flow rates, temperatures, pressures as follows:

- a) Record data on water side and air side of all air handling units, fans, coils, water chillers, condensers, etc. Data shall include all water and airflow, motor, starter heaters, manufacturer, nameplate data.
- b) Balance air distribution system within + 10% of air quantities shown on project drawings and record actual readings taken.
- c) Provide construction drawings, reduced to 280 x 430 mm of every duct, air outlet, air return measured. Identify each measurement point on this construction drawing and on record data sheets.
- d) Adjust all chilled water balance valves for quantities to within 5% of values shown on project drawings and record actual readings.
- e) Check operation of all controls to insure that all actuators cycle in accordance with the designed action of the controlling device and the sequence of operation. Check all control element for proper "normally open" or "normally closed" positions upon loss of power or instrument air.
- f) Provide test points and plugs or covers for all openings in duct.

6.2 Testing Organization

The Testing and Balancing (TAB) work for HVAC installation shall be accomplished by a Balancing Contractor who has:

- a) an organization whose regular activities include testing, adjusting and balancing environmental systems;
 - b) an organization which utilized only regular employees experienced and trained specifically in the total balancing of environmental systems; and
 - c) an organization which has satisfactorily balanced at least five systems of comparable type and size.
 - d) an organization which is approved by Saudi Aramco to perform TAB of HVAC systems.
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6.3 Test Procedures

6.3.1 The Test and Balance Organization shall perform testing, adjustment and balancing of all equipment and systems, and publish a Testing and Balancing report using the general procedures for testing and balancing of:

- a) ASHRAE STD 111 (latest edition), Practices for Measurement, Testing, Adjusting and Balancing of Heating, Ventilation, Air Conditioning and Refrigeration Systems
- b) ASHRAE Applications Handbook (latest edition), Chapter on "Testing, Adjusting and Balancing";
- c) SMACNA (latest edition), "HVAC Systems - Testing, Adjusting and Balancing."
- d) Construction Specification Institute, Section 15990
- e) NEBB "Testing, Adjusting and Balancing of Environmental Systems."

6.3.2 The system balance contractor shall verify installation of mechanical systems and equipment in accordance with design and construction drawings.

6.4 Test and Balance Report

The report shall include the detailed information of either:

- a) AABC "National Standards for Field Measurement and Instrumentation, Total System Balance", Volume 1; or
- b) NEBB "Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems."
- c) The TAB report shall be reviewed and approved by the concerned HVAC maintenance/operation organization. Afterwhich, random points may be selected by the concerned organizations for re-measurement to verify the accuracy of the TAB report.

6.5 Instrumentation

Testing and balancing instruments shall be of types described in NEBB or AABC manuals. Instruments shall be calibrated every six months. Calibration shall be in accordance with NEBB and AABC procedures.

Revision Summary

31 May, 2004

Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.
