CONCEPT

HVAC Systems: Design Principles, Operation, Energy Efficiency and Maintenance

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Introduction:

HVAC systems in commercial, healthcare and industrial buildings often run far from their design intent: loads were estimated loosely, air and water flows were never balanced, and controls drift until chillers, cooling towers and air handling units fight each other. In hot climates this shows up as warm zones, high humidity, dusty coils and early compressor failures. This Core Concept course takes building services teams from psychrometrics and load estimation through system selection, commissioning, testing, adjusting and balancing to preventive maintenance and fault diagnosis. Participants produce an HVAC Plant Performance and Maintenance Plan for their own building.

Course Objectives:

- Estimate cooling and heating loads and read the psychrometric chart to set supply air conditions and comfort criteria for occupied spaces
- Select a suitable HVAC system type among split, VRF, chilled water and district cooling options for a given building and climate
- Operate chillers, cooling towers, air handling units and fan coil units within their design limits and interpret plant log readings
- Configure BMS control sequences, outdoor air rates and filtration to hold indoor air quality while reducing plant energy use
- Plan commissioning, testing, adjusting and balancing and preventive maintenance tasks for building HVAC plant
- Diagnose recurring HVAC faults under hot, dusty and humid conditions and record corrective actions in a maintenance plan

Target Audience:

- HVAC engineers responsible for design review, plant selection and system performance in occupied buildings
- Building services engineers responsible for mechanical plant in offices, hospitals, hotels, malls and campuses
- Facilities engineers responsible for day-to-day running of chilled water plants and air-side equipment
- HVAC technicians responsible for maintenance, fault finding and repair of chillers, AHUs, FCUs and split and VRF units
- BMS operators responsible for control sequences, alarms and trend data of building mechanical systems

Course Outline:

Day 1: HVAC Fundamentals, Psychrometrics and the Building Baseline

- Refrigeration Cycle Basics: Compressor, Condenser, Expansion Device and Evaporator Coil
- Psychrometric Chart Reading: Dry-Bulb, Wet-Bulb, Dew Point and Relative Humidity
- Thermal Comfort Criteria per ASHRAE Standard 55-2023
- Cooling and Heating Load Estimation: Envelope, Solar, Occupant, Lighting and Ventilation Gains
- Building HVAC Baseline Survey: Equipment Register, Design Data and Comfort Complaint Log

Day 2: HVAC System Types, Chilled Water Plant and Air-Side Equipment

- System Selection Matrix: Split, Packaged, VRF, Chilled Water and District Cooling
- Vapour-Compression Chillers: Scroll, Screw and Centrifugal Compressors with Variable Speed Drives
- Air-Cooled Versus Water-Cooled Chillers and Cooling Tower Heat Rejection Near Wet-Bulb
- Air Handling Unit Sections: Mixing Box, Filters, Coils, Supply Fans and Humidity Control
- Fan Coil Units, Duct Sizing and Diffuser Selection for Room Air Distribution

Day 3: Controls, BMS, Ventilation and HVAC Energy Efficiency

- BMS Architecture: Controllers, Sensors, Actuators and Trend Logging
- Control Sequences: Supply Air Temperature Reset, Chilled Water Reset and Economiser Logic
- Outdoor Air Rates and Indoor Air Quality per ASHRAE Standard 62.1-2025
- Filtration Grades, Air Changes per Hour and Dust Load Management on Arid Sites
- HVAC Energy Efficiency Measures: Chiller Sequencing, Variable Flow and COP and kW per Ton Tracking

Day 4: Commissioning, TAB, Preventive Maintenance and Fault Diagnosis

- Commissioning Process per ASHRAE Standard 202-2024 and Functional Performance Test Scripts
- Testing, Adjusting and Balancing per ASHRAE Standard 111-2024: Airflow and Water Flow Readings
- Preventive Maintenance Tasks per ASHRAE Standard 180-2018 for Chillers, Towers, AHUs and FCUs
- Chiller Fault Diagnosis: High Head Pressure, Low Suction, Refrigerant Leaks and Condenser Fouling
- Cooling Tower Water Treatment: Scale, Corrosion, Drift and Legionella Risk Control

Day 5: Plant Walkthrough Case Work and the HVAC Maintenance Plan

- Inspection Walkthrough: Chilled Water Plant Room Readings and Log Sheet Review
- Office Tower Case: Hot and Humid Zones Traced to Airflow Imbalance and Control Faults
- Hospital Case: Room Pressure Relationships, Filtration and Humidity in Critical Areas
- Peak Summer Readiness Schedule and Critical Spare Parts List Build
- HVAC Plant Performance and Maintenance Plan Presentation and Peer Review

Skills You Will Gain:

- Psychrometric Analysis
- Cooling Load Estimation
- HVAC System Selection
- Chilled Water Plant Operation
- BMS Sequence Tuning
- Air and Water Balancing
- HVAC Commissioning
- Refrigeration Fault Diagnosis

Why Attend This Course:

- Return with an HVAC Plant Performance and Maintenance Plan for your own building, ready for review by engineering management
- Trace warm zones, humidity complaints and high plant power to their root causes in airflow, water flow or control logic
- Prepare chillers, cooling towers and air-side equipment for peak summer loads, dust storms and high ambient temperatures
- Compare HVAC practice with engineers and technicians from commercial, healthcare, hospitality and industrial buildings

Conclusion:

Reliable cooling comes from HVAC plant that is designed on sound loads, set up to its design flows and maintained against clear tasks. The course moves from the refrigeration cycle, psychrometrics and comfort criteria, through system types, chillers, cooling towers and air-side equipment, to BMS control, ventilation and plant efficiency. It then covers commissioning, testing, adjusting and balancing, preventive maintenance and fault diagnosis, before the final day applies them in a plant walkthrough and builds an HVAC Plant Performance and Maintenance Plan.