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MODULE
14

Indoor and Site Environment: Thermal Comfort

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This chapter explores the importance of indoor and site environments in architecture, environmental science, urban planning, and psychology, highlighting their characteristics, significance, and implications for creating spaces that promote well-being, sustainability, and functionality.

Learning Objectives +

- Energy Analysis: Envelope, Massing, and Orientation Optimization
- Energy Analysis: Initial Assessment
- Energy Analysis: Ventilation
- Energy compliance modeling
- Indoor and Site Environment: Thermal Comfort
- Indoor and site environments: air quality
- Indoor and Site Environment: Lighting
- Controls and monitoring: Control Hardware
- Controls and Monitoring: Control Strategies



INTRODUCTION

Indoor Environment

Defined as the atmospheric conditions within a building or enclosed space, influencing human activities, health, and comfort.

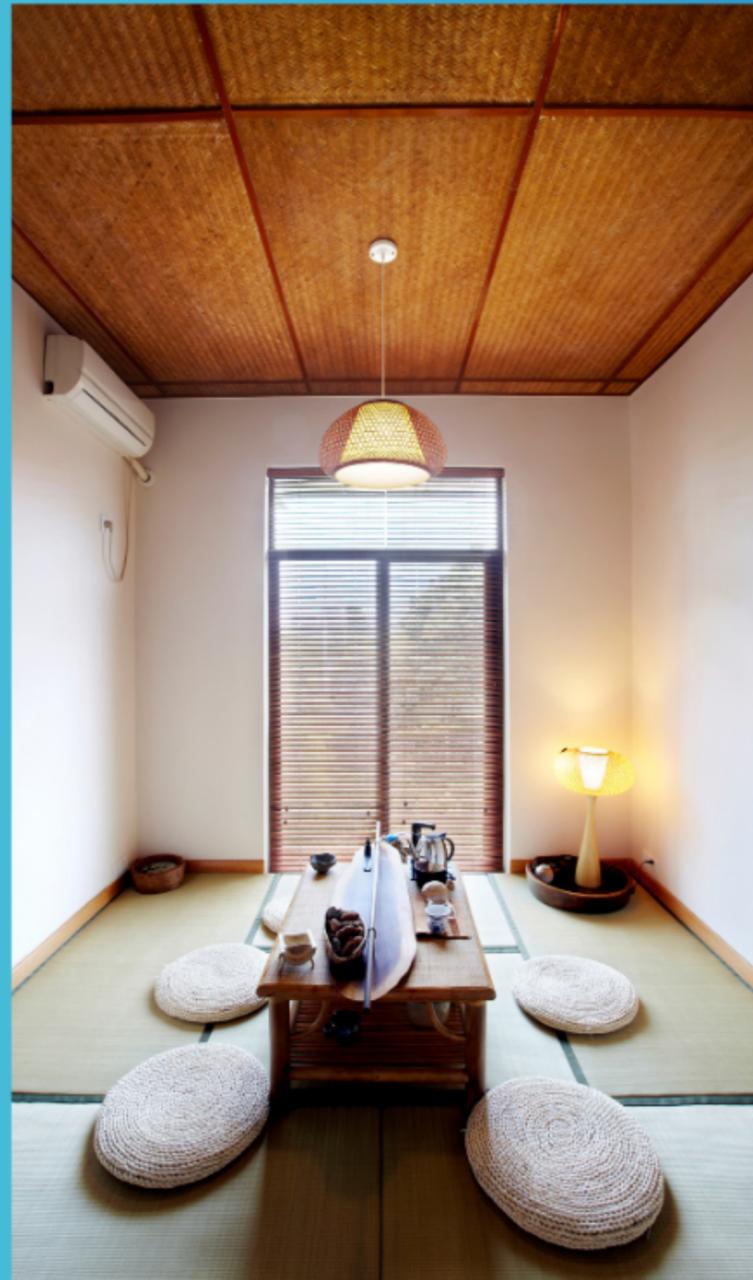
Key Components:

- Air Quality: Influenced by ventilation, presence of pollutants, and humidity levels.
- Lighting: Quality and quantity of light can affect mood, productivity, and circadian rhythms.
- Temperature and Humidity: Vital for human productivity and comfort.
- Acoustics: Essential for peaceful and productive indoor environments.

Significance

- Importance: Improved indoor air quality can lead to reduced absenteeism and increased productivity.

INDOOR AND SITE ENVIRONMENT OVERVIEW



Site Environment

- Definition: Excludes the external and surrounding conditions of a given location, influencing their design, functionality, and interaction with the ecosystem.
- Key Components:
 - Geographic Factors: Topography, soil type, and orientation of a site can significantly affect architectural design and construction practices.
 - Climate Conditions: Local climate dictates design strategies for energy efficiency and comfort.
 - Ecological Considerations: Understanding of biodiversity and natural resources is necessary.
 - Cultural Context: The cultural and historical significance of a site can influence its development and usage.

Significance

- Importance: Shapes the sustainability and resilience of buildings and urban areas.

INDOOR AND SITE ENVIRONMENT: THERMAL COMFORT

- Thermal comfort is a critical aspect of indoor and outdoor environments, affecting occupants' well-being, productivity, and health.
- It is defined by the International Organization for Standardization (ISO) as a state of mind that expresses satisfaction with the thermal environment.

Factors Influencing Thermal Comfort

- **Air Temperature:** Measured in degrees Celsius ($^{\circ}\text{C}$) or Fahrenheit ($^{\circ}\text{F}$), air temperature is the most direct measure of thermal comfort. Deviations from this temperature can lead to discomfort.
- **Humidity:** Refers to the amount of moisture in the air, influencing how heat is perceived by the body.
- **Air Velocity:** The speed of air movement around the body, which can enhance thermal comfort by increasing the rate of heat loss through convection.
- **Mean Radiant Temperature:** Accounts for the combined impact of temperature from surrounding surfaces, such as walls, windows, and furnishings.





THERMAL COMFORT +

Adaptive Comfort Model

- The adaptive comfort model posits that individuals adjust their perception of thermal comfort based on their previous experiences and the environmental conditions to which they are exposed.
- Example: In regions with high seasonal temperature variability, individuals may adapt to higher indoor temperatures during summer, finding comfort at levels that would be considered uncomfortable in more temperate climates.

Implications for Design

- Passive Design Strategies: Positioning buildings to maximize natural ventilation and minimize direct sunlight exposure can enhance thermal comfort.
- Active Design Strategies: Advanced HVAC systems allow for precise control of indoor climate.
- Smart Technology: Integration of smart thermostats and automated shading can optimize energy use while maintaining comfort levels.



COMFORT VARIABLES AFFECTING OCCUPANT WELL-BEING

Introduction to Comfort Variables

- Occupant comfort in built environments impacts productivity, health, and overall satisfaction.
- Operative temperature, clo value, and metabolic rate are critical variables that influence occupants.

Operative Temperature

- Operative temperature is a composite measurement reflecting the combined effects of air temperature and mean radiant temperature.
- It can be influenced by factors such as insulation, window orientation, and shading devices.
- Maintaining an appropriate operative temperature is crucial for occupant comfort and minimizing energy consumption in heating and cooling systems.



COMFORT VARIABLES AFFECTING OCCUPANT WELL-BEING

Clo Value

- Clo value is a unit of measurement that quantifies the thermal insulation provided by clothing.
- It varies with the type of clothing worn and can range from 0.5 for light clothing to 3.0 or more for heavy winter garments.
- Designers must consider typical clothing levels when determining temperature settings in spaces intended for human occupancy.

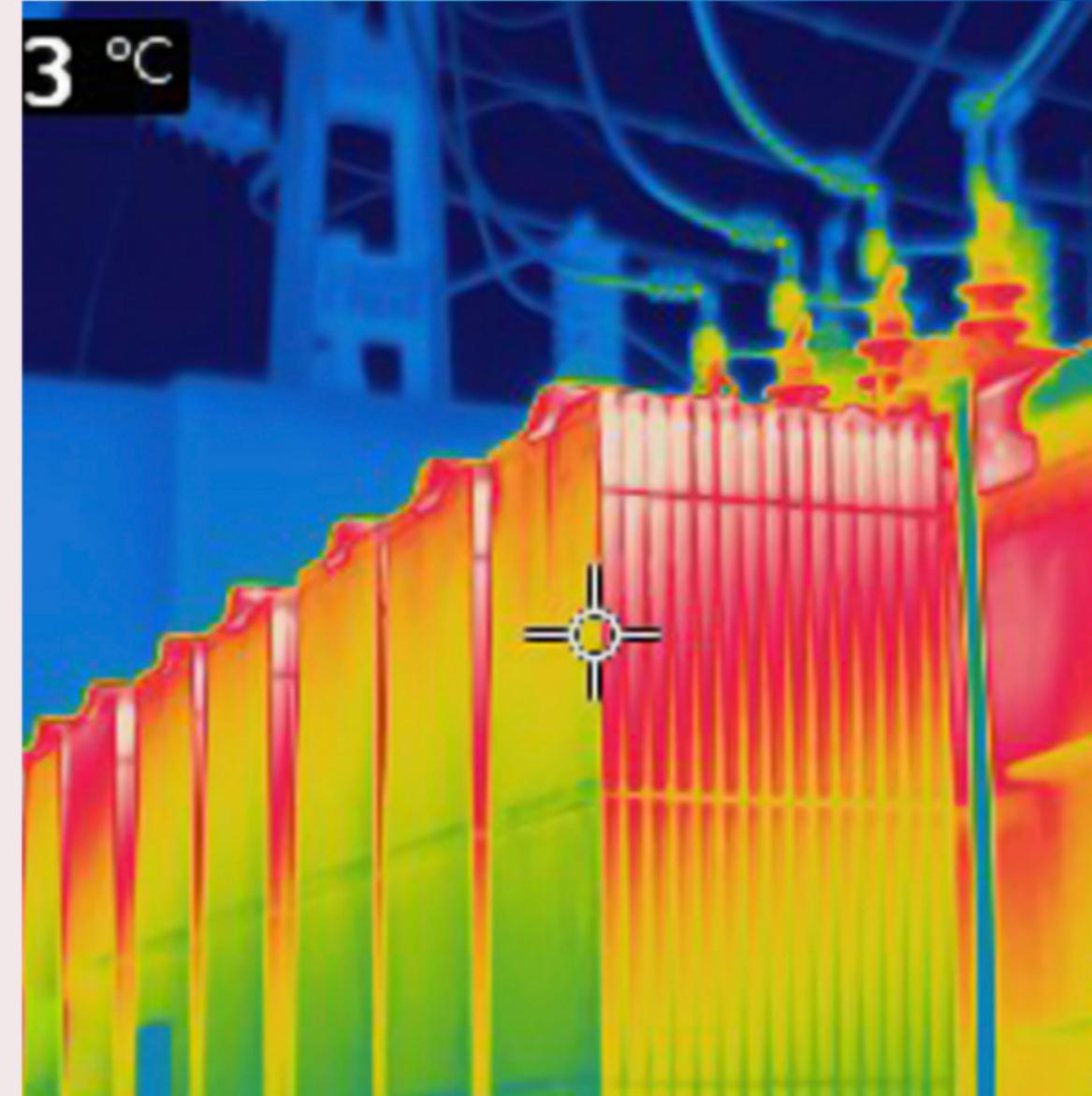
Metabolic Rate

- Metabolic rate refers to the rate at which the body generates heat through physiological processes.
- Higher metabolic rates associated with more vigorous activities can lead to a cooler environment.
- In an office setting, desk workers may require a cooler environment, while maintenance staff may prefer a warmer setting.



INTERACTION OF COMFORT VARIABLES +

- The interaction among operative temperature, clo value, and metabolic rate creates a complex web of influences that define occupant comfort.
- A decrease in operative temperature may necessitate an increase in clo value or a reduction in metabolic activity to maintain comfort levels.
- In a gymnasium, where occupants are actively exercising, the operative temperature may be set higher than in an office environment.





KEY REFERENCE DOCUMENTS FOR THERMAL COMFORT IN INDOOR ENVIRONMENTS

- ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy
- Provides guidelines on acceptable thermal conditions for human occupancy in buildings.
- Highlights the range of thermal sensations from cold to hot, measured through subjective assessments and objective parameters.
- Incorporates the adaptive comfort model, suggesting occupants can adjust to varying indoor climates.
- Emphasizes the importance of occupant control over their immediate thermal environment.



ISO 7730: Ergonomics of the Thermal Environment

- Focuses on the ergonomics of thermal environments and provides a method for assessing thermal comfort.
- Emphasizes the concept of operative temperature, which combines air temperature and mean radiant temperature.
- Accounts for the discrepancy between air temperature and surface temperatures to achieve optimal comfort.

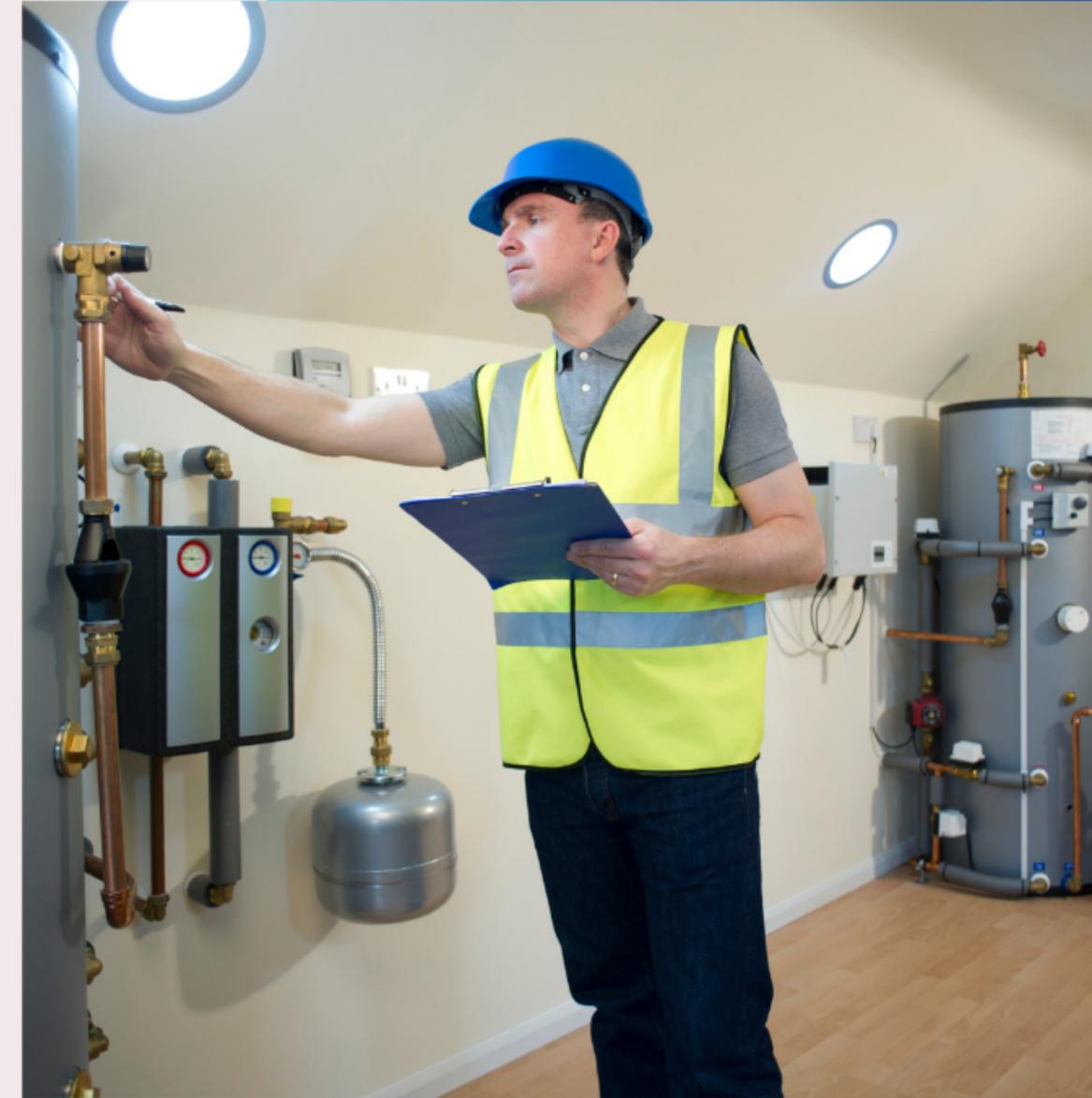
KEY REFERENCE DOCUMENTS FOR THERMAL COMFORT IN INDOOR ENVIRONMENTS +

EN 15251: Indoor Climate and Energy Performance of Buildings

- Addresses indoor climate and energy performance in buildings, linking thermal comfort with energy efficiency.
- Classifies indoor climate conditions into categories based on the intended use of the space.
- Acknowledges seasonal variations in thermal comfort, proposing different criteria for summer and winter months.

CEN/TS 17961: Indoor Environment and Energy Performance

- Integrates thermal comfort with other indoor environmental factors such as air quality, lighting, and acoustic conditions.
- Encourages the use of dynamic simulation tools to predict indoor climate conditions.
- Encourages designers to synthesize different environmental factors to achieve a cohesive indoor climate where thermal comfort is achieved without compromising energy performance.



THERMAL COMFORT: INDIVIDUAL AND GROUP VARIABILITY

Factors Influencing Thermal Comfort

- Physiological Factors: Age, gender, body mass, metabolic rate, and health status influence individual thermal comfort.
- Psychological Factors: Past experiences, cultural background, and individual preferences shape temperature perception.
- Environmental Factors: Humidity levels, air movement, and radiant temperature significantly impact thermal comfort.
- Activity Level: Higher activity levels increase metabolic heat production, leading to discomfort in cooler environments.

Group Dynamics and Consensus in Thermal Comfort

- Variability in individual preferences can lead to challenges in achieving consensus temperature.
- Group dynamics, such as social interactions and roles, can complicate these preferences.
- In a shared workspace, individuals may have to negotiate comfort levels, leading to potential conflicts.



THERMAL COMFORT: INDIVIDUAL AND GROUP VARIABILITY

Strategies for Addressing Thermal Comfort Variability

- Personalized Climate Control: Implement localized heating and cooling solutions.
- Flexible Design Spaces: Design spaces with adjustable environmental controls or movable partitions.
- User Surveys and Feedback: Regularly soliciting feedback from occupants about their thermal comfort.
- Education and Awareness: Promote understanding and empathy among individuals in shared environments.





BUILDING PRESSURIZATION AND ZONING FOR OPTIMIZED COMFORT AND ENERGY EFFICIENCY

Introduction to Building Zoning

- Building zoning involves the strategic division of a structure into distinct areas for heating, cooling, and ventilation.
- The aim is to enhance occupant comfort while maximizing energy efficiency.
- Zoning can be compared to a tailored suit, where each section is adjusted to fit the unique contours of the wearer.



Principles of Building Pressurization

- Building pressurization refers to the management of air pressure within a building relative to the outside environment.
- It is crucial for comfort, indoor air quality, and energy efficiency.

Types of Pressurization

- Positive Pressurization: Interior air pressure is greater than the outside air pressure, discourages entry of outdoor pollutants.
- Negative Pressurization: Interior air pressure is lower than the outside, common in areas where containment of hazardous materials is necessary.
- Neutral Pressurization: Indoor and outdoor pressures are equal, minimizing energy loss but not effectively controlling air quality and comfort.

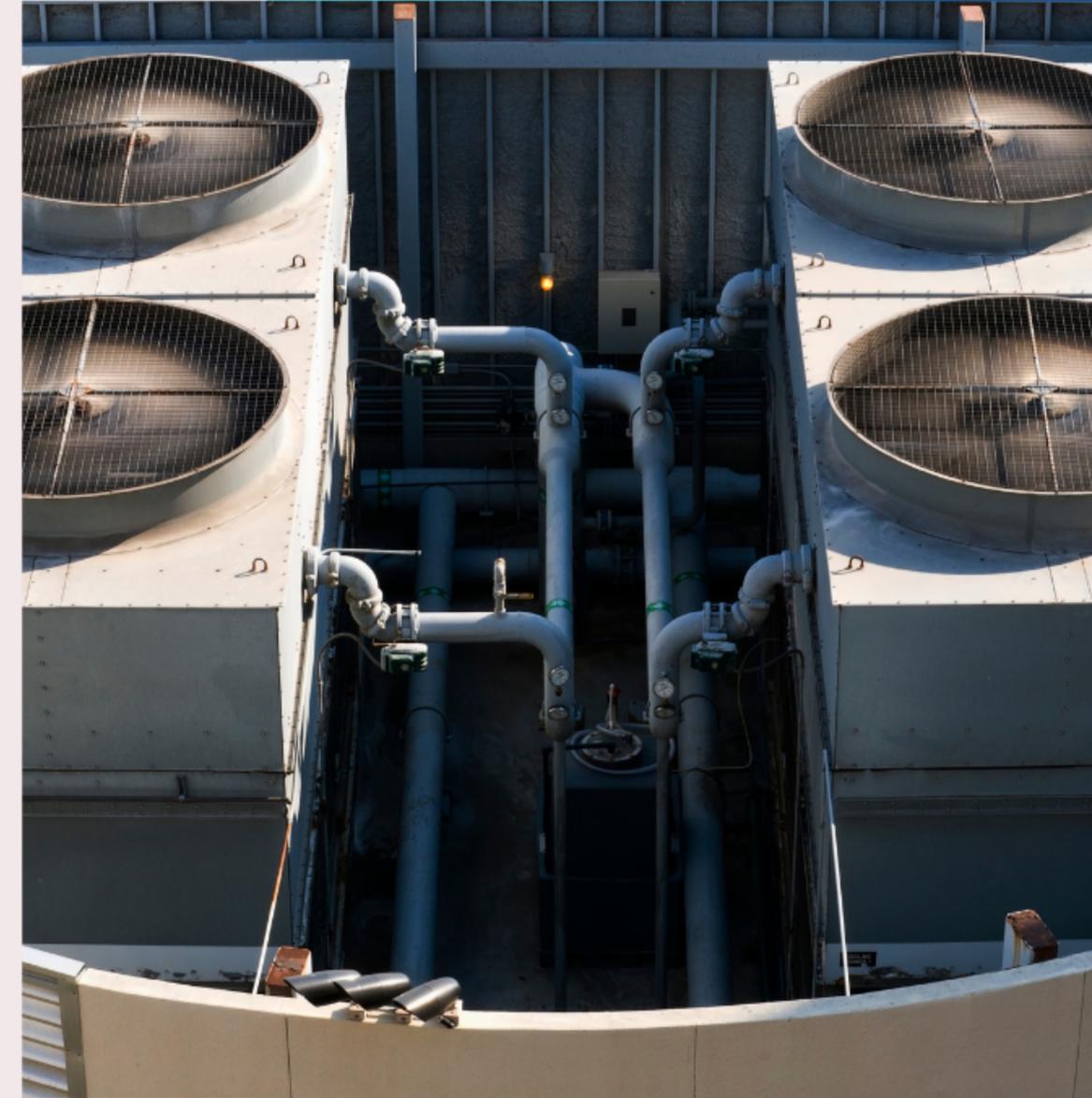
BUILDING PRESSURIZATION AND ZONING FOR OPTIMIZED COMFORT AND ENERGY EFFICIENCY +

Determining Pressurization Requirements

- Building layout, occupancy patterns, HVAC system design, weather conditions, and building envelope performance are key factors in determining pressurization requirements.

Zoning Strategies for Comfort and Efficiency

- Technologies include thermostatic controls, Variable Air Volume (VAV) Systems, Ductless Mini-Split Systems, and Smart Building Technologies.



ACHIEVING THERMAL COMFORT THROUGH INDIVIDUAL CONTROL AND ZONING STRATEGIES

Understanding Thermal Comfort

- Thermal comfort is defined by ASHRAE as a state of mind that expresses satisfaction with the thermal environment.
- It is influenced by personal preferences, environmental conditions, and activity levels.
- Predicted Mean Vote (PMV) and the Predicted Percentage of Dissatisfied (PPD) are used to evaluate thermal comfort.

Individual Control Strategies

- Implementation of personal climate control devices, such as localized heating and cooling units, personal fans, or heated blankets.
- Smart thermostats and mobile applications that learn occupants' behavior and preferences over time.
- Mobile applications can enable individuals to control their environmental settings remotely.



ACHIEVING THERMAL COMFORT THROUGH INDIVIDUAL CONTROL AND ZONING STRATEGIES +

Zoning Strategies

- Thermal Zoning: The practice of dividing a building into distinct areas for independent control regarding heating, cooling, and ventilation.
- Dynamic Zoning Based on Occupancy and Activity: Utilizing occupancy sensors and building management systems to adjust environmental conditions in real-time.
- This flexibility improves occupant satisfaction and contributes to energy savings.

Integration of Strategies

- Effective integration of individual control and zoning strategies is crucial.
- An office building implemented an integrated system where each workstation was equipped with personal fans and local heating units, while the building's HVAC system was divided into zones controlled by smart thermostats.
- This approach increased comfort levels and productivity, and reduced energy consumption.



OPTIMIZING COMFORT AND ENERGY EFFICIENCY: ZONING AND BUILDING PRESSURIZATION REQUIREMENTS



Zoning in Building Design

- Zoning divides a building into distinct areas controlled for temperature, airflow, and lighting.
- The goal is to tailor the indoor environment to specific needs and activities within each zone.
- Zoning can reduce energy consumption and enhance comfort by allowing for differentiated heating, cooling, and ventilation based on occupancy patterns and usage.
- An example of zoning is a multi-story office building with different functions on each floor.

Building Pressurization Requirements

- Building pressurization is the differential pressure between the interior of a building and the outside environment.
- Effective management of building pressurization is crucial for indoor air quality, energy efficiency, and comfort.
- An example of building pressurization is in a hospital setting where operating rooms are kept at higher pressure relative to adjacent areas to prevent contaminated air from entering.

OPTIMIZING COMFORT AND ENERGY EFFICIENCY: ZONING AND BUILDING PRESSURIZATION REQUIREMENTS

Interplay Between Zoning and Pressurization

- The relationship between zoning and building pressurization is symbiotic; effective zoning aids in achieving optimal pressurization levels, while proper pressurization supports the functionality of zoning systems.
- A well-designed HVAC system balances the needs of each zone and the overall building pressurization.

Conclusion

- The optimization of comfort and energy efficiency in building design is tied to the principles of zoning and building pressurization.
- The integration of advanced zoning strategies and precise pressurization control will continue to shape the future of indoor environmental quality.



ACHIEVING THERMAL COMFORT THROUGH INDIVIDUAL CONTROL AND ZONING STRATEGIES



Understanding Thermal Comfort

- Thermal comfort is a subjective measure influenced by factors like air temperature, humidity, air velocity, and radiant surfaces.
- Achieving thermal comfort for all occupants in modern buildings is complex and requires individualized control and zoning strategies within HVAC systems.



Individual Control Strategies

- Personalized Thermostats: Allows occupants to adjust their thermal environment according to personal preferences.
- Radiant Heating/Cooling Panels: Provide localized heating or cooling, allowing individuals to control their comfort without affecting the entire building's climate.
- Smart Devices and IoT Integration: Enhances individual control by detecting when a space is occupied and adjusting the temperature accordingly.

ACHIEVING THERMAL COMFORT THROUGH INDIVIDUAL CONTROL AND ZONING STRATEGIES +

Zoning Strategies

- Thermal Zoning: Divides a building into distinct thermal zones, each controlled independently.
- Dynamic Zoning Based on Occupancy: Uses occupancy sensors to adjust the thermal settings of individual zones.
- Seasonal Adjustments: Adjusts HVAC settings for each zone based on seasonal data to maximize energy efficiency and maintain comfort.

Conclusion

- Implementing individual control and zoning strategies is critical for achieving thermal comfort in modern buildings.
- Effective thermal comfort management improves occupant satisfaction, contributes to energy efficiency, and sustainable building practices.





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THANK YOU

