Air Quality

- **Mapping Duct Layouts for Cleaner Airflow in Mobile Homes**
  Mapping Duct Layouts for Cleaner Airflow in Mobile Homes Inspecting Vent Connections for Improved Air Quality Minimizing Drafts Through Sealed Mobile Home Duct Systems Scheduling Regular Cleanings for Mobile Home Ventilation Evaluating Filter Efficiency for Enhanced Mobile Home Air Quality Addressing Mold Risks in Mobile Home Ductwork Installing Air Purification Systems in Mobile Homes Checking Air Pressure to Reduce Allergens in Mobile Home Interiors Identifying Common Leaks in Flexible Mobile Home Ducts Balancing Humidity Levels for Healthier Mobile Home Air Considering UV Technology for Mobile Home Air Treatment Using Diagnostic Tools to Assess Air Quality in Mobile Homes
- **Preparing Mobile Home HVAC Units for Intense Summer Heat**
  Preparing Mobile Home HVAC Units for Intense Summer Heat Protecting Mobile Home Furnaces During Low Temperature Periods Coping with Storm Related Damage to Mobile Home Air Conditioners Adjusting Climate Control in Mobile Homes for Coastal Humidity Handling Power Outages in Mobile Home Heating Systems Planning Winterization Steps for Mobile Home HVAC Equipment Adapting Mobile Homes to Rapid Seasonal Swings in Temperature Evaluating Wind Exposure Factors for Mobile Home AC Placement Addressing Extended Rainy Periods in Mobile Home Ventilation Considering Local Building Codes for Mobile Home Climate Adaptations Balancing Heat Needs in Mobile Homes Across Different Regions Checking Insurance Coverage for Storm Damaged Mobile Home AC Units
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Adapting Mobile Homes to Rapid Seasonal Swings in Temperature

Importance of Efficient Duct Layouts for Airflow

In recent years, the phenomenon of rapid seasonal swings in temperature has become increasingly prevalent due to climate change. Smart thermostats offer convenient temperature control for mobile homes **best hvac system for mobile home** ceiling. Mobile homes, known for their affordability and flexibility, are particularly susceptible to these drastic weather changes. Hence, the importance of efficient HVAC (Heating, Ventilation, and Air Conditioning) systems in mobile homes cannot be overstated. These systems play a crucial role in maintaining comfort, ensuring energy efficiency, and safeguarding the health of occupants.

Firstly, the primary function of an HVAC system is to provide consistent indoor climate control regardless of external weather conditions. In mobile homes, which often have less robust insulation compared to traditional houses, maintaining a stable indoor environment can be challenging. Efficient HVAC systems are designed to rapidly adjust to changing temperatures outside, ensuring that heating or cooling demands are met promptly. This adaptability is essential for occupant comfort during extreme heat waves or sudden cold spells.

Moreover, an efficient HVAC system contributes significantly to energy savings and cost-effectiveness. Mobile homes typically have smaller interiors which require less energy for heating and cooling than larger structures. However, without an efficient system in place, even this reduced energy requirement can lead to excessive utility bills during periods of extreme temperature fluctuations. Modern HVAC systems employ advanced technology such as programmable thermostats and variable-speed compressors that optimize energy use based on real-time needs. As a result, homeowners can enjoy lower energy costs while reducing their environmental footprint.

In addition to comfort and cost concerns, efficient HVAC systems also play a vital role in promoting good air quality within mobile homes. Seasonal weather changes often bring about variations in humidity levels which can affect indoor air quality if not properly managed. High humidity can lead to mold growth and musty odors while low humidity may cause dry skin and respiratory issues. An efficient HVAC system helps regulate these levels by incorporating features like dehumidifiers or humidifiers as necessary.

Furthermore, the health benefits associated with proper climate control should not be overlooked. Vulnerable populations such as children and the elderly are particularly susceptible to extreme temperatures which could exacerbate existing health conditions or lead to heatstroke or hypothermia in severe cases. A reliable HVAC system ensures that these risks are minimized by maintaining safe temperature ranges indoors.

In conclusion, adapting mobile homes to cope with rapid seasonal swings in temperature is imperative given current climate challenges-and efficient HVAC systems are at the heart of this adaptation process. By investing in modernized heating and cooling solutions tailored specifically for mobile homes' unique needs-balancing comfort with cost-efficiency-homeowners can effectively mitigate against adverse weather impacts while enhancing overall well-being for all occupants involved.

Mobile homes offer a unique blend of affordability and convenience, providing a housing solution for many people. However, they also present distinctive challenges when it comes to maintaining comfortable indoor temperatures, particularly in the face of rapid seasonal swings. Standard HVAC systems often struggle to cope with these challenges due to the specific characteristics and constraints of mobile homes.

Firstly, mobile homes typically have less insulation compared to traditional houses. This lack of insulation is a significant factor that hampers the efficiency of standard HVAC systems. In winter, heat can escape quickly through poorly insulated walls and windows, while in summer, the sun's warmth can easily penetrate into the living space, making it difficult for HVAC systems to maintain a stable indoor environment. As seasons change rapidly, these temperature fluctuations become more pronounced and challenging to manage.

Moreover, mobile homes generally have limited space for installing HVAC equipment. The compact nature of these dwellings means that standard units may not fit or function optimally within the available space. This limitation often forces homeowners to opt for smaller or less powerful units that may not be capable of efficiently heating or cooling the entire home during extreme weather conditions.

Another challenge is related to energy efficiency. Mobile homes often have older electrical systems that are less efficient and cannot handle high-powered appliances like modern HVAC units without significant upgrades. This inefficiency not only leads to increased energy consumption but also higher utility bills-a burden on many families living in mobile homes who are already budget-conscious.

Additionally, ductwork in mobile homes can be problematic. Many mobile homes utilize flexible ducting which is prone to leaks and losses over time. These leaks significantly reduce system efficiency by allowing conditioned air to escape before it ever reaches the living spaces.

To adapt mobile homes effectively to rapid seasonal swings in temperature, several strategies could be employed beyond conventional HVAC solutions. Improving insulation should be a priority; even simple measures like sealing windows and adding skirting around the base can make noticeable differences in indoor comfort levels.

Considering alternative heating and cooling options tailored specifically for mobile homes might also prove beneficial. Ductless mini-split systems are one such option; they provide flexibility in installation due their smaller size and offer better control over individual room temperatures without relying on extensive ductwork.

Regular maintenance of existing HVAC components-such as replacing filters frequently-can help optimize performance even if larger modifications aren't feasible immediately.

Lastly, educating homeowners about effective ways to manage indoor climates with minimal reliance on mechanical systems can empower them further: using fans strategically or employing thermal curtains during peak heat periods are simple yet effective techniques that complement any mechanical interventions made within these compact dwellings.

In conclusion, while standard HVAC systems face several challenges when adapting mobile homes for rapid seasonal temperature changes-from inadequate insulation and spatial constraints through inefficient energy use-the integration of targeted improvements alongside educational efforts offers promising potential towards achieving greater comfort sustainably throughout year-round climate shifts experienced by residents across various geographical locations worldwide.

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Techniques for Mapping Duct Layouts

In recent years, the impacts of climate change have become increasingly evident, manifesting through unpredictable weather patterns and extreme temperature fluctuations. For those living in mobile homes, these rapid seasonal swings present unique challenges in maintaining a comfortable living environment. Unlike traditional houses, mobile homes often lack the robust insulation and thermal regulation systems needed to manage such dramatic changes effectively. Consequently, innovative HVAC (Heating, Ventilation, and Air Conditioning) solutions are not just desirable but essential for adapting mobile homes to these environmental stresses.

Mobile homes are characteristically lightweight and portable, features that make them susceptible to rapid temperature changes. During sweltering summer days or bone-chilling winter nights, conventional heating and cooling methods may prove inadequate. Innovative HVAC solutions offer a promising avenue for addressing these challenges by providing efficient climate control systems tailored specifically for the unique needs of mobile home residents.

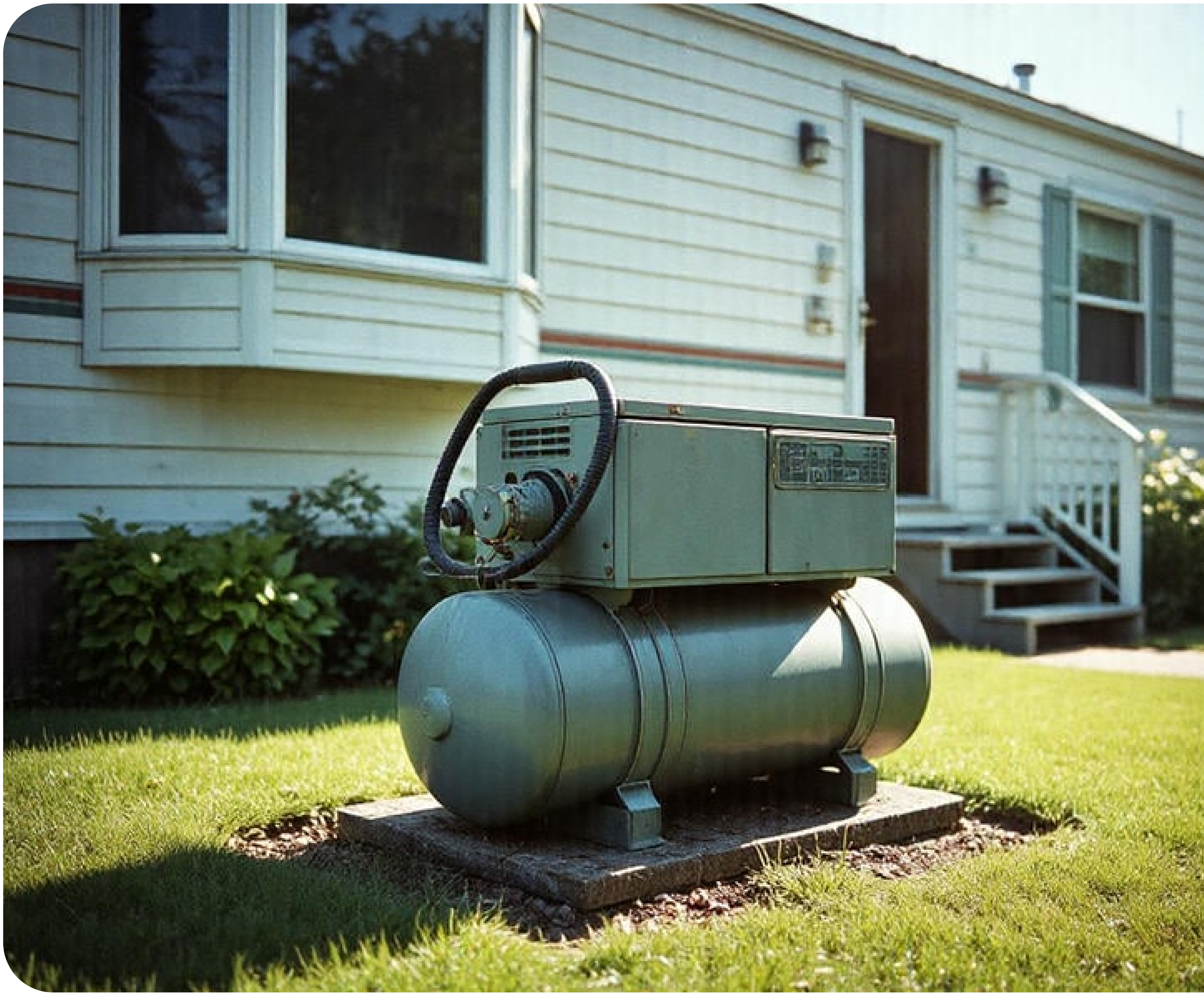
One promising solution is the integration of smart HVAC systems equipped with adaptive technology. These systems use sensors and algorithms to monitor both indoor and outdoor temperatures continuously. By analyzing this data in real-time, smart HVAC units can adjust heating or cooling output dynamically, ensuring that the interior of a mobile home remains comfortable regardless of external conditions. This adaptability not only enhances comfort but also optimizes energy efficiency-a critical consideration given the limited space and resources typical of mobile homes.

Another innovative approach involves using geothermal heat pumps specifically designed for smaller spaces like mobile homes. Geothermal systems leverage the stable temperatures found underground to heat or cool interiors efficiently. By tapping into this renewable energy source, homeowners can reduce their reliance on fossil fuels while minimizing utility costs-a win-win scenario for both residents and the environment.

Additionally, developments in radiant flooring technology present an effective alternative for managing temperature swings in mobile homes. Unlike traditional forced-air systems that rely on air circulation to distribute heat or cold, radiant floors provide consistent thermal comfort by directly warming (or cooling) surfaces within the home. This method reduces energy consumption while delivering even temperature distribution throughout each room.

Finally, advancements in building materials also play a pivotal role in enhancing thermal management capabilities within mobile homes. High-performance insulation materials such as spray foam or reflective barriers can significantly mitigate unwanted heat gain or loss through walls and roofs-common weak points in many older models of mobile homes.

In conclusion, as climate patterns continue evolving unpredictably due to global warming effects; it is crucial that we adopt innovative solutions capable of meeting modern demands head-on-especially within vulnerable housing sectors like mobile homes which face heightened exposure risks from rapid seasonal shifts outside their doors daily! By embracing cutting-edge technologies available today across various fields related directly towards improving overall efficiency levels associated primarily around maintaining optimal indoor climates-homeowners stand better chances not only surviving but thriving under any circumstances arise tomorrow too!



Tools and Technologies for Accurate Duct Mapping

As climate change continues to influence global weather patterns, the need for energy-efficient practices in mobile home HVAC systems becomes increasingly pressing. Mobile homes, often less insulated than traditional structures, face unique challenges when adapting to rapid seasonal swings in temperature. Implementing energy efficiency practices and technologies is not only essential for reducing environmental impact but also for enhancing comfort and lowering energy costs for residents.

Mobile homes traditionally struggle with heat retention due to thinner walls and less insulation compared to conventional houses. This makes them particularly susceptible to external temperature fluctuations. To counteract these limitations, adopting advanced insulation techniques can be a game-changer. For instance, using high-performance materials such as spray foam or rigid foam boards can significantly reduce heat loss during winter and minimize heat gain in summer. Such improvements create a more stable internal environment, decreasing the reliance on HVAC systems and thus conserving energy.

Another pivotal strategy involves upgrading HVAC units themselves. Older models are typically less efficient, leading to higher energy consumption and costs. By replacing them with modern high-efficiency units designed specifically for mobile homes, residents can experience enhanced performance at a reduced operational cost. These units often incorporate smart technology that allows precise control over heating and cooling processes, ensuring that the system operates only when necessary.

Moreover, integrating programmable thermostats offers an additional layer of efficiency. These devices allow homeowners to schedule heating and cooling cycles according to their daily routines, preventing unnecessary energy use when the home is vacant or occupants are asleep. Some advanced models even adapt automatically based on occupancy patterns or weather forecasts.

In addition to upgrading existing systems, incorporating renewable energy sources could further heighten efficiency levels in mobile homes. Solar panels provide a sustainable option; they can power HVAC systems while simultaneously reducing reliance on non-renewable electricity sources. Even small-scale implementations can make a significant difference in both carbon footprint and utility bills over time.

Ventilation is another critical component of an efficient HVAC system within mobile residences; without proper airflow management, indoor air quality may deteriorate rapidly due to humidity build-up or pollutants from cooking appliances or other household activities. Installing energy recovery ventilators (ERVs) ensures consistent fresh air flow without sacrificing thermal comfort by capturing outgoing thermal energy from stale air before it exits the building envelope-returning it back into incoming fresh air streams instead.

Finally, educating mobile home residents about best practices concerning their HVAC system usage plays an essential role in maintaining long-term efficiency gains achieved through technological upgrades alone will not suffice if users do not understand how best utilize these tools effectively-for example sealing leaks around windows/doors prevents conditioned air escaping outdoors unnecessarily-and implementing regular maintenance checks keeps everything running smoothly while prolonging lifespan equipment itself too!

In conclusion: embracing innovative solutions tailored specifically towards improving overall performance within context unique constraints faced by those living inside mobile dwellings presents tremendous opportunity-not just save money but also contribute positively broader fight against ongoing ecological crisis confronting planet today!

Best Practices for Cleaner Airflow

As the world experiences increasingly unpredictable weather patterns due to climate change, mobile home residents face unique challenges in maintaining comfortable living environments. Mobile homes, often characterized by their lightweight construction and limited insulation, can be particularly vulnerable to rapid seasonal temperature swings. Successfully adapting HVAC (Heating, Ventilation, and Air Conditioning) systems in these homes is crucial for ensuring comfort and energy efficiency across diverse climates.

Case studies from various regions provide valuable insights into effective strategies for modifying HVAC systems in mobile homes. In the northern United States, where winters are harsh and summers can be intensely hot, one successful adaptation involved upgrading traditional furnaces and air conditioning units to high-efficiency heat pumps. Heat pumps are versatile; they provide both heating and cooling by transferring heat between the home and the outside air. This dual functionality makes them an ideal choice for areas with significant temperature fluctuations throughout the year.

In addition to installing heat pumps, homeowners also benefited from sealing ductwork and adding insulation. Many older mobile homes suffer from poorly sealed ducts that lead to significant energy loss. By addressing this issue, residents were able to reduce their energy consumption while maintaining a steady indoor climate during extreme weather conditions.

In contrast, regions like the southwestern United States experience milder winters but extremely hot summers. Here, evaporative coolers have proven effective as an energy-efficient alternative or supplement to traditional air conditioning systems. Also known as swamp coolers, these devices utilize evaporation to lower air temperature-a process that works exceptionally well in dry climates. As a result of implementing evaporative cooling solutions alongside efficient ventilation systems, mobile home occupants reported improved interior comfort without incurring excessive utility costs.

Meanwhile, in humid subtropical climates such as those found in parts of the southeastern United States, dehumidification plays a critical role in enhancing HVAC performance. High humidity levels can exacerbate discomfort during warm seasons by hindering sweat evaporation and making temperatures feel hotter than they actually are. By integrating dehumidifiers into their existing HVAC setups or opting for modern AC units with built-in dehumidification capabilities, homeowners managed not only to cool their spaces more effectively but also prevent moisture-related issues like mold growth.

Across all these settings, smart technology has emerged as a game-changer in optimizing HVAC operations within mobile homes. Programmable thermostats allow residents greater control over indoor temperatures by scheduling heating or cooling according to occupancy patterns-a feature that ensures maximum efficiency while minimizing wasteful energy consumption when no one is at home.

The success stories highlighted above underscore how adaptable HVAC solutions tailored specifically for mobile homes can dramatically improve living conditions amidst rapid seasonal swings in temperature across different climates around the globe-whether through adopting innovative technologies like heat pumps or leveraging natural processes via evaporative cooling methods suited perfectly depending on each region's specific needs combined with strategic enhancements aimed at insulating against external elements efficiently thus creating resilient comfortable habitats regardless wherever situated ultimately empowering individuals families communities alike fostering sustainable lifestyles long term benefiting generations come ahead future endeavors alike similar pursuits worldwide further advancing collective understanding knowledge expertise field bringing us ever closer achieving common goals shared prosperity united vision forward always determined together thrive flourish persistently resolute hopeful optimistic potential limitless possibilities await unfold seemingly boundless opportunities horizon beckoning inviting eagerly embrace step boldly confidently stride forth courageously toward brighter tomorrow promising dawn anew!

Case Studies of Improved Air Quality in Mobile Homes

In recent years, the mobile home industry has witnessed a significant technological evolution, particularly in the realm of HVAC (Heating, Ventilation, and Air Conditioning) systems. As climate change contributes to increasingly unpredictable weather patterns and more rapid swings in temperature, adapting mobile homes to these conditions has become a priority for manufacturers and homeowners alike. This essay explores future trends in mobile home HVAC technology and how these innovations are poised to enhance seasonal adaptation.

One of the most promising trends in mobile home HVAC technology is the integration of smart systems. These intelligent systems can monitor environmental conditions both inside and outside the home, adjusting heating or cooling output as needed to maintain optimal comfort levels. For instance, smart thermostats can learn a homeowner's schedule and preferences over time, automatically optimizing energy usage to reduce costs while ensuring that the interior environment remains pleasant regardless of external temperatures. Furthermore, some advanced systems can even be controlled remotely via smartphone apps, giving users unprecedented control over their home's climate from virtually anywhere.

Another major advancement is the development of energy-efficient HVAC units tailored specifically for mobile homes. Traditional systems often struggle with inefficiencies due to poor insulation or inadequate ductwork common in older models of mobile homes. Newer units are designed with compact sizes that fit better within smaller spaces while offering improved performance through enhanced airflow technologies. Innovations such as variable speed compressors allow these units to adapt more seamlessly to changing weather conditions by modulating power output rather than running at full capacity constantly.

The trend towards sustainability also plays a crucial role in shaping future HVAC developments for mobile homes. As more consumers become environmentally conscious, there is growing demand for eco-friendly solutions that minimize carbon footprints without sacrificing comfort. Solar-powered HVAC systems are emerging as a viable solution; they harness renewable energy from solar panels installed on rooftops or nearby structures to power heating and cooling operations sustainably. This not only reduces reliance on fossil fuels but also provides cost savings on utility bills over time.

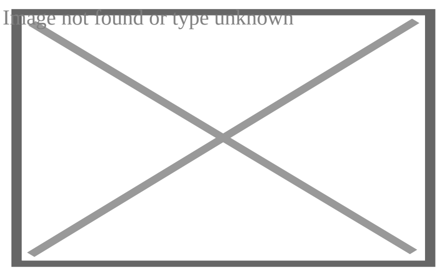
Moreover, advancements in materials science have led to better insulation technologies that significantly improve a mobile home's ability to withstand rapid temperature fluctuations. High-performance insulating materials like spray foam or insulated skirting help maintain internal temperatures by minimizing heat transfer between the indoors and outdoors. Coupled with modern airtight construction techniques, these materials contribute substantially towards creating an energy-efficient living space that adapts more readily to seasonal changes.

Finally, modularity is becoming an integral part of future HVAC designs for mobile homes. Modular systems offer flexibility by allowing homeowners to customize their climate control setup according to specific needs or preferences whether it involves adding extra units during particularly harsh seasons or upgrading components over time as newer technologies become available.

In conclusion, the future of mobile home HVAC technology lies at the intersection of smart automation, energy efficiency, sustainability practices, superior insulation methods, and modular adaptability. By embracing these innovations collectively aimed at enhancing seasonal adaptation capabilities amidst rapid climatic shifts-homeowners can look forward not only towards greater comfort but also contribute meaningfully towards sustainable living practices within this unique housing sector.

About Thermal comfort

This article is about comfort zones in building construction. For other uses, see Comfort zone (disambiguation).



A thermal image of human

Thermal comfort is the condition of mind that expresses subjective satisfaction with the thermal environment.[1] The human body can be viewed as a heat engine where food is the input energy. The human body will release excess heat into the environment, so the body can continue to operate. The heat transfer is proportional to temperature difference. In cold environments, the body loses more heat to the environment and in hot environments the body does not release enough heat. Both the hot and cold scenarios lead to discomfort.[2] Maintaining this standard of thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC (heating, ventilation, and air conditioning) design engineers.

Thermal neutrality is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. The main factors that influence thermal neutrality are those that determine heat gain and loss, namely metabolic rate, clothing insulation, air temperature, mean radiant temperature, air speed and relative humidity. Psychological parameters, such as individual expectations, and physiological parameters also affect thermal neutrality.[3] Neutral temperature is the temperature that can lead to thermal neutrality and it may vary greatly between individuals and depending on factors such as activity level, clothing, and humidity. People are highly sensitive to even small differences in environmental temperature. At 24 °C, a difference of 0.38 °C can be detected between the temperature of two rooms.[4]

The Predicted Mean Vote (PMV) model stands among the most recognized thermal comfort models. It was developed using principles of heat balance and experimental data collected in a controlled climate chamber under steady state conditions.[5] The adaptive model, on the other hand, was developed based on hundreds of field studies with the idea that occupants dynamically interact with their environment. Occupants control their thermal environment by means of clothing, operable windows, fans, personal heaters, and sun shades.[3][6] The PMV model can be applied to air-conditioned buildings, while the adaptive model can be applied only to buildings where no mechanical systems have been installed.[1] There is no consensus about which comfort model should be applied for buildings that are partially air-conditioned spatially or temporally.

Thermal comfort calculations in accordance with the ANSI/ASHRAE Standard 55,[1] the ISO 7730 Standard[7] and the EN 16798-1 Standard[8] can be freely performed with either the CBE Thermal Comfort Tool for ASHRAE 55,[9] with the Python package pythermalcomfort[10] or with the R package comf.

Significance

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Satisfaction with the thermal environment is important because thermal conditions are potentially life-threatening for humans if the core body temperature reaches conditions of hyperthermia, above 37.5–38.3 °C (99.5–100.9 °F),[11][12] or hypothermia, below 35.0 °C (95.0 °F).[13] Buildings modify the conditions of the external environment and reduce the effort that the human body needs to do in order to stay stable at a normal human body temperature, important for the correct functioning of human physiological processes.

The Roman writer Vitruvius actually linked this purpose to the birth of architecture.[14] David Linden also suggests that the reason why we associate tropical beaches with paradise is because in those environments is where human bodies need to do less metabolic effort to maintain their core temperature.[15] Temperature not only supports human life; coolness and warmth have also become in different cultures a symbol of protection, community and even the sacred.[16]

In building science studies, thermal comfort has been related to productivity and health. Office workers who are satisfied with their thermal environment are more productive.[17][18] The combination of high temperature and high relative humidity reduces thermal comfort and indoor air quality.[19]

Although a single static temperature can be comfortable, people are attracted by thermal changes, such as campfires and cool pools. Thermal pleasure is caused by varying thermal sensations from a state of unpleasantness to a state of pleasantness, and the scientific term for it is positive thermal alliesthesia.[20] From a state of thermal neutrality or comfort any change will be perceived as unpleasant.[21] This challenges the assumption that mechanically controlled buildings should deliver uniform temperatures and comfort, if it is at the cost of excluding thermal pleasure.[22]

Influencing factors

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Since there are large variations from person to person in terms of physiological and psychological satisfaction, it is hard to find an optimal temperature for everyone in a given space. Laboratory and field data have been collected to define conditions that will be found comfortable for a specified percentage of occupants.[1]

There are numerous factors that directly affect thermal comfort that can be grouped in two categories:

1. **Personal factors** – characteristics of the occupants such as metabolic rate and clothing level

2. **Environmental factors** – which are conditions of the thermal environment, specifically air temperature, mean radiant temperature, air speed and humidity

Even if all these factors may vary with time, standards usually refer to a steady state to study thermal comfort, just allowing limited temperature variations.

Personal factors

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Metabolic rate

[edit]
Main article: Metabolic rate

People have different metabolic rates that can fluctuate due to activity level and environmental conditions.[23][24][25] ASHRAE 55-2017 defines metabolic rate as the rate of transformation of chemical energy into heat and mechanical work by metabolic activities of an individual, per unit of skin surface area.[1]
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Metabolic rate is expressed in units of met, equal to 58.2 W/m² (18.4 Btu/h·ft²). One met is equal to the energy produced per unit surface area of an average person seated at rest.

ASHRAE 55 provides a table of metabolic rates for a variety of activities. Some common values are 0.7 met for sleeping, 1.0 met for a seated and quiet position, 1.2–1.4 met for light activities standing, 2.0 met or more for activities that involve movement, walking, lifting heavy loads or operating machinery. For intermittent activity, the standard states that it is permissible to use a time-weighted average metabolic rate if individuals are performing activities that vary over a period of one hour or less. For longer periods, different metabolic rates must be considered.[1]

According to ASHRAE Handbook of Fundamentals, estimating metabolic rates is complex, and for levels above 2 or 3 met – especially if there are various ways of performing such activities – the accuracy is low. Therefore, the standard is not applicable for activities with an average level higher than 2 met. Met values can also be determined more accurately than the tabulated ones, using an empirical equation that takes into account the rate of respiratory oxygen consumption and carbon dioxide production. Another physiological yet less accurate method is related to the heart rate, since there is a relationship between the latter and oxygen consumption.[26]

The Compendium of Physical Activities is used by physicians to record physical activities. It has a different definition of met that is the ratio of the metabolic rate of the activity in question to a resting metabolic rate.[27] As the formulation of the concept is different from the one that ASHRAE uses, these met values cannot be used directly in PMV calculations, but it opens up a new way of quantifying physical activities.

Food and drink habits may have an influence on metabolic rates, which indirectly influences thermal preferences. These effects may change depending on food and drink intake.[28]

Body shape is another factor that affects metabolic rate and hence thermal comfort. Heat dissipation depends on body surface area. The surface area of an average person is 1.8 m^2 (19 ft^2).[1] A tall and skinny person has a larger surface-to-volume ratio, can dissipate heat more easily, and can tolerate higher temperatures more than a person with a rounded body shape.[28]

Clothing insulation

[edit]
Main article: Clothing insulation

The amount of thermal insulation worn by a person has a substantial impact on thermal comfort, because it influences the heat loss and consequently the thermal balance. Layers of insulating clothing prevent heat loss and can either help keep a person warm or lead to overheating. Generally, the thicker the garment is, the greater insulating ability it has. Depending on the type of material the clothing is made out of, air movement and relative humidity can decrease the insulating ability of the material.[29][30]

1 clo is equal to 0.155 m^2·K/W (0.88 °F·ft^2·h/Btu). This corresponds to trousers, a long sleeved shirt, and a jacket. Clothing insulation values for other common ensembles or single garments can be found in ASHRAE 55.[1]

Skin wetness

[edit]

Skin wetness is defined as "the proportion of the total skin surface area of the body covered with sweat".[31] The wetness of skin in different areas also affects perceived thermal comfort. Humidity can increase wetness in different areas of the body, leading to a perception of discomfort. This is usually localized in different parts of the body, and local thermal comfort limits for skin wetness differ by locations of the body.[32] The extremities are much more sensitive to thermal discomfort from wetness than the trunk of the body. Although local thermal discomfort can be caused by wetness, the thermal comfort of the whole body will not be affected by the wetness of certain parts.

Environmental factors

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Air temperature

[edit]
Main article: Dry-bulb temperature

The air temperature is the average temperature of the air surrounding the occupant, with respect to location and time. According to ASHRAE 55 standard, the spatial average takes into account the ankle, waist and head levels, which vary for seated or standing occupants. The temporal average is based on three-minutes intervals with at least 18 equally spaced points in time. Air temperature is measured with a dry-bulb thermometer and for this reason it is also known as dry-bulb temperature.

Mean radiant temperature

[edit]
Main article: Mean radiant temperature

The radiant temperature is related to the amount of radiant heat transferred from a surface, and it depends on the material's ability to absorb or emit heat, or its emissivity. The mean radiant temperature depends on the temperatures and emissivities of the surrounding surfaces as well as the view factor, or the amount of the surface that is "seen" by the object. So the mean radiant temperature experienced by a person in a room with the sunlight streaming in varies based on how much of their body is in the sun.

Air speed

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Air speed is defined as the rate of air movement at a point, without regard to direction. According to ANSI/ASHRAE Standard 55, it is the average speed of the air surrounding a representative occupant, with respect to location and time. The spatial average is for three heights as defined for average air temperature. For an occupant moving in a space the sensors shall follow the movements of the occupant. The air speed is averaged over an interval not less than one and not greater than three minutes. Variations that occur over a period greater than three minutes shall be treated as multiple different air speeds.[33]

Relative humidity

[edit]
Main article: Relative humidity

Relative humidity (RH) is the ratio of the amount of water vapor in the air to the amount of water vapor that the air could hold at the specific temperature and pressure. While the human body has thermoreceptors in the skin that enable perception of temperature, relative humidity is detected indirectly. Sweating is an effective heat loss mechanism that relies on evaporation from the skin. However at high RH, the air has close to the maximum water vapor that it can hold, so evaporation, and therefore heat loss, is decreased. On the other hand, very dry environments (RH < 20–30%) are also uncomfortable because of their effect on the mucous membranes. The recommended level of indoor humidity is in the range of 30–60% in air conditioned buildings,[34][35] but new standards such as the adaptive model allow lower and higher humidity, depending on the other factors involved in thermal comfort.

Recently, the effects of low relative humidity and high air velocity were tested on humans after bathing. Researchers found that low relative humidity engendered thermal discomfort as well as the sensation of dryness and itching. It is recommended to keep relative humidity levels higher in a bathroom than other rooms in the house for optimal conditions.[36]

Various types of apparent temperature have been developed to combine air temperature and air humidity. For higher temperatures, there are quantitative scales, such as the heat index. For lower temperatures, a related interplay was identified only qualitatively:

- High humidity and low temperatures cause the air to feel chilly.[37]
- Cold air with high relative humidity "feels" colder than dry air of the same temperature because high humidity in cold weather increases the conduction of heat from the body.[38]

There has been controversy over why damp cold air feels colder than dry cold air. Some believe it is because when the humidity is high, our skin and clothing become moist and are better conductors of heat, so there is more cooling by conduction.[39]

The influence of humidity can be exacerbated with the combined use of fans (forced convection cooling).[40]

Natural ventilation

[edit]
Main article: Natural ventilation

Many buildings use an HVAC unit to control their thermal environment. Other buildings are naturally ventilated (or would have cross ventilation) and do not rely on mechanical systems to provide thermal comfort. Depending on the climate, this can drastically reduce energy consumption. It is sometimes seen as a risk, though, since indoor temperatures can be too extreme if the building is poorly designed. Properly designed, naturally ventilated buildings keep indoor conditions within the range where opening windows and using fans in the summer, and wearing extra clothing in the winter, can keep people thermally comfortable.[41]

Models and indices

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There are several different models or indices that can be used to assess thermal comfort conditions indoors as described below.

PMV/PPD method

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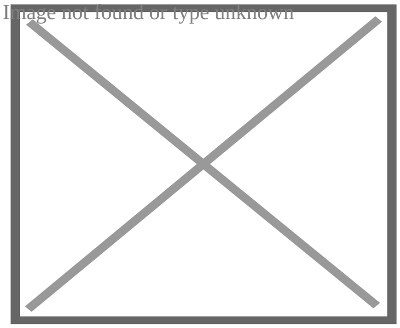
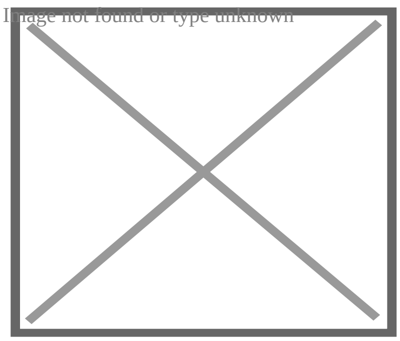


Psychrometric Chart



Temperature-relative humidity chart

Two alternative representations of thermal comfort for the PMV/PPD method

The PMV/PPD model was developed by P.O. Fanger using heat-balance equations and empirical studies about skin temperature to define comfort. Standard thermal comfort surveys ask subjects about their thermal sensation on a seven-point scale from cold (-3) to hot (+3). Fanger's equations are used to calculate the predicted mean vote (PMV) of a group of subjects for a particular combination of air temperature, mean radiant temperature, relative humidity, air speed, metabolic rate, and clothing insulation.[5] PMV equal to zero is representing thermal neutrality, and the comfort zone is defined by the combinations of the six parameters for which the PMV is within the recommended limits $(-0.5 < PMV < +0.5)$.[1] Although predicting the thermal sensation of a population is an important step in determining what conditions are comfortable, it is more useful to consider whether or not people will be satisfied. Fanger developed another equation to relate the PMV to the Predicted Percentage of Dissatisfied (PPD). This relation was based on studies that surveyed subjects in a chamber where the indoor conditions could be precisely controlled.[5]

The PMV/PPD model is applied globally but does not directly take into account the adaptation mechanisms and outdoor thermal conditions.[3][42][43]

ASHRAE Standard 55-2017 uses the PMV model to set the requirements for indoor thermal conditions. It requires that at least 80% of the occupants be satisfied.[1]

The CBE Thermal Comfort Tool for ASHRAE 55[9] allows users to input the six comfort parameters to determine whether a certain combination complies with ASHRAE 55. The results are displayed on a psychrometric or a temperature-relative humidity chart and indicate the ranges of temperature and relative humidity that will be comfortable with the given the values input for the remaining four parameters.[44]

The PMV/PPD model has a low prediction accuracy.[45] Using the world largest thermal comfort field survey database,[46] the accuracy of PMV in predicting occupant's thermal sensation was only 34%, meaning that the thermal sensation is correctly predicted one out of three times. The PPD was overestimating subject's thermal unacceptability outside the thermal neutrality ranges (-1≤PMV≤1). The PMV/PPD accuracy varies strongly between ventilation strategies, building types and climates.[45]

Elevated air speed method

[edit]

ASHRAE 55 2013 accounts for air speeds above 0.2 metres per second (0.66 ft/s) separately than the baseline model. Because air movement can provide direct cooling to people, particularly if they are not wearing much clothing, higher temperatures can be more comfortable than the PMV model predicts. Air speeds up to 0.8 m/s (2.6 ft/s) are allowed without local control, and 1.2 m/s is possible with local control. This elevated air movement increases the maximum temperature for an office space in the summer to 30 °C from 27.5 °C (86.0–81.5 °F).[1]

Virtual Energy for Thermal Comfort

[edit]

"Virtual Energy for Thermal Comfort" is the amount of energy that will be required to make a non-air-conditioned building relatively as comfortable as one with air-conditioning. This is based on the assumption that the home will eventually install air-conditioning or heating.[47] Passive design improves thermal comfort in a building, thus reducing demand for heating or cooling. In many developing countries, however, most occupants do not currently heat or cool, due to economic constraints, as well as climate conditions which border lines comfort conditions such as cold winter nights in Johannesburg (South Africa) or warm summer days in San Jose, Costa Rica. At the same time, as incomes rise, there is a strong tendency to introduce cooling and heating systems. If we recognize and reward passive design features that improve thermal comfort today, we diminish the risk of having to install HVAC systems in the future, or we at least ensure that such systems will be smaller and less frequently used. Or in case the heating or cooling system is not installed due to high cost, at least people should not suffer from discomfort indoors. To provide an example, in San Jose, Costa Rica, if a house were being designed with high level of glazing and small opening sizes, the internal temperature would easily rise above 30 °C (86 °F) and natural ventilation would not be enough to remove the internal heat gains and solar gains. This is why Virtual Energy for Comfort is important.

World Bank's assessment tool the EDGE software (Excellence in Design for Greater Efficiencies) illustrates the potential issues with discomfort in buildings and has created the concept of Virtual Energy for Comfort which provides for a way to present potential thermal discomfort. This approach is used to award for design solutions which improves thermal comfort even in a fully free running building. Despite the inclusion of requirements for overheating in CIBSE, overcooling has not been assessed. However, overcooling can be an issue, mainly in the developing world, for example in cities such as Lima (Peru), Bogota, and Delhi, where cooler indoor temperatures can occur frequently. This may be a new area for research and design guidance for reduction of discomfort.

Cooling Effect

[edit]

ASHRAE 55-2017 defines the Cooling Effect (CE) at elevated air speed (above 0.2 metres per second (0.66 ft/s)) as the value that, when subtracted from both the air temperature and the mean radiant temperature, yields the same SET value under still air (0.1 m/s) as in the first SET calculation under elevated air speed.[1]

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$$\displaystyle SET(t_a,t_r,v,met,clo,RH)=SET(t_a-CE,t_r-CE,v=0.1,met,clo,RH)$$

The CE can be used to determine the PMV adjusted for an environment with elevated air speed using the adjusted temperature, the adjusted radiant temperature and still air (0.2 metres per second (0.66 ft/s)). Where the adjusted temperatures are equal to the original air and mean radiant temperatures minus the CE.

Local thermal discomfort

[edit]

Avoiding local thermal discomfort, whether caused by a vertical air temperature difference between the feet and the head, by an asymmetric radiant field, by local convective cooling (draft), or by contact with a hot or cold floor, is essential to providing acceptable thermal comfort. People are generally more sensitive to local discomfort when their thermal sensation is cooler than neutral, while they are less sensitive to it when their body is warmer than neutral.[33]

Radiant temperature asymmetry

[edit]

Large differences in the thermal radiation of the surfaces surrounding a person may cause local discomfort or reduce acceptance of the thermal conditions. ASHRAE

Standard 55 sets limits on the allowable temperature differences between various surfaces. Because people are more sensitive to some asymmetries than others, for example that of a warm ceiling versus that of hot and cold vertical surfaces, the limits depend on which surfaces are involved. The ceiling is not allowed to be more than +5 °C (9.0 °F) warmer, whereas a wall may be up to +23 °C (41 °F) warmer than the other surfaces.[1]

Draft

[edit]

While air movement can be pleasant and provide comfort in some circumstances, it is sometimes unwanted and causes discomfort. This unwanted air movement is called "draft" and is most prevalent when the thermal sensation of the whole body is cool. People are most likely to feel a draft on uncovered body parts such as their head, neck, shoulders, ankles, feet, and legs, but the sensation also depends on the air speed, air temperature, activity, and clothing.[1]

Floor surface temperature

[edit]

Floors that are too warm or too cool may cause discomfort, depending on footwear. ASHRAE 55 recommends that floor temperatures stay in the range of 19–29 °C (66–84 °F) in spaces where occupants will be wearing lightweight shoes.[1]

Standard effective temperature

[edit]

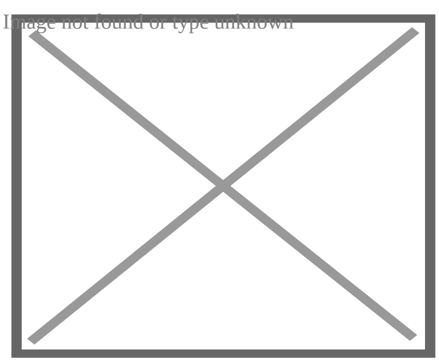
Standard effective temperature (SET) is a model of human response to the thermal environment. Developed by A.P. Gagge and accepted by ASHRAE in 1986,[48] it is also referred to as the Pierce Two-Node model.[49] Its calculation is similar to PMV because it is a comprehensive comfort index based on heat-balance equations that incorporates the personal factors of clothing and metabolic rate. Its fundamental difference is it takes a two-node method to represent human physiology in measuring skin temperature and skin wettedness.[48]

The SET index is defined as the equivalent dry bulb temperature of an isothermal environment at 50% relative humidity in which a subject, while wearing clothing standardized for activity concerned, would have the same heat stress (skin temperature) and thermoregulatory strain (skin wettedness) as in the actual test environment.[48]

Research has tested the model against experimental data and found it tends to overestimate skin temperature and underestimate skin wettedness.[49][50] Fountain and Huizenga (1997) developed a thermal sensation prediction tool that computes SET.[51] The SET index can also be calculated using either the CBE Thermal Comfort Tool for ASHRAE 55,[9] the Python package pythermalcomfort,[10] or the R package comf.

Adaptive comfort model

[edit]



Adaptive chart according to ASHRAE Standard 55-2010

The adaptive model is based on the idea that outdoor climate might be used as a proxy of indoor comfort because of a statistically significant correlation between them. The adaptive hypothesis predicts that contextual factors, such as having access to environmental controls, and past thermal history can influence building occupants' thermal expectations and preferences.[3] Numerous researchers have conducted field studies worldwide in which they survey building occupants about their thermal comfort while taking simultaneous environmental measurements. Analyzing a database of results from 160 of these buildings revealed that occupants of naturally ventilated buildings accept and even prefer a wider range of temperatures than their counterparts in sealed, air-conditioned buildings because their preferred temperature depends on outdoor conditions.[3] These results were incorporated in the ASHRAE 55-2004 standard as the adaptive comfort model. The adaptive chart relates indoor comfort temperature to prevailing outdoor temperature and defines zones of 80% and 90% satisfaction.[1]

The ASHRAE-55 2010 Standard introduced the prevailing mean outdoor temperature as the input variable for the adaptive model. It is based on the arithmetic average of the mean daily outdoor temperatures over no fewer than 7 and no more than 30 sequential days prior to the day in question.[1] It can also be calculated by weighting the temperatures with different coefficients, assigning increasing importance to the most recent temperatures. In case this weighting is used, there is no need to respect the upper limit for the subsequent days. In order to apply the adaptive model, there should be no mechanical cooling system for the space, occupants should be engaged in sedentary activities with metabolic rates of 1–1.3 met, and a prevailing mean temperature of 10–33.5 °C (50.0–92.3 °F).[1]

This model applies especially to occupant-controlled, natural-conditioned spaces, where the outdoor climate can actually affect the indoor conditions and so the comfort zone. In fact, studies by de Dear and Brager showed that occupants in naturally ventilated buildings were tolerant of a wider range of temperatures.[3] This is due to both behavioral and physiological adjustments, since there are different types of adaptive processes.[52] ASHRAE Standard 55-2010 states that differences in recent thermal experiences, changes in clothing, availability of control options, and shifts in occupant expectations can change people's thermal responses.[1]

Adaptive models of thermal comfort are implemented in other standards, such as European EN 15251 and ISO 7730 standard. While the exact derivation methods and results are slightly different from the ASHRAE 55 adaptive standard, they are substantially the same. A larger difference is in applicability. The ASHRAE adaptive standard only applies to buildings without mechanical cooling installed, while EN15251 can be applied to mixed-mode buildings, provided the system is not running.[53]

There are basically three categories of thermal adaptation, namely: behavioral, physiological, and psychological.

Psychological adaptation

[edit]

An individual's comfort level in a given environment may change and adapt over time due to psychological factors. Subjective perception of thermal comfort may be influenced by the memory of previous experiences. Habituation takes place when repeated exposure moderates future expectations, and responses to sensory input. This is an important factor in explaining the difference between field observations and PMV predictions (based on the static model) in naturally ventilated buildings. In these buildings, the relationship with the outdoor temperatures has been twice as strong as predicted.[3]

Psychological adaptation is subtly different in the static and adaptive models. Laboratory tests of the static model can identify and quantify non-heat transfer (psychological) factors that affect reported comfort. The adaptive model is limited to reporting differences (called psychological) between modeled and reported comfort.[*citation n*

Thermal comfort as a "condition of mind" is *defined* in psychological terms. Among the factors that affect the condition of mind (in the laboratory) are a sense of control over the temperature, knowledge of the temperature and the appearance of the (test) environment. A thermal test chamber that appeared residential "felt" warmer than one which looked like the inside of a refrigerator.[54]

Physiological adaptation

[edit]

Further information: Thermoregulation

The body has several thermal adjustment mechanisms to survive in drastic temperature environments. In a cold environment the body utilizes vasoconstriction; which reduces blood flow to the skin, skin temperature and heat dissipation. In a warm environment, vasodilation will increase blood flow to the skin, heat transport, and skin temperature and heat dissipation.[55] If there is an imbalance despite the vasomotor adjustments listed above, in a warm environment sweat production will start and provide evaporative cooling. If this is insufficient, hyperthermia will set in, body temperature may reach 40 °C (104 °F), and heat stroke may occur. In a cold environment, shivering will start, involuntarily forcing the muscles to work and increasing the heat production by up to a factor of 10. If equilibrium is not restored, hypothermia can set in, which can be fatal.[55] Long-term adjustments to extreme temperatures, of a few days to six months, may result in cardiovascular and endocrine adjustments. A hot climate may create increased blood volume, improving the effectiveness of vasodilation, enhanced performance of the sweat mechanism, and the readjustment of thermal preferences. In cold or underheated conditions, vasoconstriction can become permanent, resulting in decreased blood volume and increased body metabolic rate.[55]

Behavioral adaptation

[edit]

In naturally ventilated buildings, occupants take numerous actions to keep themselves comfortable when the indoor conditions drift towards discomfort. Operating windows and fans, adjusting blinds/shades, changing clothing, and consuming food and drinks are some of the common adaptive strategies. Among these, adjusting windows is the most common.[56] Those occupants who take these sorts of actions tend to feel cooler at warmer temperatures than those who do not.[57]

The behavioral actions significantly influence energy simulation inputs, and researchers are developing behavior models to improve the accuracy of simulation results. For example, there are many window-opening models that have been developed to date, but there is no consensus over the factors that trigger window opening.[56]

People might adapt to seasonal heat by becoming more nocturnal, doing physical activity and even conducting business at night.

Specificity and sensitivity

[edit]

Individual differences

[edit]
Further information: Cold sensitivity

The thermal sensitivity of an individual is quantified by the descriptor *FS*, which takes on higher values for individuals with lower tolerance to non-ideal thermal conditions.[58] This group includes pregnant women, the disabled, as well as individuals whose age is below fourteen or above sixty, which is considered the adult range. Existing literature provides consistent evidence that sensitivity to hot and cold surfaces usually declines with age. There is also some evidence of a gradual reduction in the effectiveness of the body in thermo-regulation after the age of sixty.[58] This is mainly due to a more sluggish response of the counteraction mechanisms in lower parts of the body that are used to maintain the core temperature of the body at ideal values.[58] Seniors prefer warmer temperatures than young adults (76 vs 72 degrees F or 24.4 vs 22.2 Celsius).[54]

Situational factors include the health, psychological, sociological, and vocational activities of the persons.

Biological sex differences

[edit]

While thermal comfort preferences between sexes seem to be small, there are some average differences. Studies have found males on average report discomfort due to rises in temperature much earlier than females. Males on average also estimate higher levels of their sensation of discomfort than females. One recent study tested males and females in the same cotton clothing, performing mental jobs while using a dial vote to report their thermal comfort to the changing temperature.[59] Many times, females preferred higher temperatures than males. But while females tend to be more sensitive to temperatures, males tend to be more sensitive to relative-humidity levels.[60][61]

An extensive field study was carried out in naturally ventilated residential buildings in Kota Kinabalu, Sabah, Malaysia. This investigation explored the sexes thermal sensitivity to the indoor environment in non-air-conditioned residential buildings. Multiple hierarchical regression for categorical moderator was selected for data analysis; the result showed that as a group females were slightly more sensitive than males to the indoor air temperatures, whereas, under thermal neutrality, it was found that males and females have similar thermal sensation.[62]

Regional differences

[edit]

In different areas of the world, thermal comfort needs may vary based on climate. In China[*where?*] the climate has hot humid summers and cold winters, causing a need for efficient thermal comfort. Energy conservation in relation to thermal comfort has become a large issue in China in the last several decades due to rapid economic and population growth.[63] Researchers are now looking into ways to heat and cool buildings in China for lower costs and also with less harm to the environment.

In tropical areas of Brazil, urbanization is creating urban heat islands (UHI). These are urban areas that have risen over the thermal comfort limits due to a large influx of people and only drop within the comfortable range during the rainy season.[64] Urban heat islands can occur over any urban city or built-up area with the correct conditions.[65][66]

In the hot, humid region of Saudi Arabia, the issue of thermal comfort has been important in mosques, because they are very large open buildings that are used only intermittently (very busy for the noon prayer on Fridays) it is hard to ventilate them properly. The large size requires a large amount of ventilation, which requires a lot of energy since the buildings are used only for short periods of time. Temperature regulation in mosques is a challenge due to the intermittent demand, leading to many mosques being either too hot or too cold. The stack effect also comes into play due to their large size and creates a large layer of hot air above the people in the mosque. New designs have placed the ventilation systems lower in the buildings to provide more temperature control at ground level.[67] New monitoring steps are also being taken to improve efficiency.[68]

Thermal stress

[edit]
Not to be confused with thermal stress on objects, which describes the change materials experience when subject to extreme temperatures.

The concept of thermal comfort is closely related to thermal stress. This attempts to predict the impact of solar radiation, air movement, and humidity for military personnel undergoing training exercises or athletes during competitive events. Several thermal stress indices have been proposed, such as the Predicted Heat Strain (PHS) or the humidex.[69] Generally, humans do not perform well under thermal stress. People's performances under thermal stress is about 11% lower than their performance at normal thermal wet conditions. Also, human performance in relation to thermal stress varies greatly by the type of task which the individual is completing. Some of the physiological effects of thermal heat stress include increased blood flow to the skin, sweating, and increased ventilation.[70][71]

Predicted Heat Strain (PHS)

[edit]

The PHS model, developed by the International Organization for Standardization (ISO) committee, allows the analytical evaluation of the thermal stress experienced by a working subject in a hot environment.[72] It describes a method for predicting the sweat rate and the internal core temperature that the human body will develop in response to the working conditions. The PHS is calculated as a function of several physical parameters, consequently it makes it possible to determine which parameter or group of parameters should be modified, and to what extent, in order to reduce the risk of physiological strains. The PHS model does not predict the physiological response of an individual subject, but only considers standard subjects in good health and fit for the work they perform. The PHS can be determined using either the Python package pythermalcomfort[10] or the R package comf.

American Conference on Governmental Industrial Hygienists (ACGIH) Action Limits and Threshold Limit Values

[edit]

ACGIH has established Action Limits and Threshold Limit Values for heat stress based upon the estimated metabolic rate of a worker and the environmental conditions the worker is subjected to.

This methodology has been adopted by the Occupational Safety and Health Administration (OSHA) as an effective method of assesing heat stress within workplaces.[73]

Research

[edit]

The factors affecting thermal comfort were explored experimentally in the 1970s. Many of these studies led to the development and refinement of ASHRAE Standard 55 and were performed at Kansas State University by Ole Fanger and others. Perceived comfort was found to be a complex interaction of these variables. It was found that the majority of individuals would be satisfied by an ideal set of values. As the range of values deviated progressively from the ideal, fewer and fewer people were satisfied. This observation could be expressed statistically as the percent of individuals who expressed satisfaction by *comfort conditions* and the *predicted mean vote* (PMV). This approach was challenged by the adaptive comfort model, developed from the ASHRAE 884 project, which revealed that occupants were comfortable in a broader range of temperatures.[3]

This research is applied to create Building Energy Simulation (BES) programs for residential buildings. Residential buildings in particular can vary much more in thermal comfort than public and commercial buildings. This is due to their smaller size, the variations in clothing worn, and different uses of each room. The main rooms of concern are bathrooms and bedrooms. Bathrooms need to be at a temperature comfortable for a human with or without clothing. Bedrooms are of importance because they need to accommodate different levels of clothing and also different metabolic rates of people asleep or awake.[74] Discomfort hours is a common metric used to evaluate the thermal performance of a space.

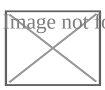
Thermal comfort research in clothing is currently being done by the military. New air-ventilated garments are being researched to improve evaporative cooling in military settings. Some models are being created and tested based on the amount of cooling they provide.[75]

In the last twenty years, researchers have also developed advanced thermal comfort models that divide the human body into many segments, and predict local thermal discomfort by considering heat balance.[76][77][78] This has opened up a new arena of thermal comfort modeling that aims at heating/cooling selected body parts.

Another area of study is the hue–heat hypothesis that states that an environment with warm colors (red, orange yellow hues) will feel warmer in terms of temperature and comfort, while an environment with cold colors (blue, green hues) will feel cooler.[79][80][81] The hue–heat hypothesis has both been investigated scientifically[82] and ingrained in popular culture in the terms warm and cold colors [83]

Medical environments

[edit]



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Whenever the studies referenced tried to discuss the thermal conditions for different groups of occupants in one room, the studies ended up simply presenting comparisons of thermal comfort satisfaction based on the subjective studies. No study tried to reconcile the different thermal comfort requirements of different types of occupants who compulsorily must stay in one room. Therefore, it looks to be necessary to investigate the different thermal conditions required by different groups of occupants in hospitals to reconcile their different requirements in this concept. To reconcile the differences in the required thermal comfort conditions it is recommended to test the possibility of using different ranges of local radiant temperature in one room via a suitable mechanical system.

Although different researches are undertaken on thermal comfort for patients in hospitals, it is also necessary to study the effects of thermal comfort conditions on the quality and the quantity of healing for patients in hospitals. There are also original researches that show the link between thermal comfort for staff and their levels of productivity, but no studies have been produced individually in hospitals in this field. Therefore, research for coverage and methods individually for this subject is recommended. Also research in terms of cooling and heating delivery systems for patients with low levels of immune-system protection (such as HIV patients, burned patients, etc.) are recommended. There are important areas, which still need to be focused on including thermal comfort for staff and its relation with their productivity, using different heating systems to prevent hypothermia in the patient and to improve the thermal comfort for hospital staff simultaneously.

Finally, the interaction between people, systems and architectural design in hospitals is a field in which require further work needed to improve the knowledge of how to design buildings and systems to reconcile many conflicting factors for the people occupying these buildings.[84]

Personal comfort systems

[edit]

Personal comfort systems (PCS) refer to devices or systems which heat or cool a building occupant personally.[85] This concept is best appreciated in contrast to central HVAC systems which have uniform temperature settings for extensive areas. Personal comfort systems include fans and air diffusers of various kinds (e.g. desk fans, nozzles and slot diffusers, overhead fans, high-volume low-speed fans etc.) and personalized sources of radiant or conductive heat (footwarmers, legwarmers, hot water bottles etc.). PCS has the potential to satisfy individual comfort requirements much better than current HVAC systems, as interpersonal differences in thermal sensation due to age, sex, body mass, metabolic rate, clothing and thermal adaptation can amount to an equivalent temperature variation of 2–5 °C (3,6–9 °F), which is impossible for a central, uniform HVAC system to cater to.[85] Besides, research has shown that the perceived ability to control one's thermal environment tends to widen one's range of tolerable temperatures.[3] Traditionally, PCS devices have been used in isolation from one another. However, it has been proposed by Andersen et al. (2016) that a network of PCS devices which generate well-connected microzones of thermal comfort, and report real-time occupant information and respond to programmatic actuation requests (e.g. a party, a conference, a concert etc.) can combine with occupant-aware building applications to enable new methods of comfort maximization.[86]

See also

[edit]

- ASHRAE
- ANSI/ASHRAE Standard 55
- Air conditioning
- Building insulation
- Cold and heat adaptations in humans
- Heat stress
- Mean radiant temperature
- Mahoney tables
- Povl Ole Fanger
- Psychrometrics
- Ralph G. Nevins
- Room air distribution
- Room temperature
- Ventilative cooling

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Heating, ventilation, and air conditioning

Fundamental concepts	◦ Air changes per hour ◦ Bake-out ◦ Building envelope ◦ Convection ◦ Dilution ◦ Domestic energy consumption ◦ Enthalpy ◦ Fluid dynamics ◦ Gas compressor ◦ Heat pump and refrigeration cycle ◦ Heat transfer ◦ Humidity ◦ Infiltration ◦ Latent heat ◦ Noise control ◦ Outgassing ◦ Particulates ◦ Psychrometrics ◦ Sensible heat ◦ Stack effect ◦ Thermal comfort ◦ Thermal destratification ◦ Thermal mass ◦ Thermodynamics ◦ Vapour pressure of water

Technology

- Absorption-compression heat pump
- Absorption refrigerator
- Air barrier
- Air conditioning
- Antifreeze
- Automobile air conditioning
- Autonomous building
- Building insulation materials
- Central heating
- Central solar heating
- Chilled beam
- Chilled water
- Constant air volume (CAV)
- Coolant
- Cross ventilation
- Dedicated outdoor air system (DOAS)
- Deep water source cooling
- Demand controlled ventilation (DCV)
- Displacement ventilation
- District cooling
- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling
- Passive daytime radiative cooling
- Passive house

- Air conditioner inverter
- Air door
- Air filter
- Air handler
- Air ionizer
- Air-mixing plenum
- Air purifier
- Air source heat pump
- Attic fan
- Automatic balancing valve
- Back boiler
- Barrier pipe
- Blast damper
- Boiler
- Centrifugal fan
- Ceramic heater
- Chiller
- Condensate pump
- Condenser
- Condensing boiler
- Convection heater
- Compressor
- Cooling tower
- Damper
- Dehumidifier
- Duct
- Economizer
- Electrostatic precipitator
- Evaporative cooler
- Evaporator
- Exhaust hood
- Expansion tank
- Fan
- Fan coil unit
- Fan filter unit
- Fan heater
- Fire damper

Measurement and control	◦ Air flow meter ◦ Aquastat ◦ BACnet ◦ Blower door ◦ Building automation ◦ Carbon dioxide sensor ◦ Clean air delivery rate (CADR) ◦ Control valve ◦ Gas detector ◦ Home energy monitor ◦ Humidistat ◦ HVAC control system ◦ Infrared thermometer ◦ Intelligent buildings ◦ LonWorks ◦ Minimum efficiency reporting value (MERV) ◦ Normal temperature and pressure (NTP) ◦ OpenTherm ◦ Programmable communicating thermostat ◦ Programmable thermostat ◦ Psychrometrics ◦ Room temperature ◦ Smart thermostat ◦ Standard temperature and pressure (STP) ◦ Thermographic camera ◦ Thermostat ◦ Thermostatic radiator valve

Professions, trades, and services	◦ Architectural acoustics ◦ Architectural engineering ◦ Architectural technologist ◦ Building services engineering ◦ Building information modeling (BIM) ◦ Deep energy retrofit ◦ Duct cleaning ◦ Duct leakage testing ◦ Environmental engineering ◦ Hydronic balancing ◦ Kitchen exhaust cleaning ◦ Mechanical engineering ◦ Mechanical, electrical, and plumbing ◦ Mold growth, assessment, and remediation ◦ Refrigerant reclamation ◦ Testing, adjusting, balancing
Industry organizations	◦ AHRI ◦ AMCA ◦ ASHRAE ◦ ASTM International ◦ BRE ◦ BSRIA ◦ CIBSE ◦ Institute of Refrigeration ◦ IIR ◦ LEED ◦ SMACNA ◦ UMC
Health and safety	◦ Indoor air quality (IAQ) ◦ Passive smoking ◦ Sick building syndrome (SBS) ◦ Volatile organic compound (VOC)

See also

- ASHRAE Handbook
- Building science
- Fireproofing
- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

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About Energy consumption

For electric consumption, see Electric energy consumption.

Energy consumption is the amount of energy used.[1]

Biology

[edit]

In the body, energy consumption is part of energy homeostasis. It derived from food energy. Energy consumption in the body is a product of the basal metabolic rate and the physical activity level. The physical activity level are defined for a non-pregnant, non-lactating adult as that person's total energy expenditure (TEE) in a 24-hour period, divided by his or her basal metabolic rate (BMR):[2]

\displaystyle \textPAL=\frac \textTEE/24h\textBMR

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Demographics

[edit]

Topics related to energy consumption in a demographic sense are:

- World energy supply and consumption
- Domestic energy consumption
- Electric energy consumption

Effects of energy consumption

[edit]

- Environmental impact of the energy industry
    - Climate change
- White's law

Reduction of energy consumption

[edit]

- Energy conservation, the practice of decreasing the quantity of energy used
- Efficient energy use

See also

[edit]

- Energy efficiency
- Energy efficiency in transport
- Electricity generation
- Energy mix
- Energy policy
- Energy transformation

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[edit]

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External links

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Wikibooks has a book on the topic of: ***How to reduce energy usage***

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- World energy consumption per capita per country

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Energy

- History
- Index
- Outline

Fundamental concepts	- Conservation of energy
	- Energetics
	- Energy
	  - Units
	- Energy condition
	- Energy level
	- Energy system
	- Energy transformation
	- Energy transition
	- Mass
	  - Negative mass
	  - Mass–energy equivalence
	- Power
	- Thermodynamics
	  - Enthalpy
	  - Entropic force
	  - Entropy
	  - Exergy
	  - Free entropy
	  - Heat capacity
	  - Heat transfer
	  - Irreversible process
	  - Isolated system
	  - Laws of thermodynamics
	  - Negentropy
	  - Quantum thermodynamics
	  - Thermal equilibrium
	  - Thermal reservoir
	  - Thermodynamic equilibrium
	  - Thermodynamic free energy
	  - Thermodynamic potential
	  - Thermodynamic state
	  - Thermodynamic system
	  - Thermodynamic temperature
	  - Volume (thermodynamics)
	  - Work

Types

- Binding
  - Nuclear
- Chemical
- Dark
- Elastic
- Electric potential energy
- Electrical
- Gravitational
  - Binding
- Interatomic potential
- Internal
- Ionization
- Kinetic
- Magnetic
- Mechanical
- Negative
- Phantom
- Potential
- Quantum chromodynamics binding energy
- Quantum fluctuation
- Quantum potential
- Quintessence
- Radiant
- Rest
- Sound
- Surface
- Thermal
- Vacuum
- Zero-point

Energy carriers	- Battery
	- Capacitor
	- Electricity
	- Enthalpy
	- Fuel
	  - Fossil
	  - Oil
	- Heat
	  - Latent heat
	- Hydrogen
	  - Hydrogen fuel
	- Mechanical wave
	- Radiation
	- Sound wave
	- Work

Primary energy	- Bioenergy
	- Fossil fuel
	  - Coal
	  - Natural gas
	  - Petroleum
	- Geothermal
	- Gravitational
	- Hydropower
	- Marine
	- Nuclear fuel
	  - Natural uranium
	- Radiant
	- Solar
	- Wind

Energy system components	◦ Biomass
	◦ Electric power
	◦ Electricity delivery
	◦ Energy engineering
	◦ Fossil fuel power station
	    ◦ Cogeneration
	    ◦ Integrated gasification combined cycle
	◦ Geothermal power
	◦ Hydropower
	    ◦ Hydroelectricity
	    ◦ Tidal power
	    ◦ Wave farm
	◦ Nuclear power
	    ◦ Nuclear power plant
	    ◦ Radioisotope thermoelectric generator
	◦ Oil refinery
	◦ Solar power
	    ◦ Concentrated solar power
	    ◦ Photovoltaic system
	◦ Solar thermal energy
	    ◦ Solar furnace
	    ◦ Solar power tower
	◦ Wind power
	    ◦ Airborne wind energy
	    ◦ Wind farm

- Efficient energy use
  - Agriculture
  - Computing
  - Transport
- Energy conservation
- Energy consumption
- Energy policy
  - Energy development
- Energy security
- Energy storage
- Renewable energy
- Sustainable energy
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- Asia
- Australia
- Canada
- Europe
- Mexico
- South America
- United States

Use and supply

- Carbon footprint
- Energy democracy
- Energy recovery
- Energy recycling
- Jevons paradox
- Waste-to-energy
  - Waste-to-energy plant

Misc.

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Things To Do in Tulsa County

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Tours of Tulsa

4.9 (291)

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Streetwalker Tours

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Golden Driller Statue

4.6 (1935)

Photo

Oxley Nature Center

4.8 (563)

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Tulsa Air and Space Museum & Planetarium

4.3 (419)

Photo

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The Outsiders House Museum

4.7 (885)

Driving Directions in Tulsa County

Driving Directions From Subway to Durham Supply Inc

Driving Directions From Harmon Security Group LLC. to Durham Supply Inc

Driving Directions From Tuff Shed Tulsa to Durham Supply Inc

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95.852285,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJs3mSYqnztocR9hGHoR6z8U
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Driving Directions From The Tulsa Arts District to Durham Supply Inc

Driving Directions From Tours of Tulsa to Durham Supply Inc

Driving Directions From The Outsiders House Museum to Durham Supply Inc

Driving Directions From Route 66 Historical Village to Durham Supply Inc

Driving Directions From Center of the Universe to Durham Supply Inc

Driving Directions From The Outsiders House Museum to Durham Supply Inc

https://www.google.com/maps/dir/The+Outsiders+House+Museum/Durham+Supply+
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95.8384781!2d36.1563128!3e0

Reviews for Durham Supply Inc

Durham Supply Inc

Image not found or type unknown

Ty Spears

(5)

Bought a door/storm door combo. Turns out it was the wrong size. They swapped it out, quick and easy no problems. Very helpful in explaining the size differences from standard door sizes.

Durham Supply Inc

Image not found or type unknown

Gerald Clifford Brewster

(5)

We will see, the storm door I bought says on the tag it's 36x80, but it's 34x80. If they return it.......they had no problems returning it. And it was no fault of there's, you measure a mobile home door different than a standard door!

Durham Supply Inc

Image not found or type unknown

Dennis Champion

(5)

Durham supply and Royal supply seems to find the most helpful and friendly people to work in their stores, we are based out of Kansas City out here for a few remodels and these guys treated us like we've gone there for years.

Adapting Mobile Homes to Rapid Seasonal Swings in Temperature**View GBP**

Check our other pages :

- **Identifying Common Leaks in Flexible Mobile Home Ducts**
- **Balancing Heat Needs in Mobile Homes Across Different Regions**
- **Using Diagnostic Tools to Assess Air Quality in Mobile Homes**
- **Mapping Duct Layouts for Cleaner Airflow in Mobile Homes**
- **Preparing Mobile Home HVAC Units for Intense Summer Heat**

Frequently Asked Questions

How can mobile home HVAC systems be optimized for rapid temperature changes between seasons?

To optimize HVAC systems, consider installing programmable or smart thermostats that allow for pre-scheduling and remote adjustments. Ensure the system is regularly maintained, and use energy-efficient units to handle varying demands effectively.

What insulation improvements can help stabilize temperatures in mobile homes during seasonal swings?

Enhancing insulation with materials like spray foam or rigid foam panels can improve thermal resistance. Sealing gaps around windows, doors, and ductwork also prevents air leaks, keeping internal temperatures more stable.

Are there portable heating or cooling options suitable for mobile homes facing extreme temperature variations?

Yes, portable electric heaters and portable air conditioners are viable options. Look for units with adjustable settings and energy efficiency features to suit temporary climate needs without significant installation.

What role does ventilation play in managing temperature extremes in mobile homes?

Proper ventilation helps regulate indoor humidity levels and improves air quality. Use exhaust fans and ventilated skirting to prevent moisture buildup while maintaining a balanced indoor environment through effective airflow.

Can solar energy contribute to adapting mobile home HVAC systems for seasonal temperature shifts?

Solar panels can offset electricity costs by powering HVAC systems directly or indirectly through grid-tied solutions. Additionally, solar water heaters can reduce reliance on electrical heating methods during colder months.

Royal Supply Inc

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Google Business Profile

Company Website : **https://royal-durhamsupply.com/locations/oklahoma-city-oklahoma/**