CHAPTER - 1: OVERVIEW OF HVAC SYSTEMS

The abbreviation HVAC stands for 'Heating, Ventilation, and Air Conditioning'.

The purpose of an HVAC system is to create a comfort condition for the occupants. Comfort condition usually refers to a specific range of temperature, relative humidity, cleanliness, and distribution of air to meet the comfort requirements of the occupants.

1.1 Air conditioning

Air conditioning serve three purposes: a) temperature control, b) humidity control, and c) air quality control. Most people only think about temperature control when it comes to air conditioners. However, humidity control and air quality control are equally important.

1.1.1 Temperature Control

Air conditioning maintains indoor temperatures. Cooling extracts indoor heat, while heating adds warmth in colder conditions. The basic air conditioning process uses refrigerant to circulate, compress, and expand, absorbing and releasing heat.

	*For comfort and energy efficiency, keep indoor temperatures around 75±2°F in cooling season and 68-70°F in heating season.*

1.1.2 Humidity Control

Air conditioning systems are vital for maintaining balanced indoor humidity levels, avoiding excessive dampness or dryness. Condensation helps achieve this equilibrium. As air cools, extra moisture turns into condensate, which is efficiently drained to prevent indoor moisture buildup. In dry regions, humidifiers add moisture to air by direct water or steam injection.

	*For comfort, indoor relative humidity (RH) of 30-60% is recommended. In stricter settings, 50±5% RH is commonly advised.*

1.1.3 Air Quality Control

Besides temperature and humidity control, air conditioning systems greatly influence indoor air quality (IAQ). They ensure proper ventilation by introducing outdoor air, filtered to remove dust and contaminants. This dual action of ventilation and filtration improves indoor environment and occupants' well-being.

	Guidelines for IAQ
	*ASHRAE Standard 62 sets minimum rates, considering occupants and floor area.* ***General spaces:*** *15-20 CFM per person.* ***Residences:*** *7.5 CFM per person + 3 CFM per 100 sq. ft. floor area (ASHRAE 62.2)* ***Commercial offices:*** *5 CFM per person + 6 CFM per 100 sq. ft. floor area (ASHRAE 62.1)*
	*For new central AC systems, it's generally recommended to use dual filters: pre-filters (MERV 8) and final filters (MERV 13) for enhanced filtration.*
	*For odor control, activated carbon or chemical filters are recommended.*
	*For cleanroom applications in healthcare or semiconductor facilities, high efficiency particulate air (HEPA) and MERV rating 16 to 20 are recommended.*

In essence, air conditioning manages temperature, humidity, and air quality. It's not just about cooling; it encompasses complete air control for the desired environment. This includes heating, cooling, humidifying, dehumidifying, purifying, and odor control.

1.2 Heating Systems

Buildings require heating in cold weather, achieved through electric heaters, gas or oil-fired furnaces, boilers, heat pumps, or renewables like solar and geothermal sources. Modern systems use energy-efficient tech like high-efficiency furnaces and heat pumps. Besides temperature and humidity control, heating systems have other roles:

1.2.1 Freeze Prevention

Heating systems prevent freezing, safeguarding pipes, equipment, and surfaces from damage and interruptions. Vital in cold regions, they avert pipe bursts and equipment malfunctions caused by extreme cold temperatures.

	*A key rule is to maintain indoor temperatures above 32°F to avoid water freezing-related problems.*

1.2.2 Condensation Control

Efficient heating regulates indoor humidity, preventing excessive condensation on surfaces like windows and walls. This control enhances indoor air quality and stops mold growth.

	*Maintain 30-50% indoor humidity to prevent condensation and mold. Ensure air's dewpoint is lower than surface temps to avoid condensation.*

1.2.3 Preservation of Materials

Sensitive items like equipment, art, and documents need controlled temperatures to avoid damage. Adequate heating safeguards against extreme cold and condensation, preserving these materials.

1.2.4 Support for Other Systems

Heating systems often work in tandem with ventilation and AC cooling system to maintain a balanced indoor environment. In certain scenarios, the concept of reheat was employed, which involved the reheating of air after it had been initially cooled. However, efficiency concerns reduced its use due to regulations and energy considerations.

1.3 Ventilation Systems

Buildings require ventilation for quality indoor air. While oxygen is vital, mechanical ventilation also controls carbon dioxide, carbon monoxide, fire smoke, and temperature.

1.3.1 Carbon Dioxide (CO2) Control

People release carbon dioxide when they breathe. In crowded spaces, CO2 levels can become uncomfortable or unsafe. Proper ventilation maintains fresh air exchange, avoiding CO2 accumulation.

	*Maintain indoor CO_2 levels between 600-1000 ppm for a healthy environment. Levels above 1000 ppm are poor, while 40,000 ppm is deadly.*

1.3.2 Carbon Monoxide (CO) Safety

Carbon monoxide (CO) is an odorless, deadly gas from incomplete fuel burning. It's risky and can be fatal. Mechanical ventilation is vital to prevent CO buildup by removing indoor pollutants.

Safety tip: Avoid using fuel-burning devices indoors without proper ventilation, especially in enclosed spaces like garages where vehicle exhaust can emit CO.

	*Brief exposure to 1-70 ppm of CO typically has no noticeable symptoms, except potential chest pain for heart patients. Levels exceeding 150-200 ppm can result in disorientation, loss of consciousness, and death.*

1.3.3 Smoke and Odor Management

Fire smoke is dangerous. Because duct systems can convey smoke, hot gases, and fire from one area to another and can accelerate a fire within the system, fire protection is an integral part of air-conditioning and ventilation system design. Fire safety codes generally mandate adherence to the standards such as NFPA Standard 90A and UL Standards 555 and 555S. In high-rise and public buildings such as shopping malls, airports, metros etc. smoke extraction system and pressure regulation is critical. Ventilation also removes odors from cooking or cleaning.

1.3.4 Temperature Regulation

Effective ventilation helps control temperature by dissipating excess heat and preventing the formation of uneven temperature zones. In industrial environments like factories and workshops housing equipment such as generators, pumps, transformers, and electrical switchgear, proper ventilation can keep the temperature within 5-10°F above the ambient

temperature. Good ventilation not only prevents overheating but also guarantees the optimal performance of critical machinery.

	*ASHRAE guidelines recommend 6-12 air changes per hour for temperature control in various spaces.*

1.3.5 Contaminant Control

Contaminant control involves the removal or reduction of pollutants and airborne particles from indoor spaces. It's done either by dilution ventilation or by local exhaust ventilation (LEV) systems that trap pollutants at their source.

	*Dilution ventilation targets 10 to 12 air changes per hour in general areas, and up to 60 in pollutant-prone zones.*
	*For Local Exhaust Ventilation (LEV), a 100 feet per minute capture velocity is recommended to protect workers and indoor air quality.*
	*ASHRAE and ACGIH (American Conference of Governmental Industrial Hygienists) provide guidelines for air change rates and ventilation for pollution control.*

1.4 Environmental Issues

The environmental impact of using HVAC systems is significant. The refrigerants used in air conditioners contribute to ozone layer depletion and global warming. To address these concerns, the HVAC industry is actively exploring more sustainable approaches. Today, it's not just about understanding how heating and cooling systems function; the emphasis is on enhancing energy efficiency. For those new to HVAC, it's wise to concentrate on energy conservation. This principle applies to individual components as well as the entire HVAC setup.

A well-designed HVAC system should place occupant comfort as a priority while simultaneously striving to minimize energy usage and environmental impact. Here are some common environmental issues associated with HVAC systems:

	KPIs	***Issues***	***Performance Targets***
	Energy Consumption	*High energy use causes increased greenhouse gas emissions and contribute to*	*Choose energy-efficient HVAC equipment and strategies, including optimized lighting, effective*

	KPIs	***Issues***	***Performance Targets***
		climate change.	*building envelope design, thermal zoning, advanced insulation materials, and intelligent controllers, all aimed at decreasing energy usage.*
	Refrigerants and Ozone Depletion	*Older HVAC systems use refrigerants that contribute to ozone depletion and global warming.*	*Choose HVAC systems with environmentally friendly refrigerants that have ZERO ozone depletion potential (ODP) and lower global warming potential (GWP) below 750.*
	Water Consumption	*HVAC systems that use water for cooling or humidification can strain water resources and impact local ecosystems.*	*Implement water-efficient HVAC technologies and practices to minimize water consumption and environmental impact. Choose air-cooled or hybrid systems where water is scarce.*
	Noise Pollution	*Poorly designed or maintained HVAC systems can generate noise pollution, affecting both indoor and outdoor environments.*	*Choose quiet HVAC equipment, implement noise-reducing designs such as liberal duct design, low air velocities, acoustic insulation, and attenuators to minimize noise impact.*
	Indoor Air Quality (IAQ)	*Poorly maintained HVAC systems can lead to indoor air quality issues, causing health problems for occupants.*	*Design ventilation systems as per ASHRAE 62.1 and keep provision for at least MERV 13 filtration for new building design.*
	Air Pollution and Fossil Fuels	*Combustion-based heating systems (e.g., oil, gas) can contribute to air pollution through the release of pollutants and greenhouse gases.*	*Transition to cleaner heating sources like electric heat pumps or renewable energy systems to reduce reliance on fossil fuels.*
	E-Waste and Disposal	*Discarded HVAC equipment can contribute to electronic*	*Choose durable HVAC equipment and consider recycling or proper*