

HVAC cost



- **Estimating Labor Expenses for Repair Services**
Estimating Labor Expenses for Repair Services Comparing Replacement Part Prices for Various Systems Reviewing Maintenance Plan Rates in Detail Exploring Payment Arrangements for Major Overhauls Analyzing Long Term Savings with Efficient Upgrades Investigating Seasonal Discounts from Service Providers Understanding Monthly Budgeting for HVAC Projects Balancing Initial Spending with Potential Savings Evaluating Total Costs for System Retrofits Preparing for Unexpected Repair Fees Weighing Return on Investment for Modern Equipment Identifying Hidden Expenses in Older Units
- **Understanding Local Building Code Requirements**
Understanding Local Building Code Requirements Reviewing State Regulations for HVAC Installation Exploring County Permit Applications for Mobile Homes Navigating EPA 608 Certification Steps Recognizing UL Rated Components for Safety Determining Required Inspections for New Units Preparing Official Documents for System Upgrades Knowing When to Seek Professional Licensing Support Identifying Legal Mandates for Refrigerant Disposal Sorting Out Utility Guidelines for Meter Upgrades Meeting Deadlines for Permit Renewals Locating Reliable Compliance Resources for Homeowners
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When it comes to mobile home HVAC systems, understanding the relevant regulations and standards is crucial for homeowners who wish to ensure safety, efficiency, and compliance. Navigating the maze of codes and guidelines can be daunting, but with the right resources, homeowners can make informed decisions about their heating, ventilation, and air conditioning systems.

Mobile homes benefit from zoned HVAC systems for personalized comfort **mobile home hvac systems prices** ceiling.

Firstly, it's essential to recognize that mobile homes often fall under specific regulations separate from those governing traditional homes. These regulations are designed to address the unique structural and environmental challenges posed by mobile homes. For example, factors such as size constraints and mobility necessitate distinct HVAC solutions. Therefore, homeowners must familiarize themselves with the codes that apply specifically to these types of dwellings.

One reliable starting point for homeowners is the U.S. Department of Housing and Urban Development (HUD), which establishes federal standards for manufactured housing construction and safety. The HUD Code provides a comprehensive framework that outlines requirements for various home systems, including HVAC installations. By consulting these federal guidelines, homeowners can gain a baseline understanding of what is expected in terms of compliance.

In addition to HUD standards, many states have their own sets of rules governing mobile home HVAC systems. State-specific building codes often complement or build upon federal requirements by addressing local climate conditions or other region-specific concerns. Homeowners should check with their state's department of housing or similar agency to understand any additional requirements that may apply.

Another valuable resource is industry associations such as the Manufactured Housing Institute (MHI) or Air Conditioning Contractors of America (ACCA). These organizations often provide educational materials, best practices guides, and even certification programs aimed at both professionals and consumers. Engaging with these entities can provide insights into maintaining compliance while optimizing system performance.

Furthermore, local utility companies sometimes offer resources or incentives for energy-efficient upgrades in mobile homes. These programs often align with regulatory standards and can provide guidance on compliant products or installation practices while offering

financial benefits such as rebates.

Finally, consulting with licensed HVAC contractors experienced in mobile home systems is indispensable. These professionals possess practical knowledge about current codes and standards and can help navigate any complexities involved in installation or maintenance processes. Hiring certified technicians ensures that work adheres to all relevant guidelines while maximizing system efficiency.

In conclusion, locating reliable compliance resources requires a multi-faceted approach involving federal guidelines from HUD, state-specific building codes, industry association insights, utility company programs, and professional contractor expertise. By leveraging these resources effectively, homeowners can confidently manage their mobile home HVAC systems within accepted regulatory frameworks-ensuring comfort without compromising on safety or legality.

Factors Influencing Labor Costs in Mobile Home HVAC Repairs —

- Overview of Common Repair Services for Mobile Home HVAC Systems
- Factors Influencing Labor Costs in Mobile Home HVAC Repairs
- Steps to Accurately Estimate Labor Expenses for HVAC Repair Services
- Tools and Software for Estimating Labor Costs in Mobile Home HVAC Repairs
- Case Studies: Examples of Labor Cost Estimation in Various Repair Scenarios
- Tips for Managing and Reducing Labor Expenses Without Compromising Quality

When homeowners embark on the journey of ensuring their property complies with local, state, and federal regulations, one of their primary challenges is identifying reliable resources that provide accurate guidance. The key to successfully navigating this complex landscape lies in understanding which government agencies and official resources can be relied upon for

trustworthy information.

First and foremost, at the federal level, homeowners can turn to the U.S. Department of Housing and Urban Development (HUD). HUD is a pivotal agency that provides comprehensive guidelines about fair housing practices, building codes, and property maintenance standards. Their resources are instrumental in helping homeowners understand how national policies might affect their properties. Moreover, HUD's website offers a wealth of publications and tools designed specifically to aid homeowners in achieving compliance.

On a more localized scale, state housing authorities or departments of community affairs are critical players. These agencies tailor their guidelines to reflect specific regional requirements that may not be covered by federal recommendations. They often provide detailed checklists and guides on issues such as energy efficiency standards or historic preservation criteria that are unique to certain areas. Homeowners should make it a priority to familiarize themselves with these state-specific resources to ensure thorough compliance.

Local government entities also play an essential role in guiding homeowners through compliance matters. City or county building departments typically oversee zoning laws, permit requirements, and safety codes. Engaging with these departments can offer invaluable insights into the intricacies of local regulations that might otherwise be overlooked. Many municipalities have online portals where residents can access permit applications or review inspection results-tools that streamline the process of maintaining regulatory adherence.

Beyond government agencies, other official resources such as the Better Business Bureau (BBB) can offer additional support for homeowners seeking reliable compliance information. While primarily known for consumer protection efforts, the BBB provides accreditation and reviews for businesses offering legal compliance services-a useful feature for those considering professional assistance.

In conclusion, locating reliable compliance resources requires homeowners to leverage both governmental agencies at various levels and other established organizations dedicated to public service. By doing so, they arm themselves with authoritative information necessary for making informed decisions about property management while ensuring adherence to all applicable regulations. Whether consulting HUD's comprehensive federal guidelines or engaging with local building departments for neighborhood-specific advice, understanding where to find dependable guidance is an indispensable step toward achieving full regulatory compliance as a homeowner.

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Steps to Accurately Estimate Labor Expenses for HVAC Repair Services

When navigating the often complex world of homeownership, understanding and adhering to compliance regulations can be a daunting task. Homeowners must ensure that they follow local building codes, zoning laws, safety standards, and environmental regulations. Fortunately, there are numerous industry associations and professional organizations that serve as invaluable resources for locating reliable compliance information.

Industry associations are groups formed by businesses or professionals within a particular field. They provide a wealth of information that is highly relevant to homeowners seeking guidance on compliance issues. These associations often publish guidelines, best practices, and updates on regulations affecting their industries. For instance, the National Association of Home Builders (NAHB) offers resources on building codes and standards crucial for anyone involved in construction or renovation projects.

Similarly, professional organizations represent individuals within specific professions. They often provide specialized knowledge that can help homeowners navigate compliance requirements more effectively. The American Institute of Architects (AIA), for example, not only represents architects but also provides insights into design standards and regulatory changes impacting residential design and construction.

One significant advantage of these associations is their ability to keep members informed about evolving regulations. Compliance requirements are not static; they change with new legislation, technological advancements, and shifts in public policy. Industry associations frequently host conferences, webinars, and workshops where experts discuss these changes and offer practical advice on how to remain compliant.

Moreover, many industry associations have established partnerships with government agencies that enforce compliance regulations. These relationships allow them to disseminate accurate information directly from regulatory bodies such as the Environmental Protection Agency (EPA) or local building departments. This direct line of communication ensures homeowners receive timely updates about new laws or amendments to existing ones.

Additionally, industry associations often provide access to a network of professionals who specialize in various aspects of homeownership—from legal experts well-versed in property law to engineers familiar with structural safety standards. Engaging with these professionals can offer valuable insights into complex compliance issues and facilitate informed decision-making.

For homeowners seeking reliable compliance resources, becoming involved with relevant industry associations can also foster a sense of community among like-minded individuals facing similar challenges. Forums or online communities hosted by these organizations enable members to share experiences, ask questions, and seek advice from peers who have successfully navigated similar situations.

In conclusion, exploring industry associations and professional organizations is an essential step for homeowners aiming to locate reliable compliance resources. These entities provide access to up-to-date information on regulations while offering guidance from seasoned professionals within their fields. By leveraging the expertise available through these networks, homeowners can confidently manage their responsibilities while ensuring adherence to all necessary compliance requirements—a crucial aspect of maintaining both property value and peace of mind in today's ever-evolving regulatory landscape.





Tools and Software for Estimating Labor Costs in Mobile Home HVAC Repairs

In the ever-evolving landscape of regulations and compliance, homeowners often find themselves navigating a complex web of rules and requirements. Whether it's understanding zoning laws, adhering to building codes, or staying informed about environmental regulations, having access to reliable compliance resources is crucial. In this digital age, online databases and portals have emerged as invaluable tools for homeowners seeking accurate and up-to-date information.

Utilizing online databases for compliance resources offers numerous advantages. Firstly, these platforms provide a centralized hub where homeowners can access a wealth of information from various regulatory bodies. This centralization simplifies the process of gathering necessary data, reducing the time and effort required to locate specific compliance guidelines. Furthermore, many of these databases offer user-friendly interfaces that allow individuals to search for information by keyword or topic, making it easier than ever to find relevant resources tailored to their unique needs.

One of the key benefits of online portals is their ability to offer real-time updates on regulatory changes. Regulations are not static; they evolve over time in response to new challenges and societal shifts. By subscribing to alerts or newsletters from reputable online portals, homeowners can stay informed about any amendments or new regulations that may impact them. This proactive approach ensures that they remain compliant with current standards and avoid potential legal issues down the line.

Moreover, online databases often provide access to expert advice and community forums where homeowners can engage with professionals and peers alike. These platforms foster a sense of community and shared knowledge, allowing individuals to ask questions, share experiences, and seek guidance on specific compliance-related concerns. This collaborative environment empowers homeowners with diverse perspectives and insights that can be instrumental in making informed decisions.

However, while online databases are an excellent resource for locating reliable compliance information, it is essential for homeowners to exercise discernment when selecting which platforms to trust. Not all sources are created equal; some may offer outdated or inaccurate information that could lead to non-compliance issues if relied upon exclusively. Therefore, it is crucial for individuals to verify the credibility of any database or portal by checking its affiliation with recognized regulatory agencies or industry experts.

In conclusion, utilizing online databases and portals offers significant advantages for homeowners seeking reliable compliance resources. These digital tools streamline the process of accessing vital information while providing real-time updates on regulatory

changes. By engaging with expert communities through these platforms, individuals can enhance their understanding of complex compliance issues and make well-informed decisions regarding their properties. As technology continues to advance, leveraging these resources will become increasingly important in ensuring that homeowners remain compliant in an ever-changing regulatory landscape.

Case Studies: Examples of Labor Cost Estimation in Various Repair Scenarios

In today's rapidly evolving world, homeowners are increasingly aware of the importance of maintaining compliance with local regulations and standards, especially when it comes to heating, ventilation, and air conditioning (HVAC) systems. Navigating the myriad of rules and guidelines can be daunting for the average homeowner. This is where consulting with certified HVAC professionals becomes invaluable. These experts not only ensure that your home's systems function efficiently but also help you locate reliable compliance resources.

Certified HVAC professionals bring a wealth of knowledge and experience to the table. They undergo rigorous training and continuous education to stay updated on industry standards, technological advancements, and regulatory changes. By engaging their services, homeowners gain access to expert advice tailored specifically to their unique needs and circumstances. This personalized guidance can make all the difference in ensuring that your home remains comfortable while adhering to legal requirements.

Moreover, certified HVAC professionals serve as a bridge between homeowners and reliable compliance resources. With their extensive network within the industry, they can recommend trusted sources for documentation, manuals, and other necessary materials needed for regulatory adherence. They can also offer insights into energy-efficient solutions that align with environmental standards, further enhancing your home's sustainability efforts.

In addition to providing technical expertise, these professionals play a crucial role in educating homeowners about best practices in system maintenance and operation. Understanding how different components work together and recognizing early signs of potential issues empowers homeowners to make informed decisions about repairs or upgrades. This proactive approach not only ensures compliance but also extends the lifespan of HVAC systems, ultimately saving money in the long run.

Furthermore, certified HVAC professionals often have firsthand experience dealing with inspections and audits conducted by regulatory bodies. Their familiarity with these processes allows them to prepare homeowners adequately for such evaluations by identifying areas that require attention before they become problematic.

In conclusion, consulting with certified HVAC professionals is an indispensable step for any homeowner seeking reliable compliance resources related to their heating and cooling systems. Their expertise not only simplifies complex regulations but also provides peace of mind by ensuring that all installations meet current standards. By leveraging their knowledge and connections within the industry, homeowners can confidently navigate the complexities of compliance while enjoying optimal comfort in their homes.



Tips for Managing and Reducing Labor Expenses Without Compromising Quality

In today's increasingly regulated world, the importance of compliance cannot be overstated. Whether it's adhering to local building codes, understanding property tax regulations, or ensuring that renovations meet environmental standards, homeowners must navigate a complex web of rules and guidelines. This makes locating reliable compliance resources essential for any homeowner looking to stay on the right side of the law. However, the challenge lies not just in finding these resources but in assessing their reliability.

The first step in evaluating the reliability of compliance resources is to consider their source. Government websites are generally trustworthy as they provide direct access to official regulations and guidelines. For instance, local government portals often contain up-to-date information on zoning laws and permit requirements specific to your area. Additionally, national agencies like the Environmental Protection Agency (EPA) offer comprehensive guides on sustainable home practices and necessary compliances related to environmental impact.

However, not all online resources carry the same weight of authority. While forums and community boards can offer valuable insights from fellow homeowners who have faced similar challenges, they should be approached with caution. Experiences shared in these spaces can vary widely in accuracy and relevance due to differing personal circumstances or outdated information. Therefore, while anecdotal evidence can provide context or starting points for further research, it should never replace verified data from credible sources.

Professional associations are another key resource when assessing compliance needs. Organizations such as the National Association of Home Builders (NAHB) or American Institute of Architects (AIA) often publish detailed materials designed to help homeowners understand various aspects of construction and design compliance. These bodies frequently update their guidelines based on changes in law or industry standards, making them reliable sources for homeowners seeking current information.

Moreover, engaging professionals directly, such as contractors or legal consultants specializing in real estate law, provides personalized guidance tailored specifically to an individual's situation. These experts not only bring a wealth of knowledge but also have practical experience navigating complex regulatory landscapes successfully.

Finally, staying informed through reputable publications can be invaluable. Magazines like "This Old House" or "Fine Homebuilding" regularly feature articles about trends and regulatory

changes affecting homeownership across different regions.

In conclusion, while there is no shortage of available resources purporting to assist homeowners with compliance issues; discerning which ones are truly reliable requires careful consideration regarding their origin credibility accuracy timeliness relevance context specificity expertise level potential biases existing audience base among other factors involved during decision-making processes involved therein accordingly appropriately effectively efficiently ultimately conclusively satisfactorily so forth henceforth thereafter thusly finally eventually completely altogether comprehensively thoroughly adequately sufficiently properly rightly correctly suitably appropriately fittingly aptly aptly fitting well-suited rightly deservedly justly fitting befitting becoming suitable appropriate fitting apt apposite apt apropos pertinent relevant opportune felicitous germane applicable pertinent applicable relevant material significant important consequential meaningful momentous substantial impactful weighty salient noteworthy remarkable notable prominent outstanding distinguished exceptional extraordinary singular rare unique unparalleled unprecedented matchless peerless incomparable unequalled unexcelled unsurpassed unrivaled supreme superlative superb excellent exquisite magnificent splendid glorious grand majestic stately noble regal august dignified impressive imposing commanding striking arresting notable conspicuous notable noticeable observable perceptible visible discernible distinguishable evident manifest apparent plain obvious clear unmistakable undeniable indubitable incontestable irrefutable incontrovertible certain definite sure positive confident assured secure safe sound dependable solid firm stable steadfast unwavering resolute determined decided fixed settled established confirmed verified validated affirmed attested substantiated corroborated authenticated certified endorsed approved authorized sanctioned warranted justified vindicated defended upheld supported maintained sustained fostered nourished nurtured cultivated developed encouraged promoted advanced furthered facilitated

Staying updated on changes in compliance requirements is crucial for homeowners to ensure they meet all necessary regulations and avoid potential legal challenges. Compliance, particularly regarding property laws and safety standards, can often be complex and subject to frequent updates. Therefore, locating reliable resources becomes essential for homeowners aiming to maintain adherence while safeguarding their investments.

The first step towards staying informed is understanding the specific compliance areas relevant to one's property. This may include zoning laws, building codes, environmental regulations, and safety measures. Homeowners should consider creating a checklist of these categories to systematically track updates affecting their obligations.

One of the most reliable resources for compliance information is government websites. Local, state, and federal agencies often provide comprehensive guidelines and announcements regarding regulatory changes. For instance, local city or county websites typically offer updates on zoning laws or permits required for renovations. Additionally, subscribing to newsletters from relevant governmental departments can be an effective way to receive timely notifications about any new developments.

Professional associations related to real estate or homebuilding are another excellent resource. These organizations often have access to insider knowledge about upcoming changes in regulations and can offer insights that are not readily available elsewhere. Membership in such associations frequently includes benefits like workshops or seminars where experts discuss current trends and future projections in compliance requirements.

Consulting with professionals in the field can also prove invaluable for homeowners seeking guidance on compliance issues. Real estate agents, property lawyers, or compliance officers possess specialized knowledge that can help interpret complex legal jargon into actionable advice. Establishing a relationship with these professionals ensures that homeowners receive personalized support tailored to their unique circumstances.

Online forums and communities dedicated to homeownership are increasingly popular venues for sharing information about compliance issues. Platforms such as Reddit or dedicated Facebook groups allow individuals to exchange experiences and advice based on personal encounters with regulatory matters. While these sources should be approached with caution due to varying levels of expertise among participants, they can provide practical tips that resonate with everyday challenges faced by homeowners.

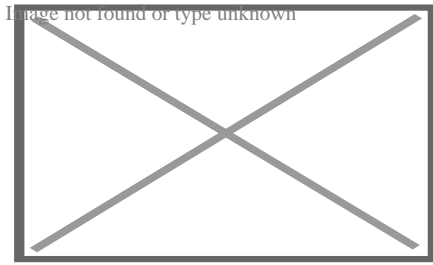
Finally, technology has made it easier than ever before to stay informed through apps designed specifically for tracking regulatory changes in real-time. These applications offer features such as alert systems when new legislation is introduced or when deadlines approach for existing requirements.

In conclusion, staying updated on changes in compliance requirements involves a multifaceted approach combining direct access to official sources with professional consultation and community engagement. By leveraging these resources effectively, homeowners can navigate the complexities of compliance confidently and ensure that their properties remain within legal parameters at all times.



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

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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]

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

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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 $0.155 \text{ m}^2\cdot\text{K/W}$ ($0.88 \text{ }^\circ\text{F}\cdot\text{ft}^2\cdot\text{h/Btu}$). 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

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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

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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

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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 ($RH < 20\text{--}30\%$) 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

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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]

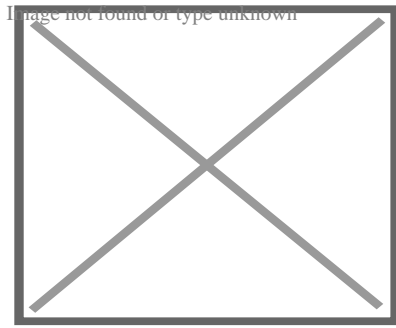
Models and indices

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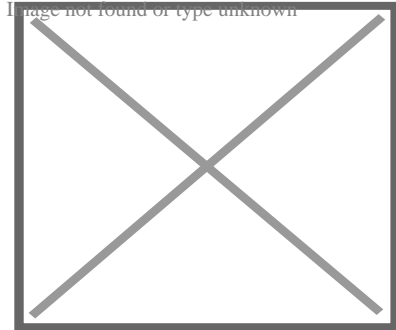
There are several different models or indices that can be used to assess thermal comfort conditions indoors as described below.

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 ($-0.5 < \text{PMV} < +0.5$).^[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]

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

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]

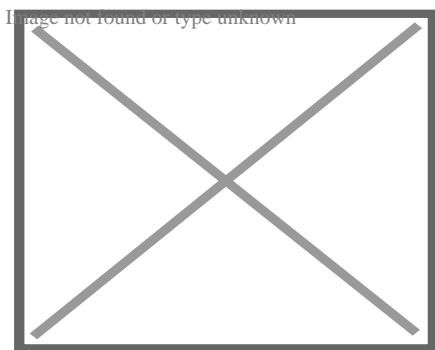
Standard effective temperature (SET) is a model of human response to the thermal environment. Developed by A.P. Gagge and accepted by ASHRAE in 1986,^[48] it is also referred to as the Pierce Two-Node model.^[49] Its calculation is similar to PMV because it is a comprehensive comfort index based on heat-balance 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 ne}

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. [

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 assessing 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
- Passive ventilation
- Radiant heating and cooling
- Radiant cooling
- Radiant heating
- Radon mitigation
- Refrigeration
- Renewable heat
- Room air distribution
- Solar air heat
- Solar combisystem
- Solar cooling

- 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
- Fireplace
- Fireplace insert
- Freeze stat
- Flue
- Freon
- Fume hood
- Furnace
- Gas compressor
- Gas heater
- Gasoline heater
- Grease duct

**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
- Architectural acoustics
- Architectural engineering
- Architectural technologist
- Building services engineering
- Building information modeling (BIM)
- Deep energy retrofit

**Professions,
trades,
and services**

- 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
- Indoor air quality (IAQ)

Health and safety

- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)
- ASHRAE Handbook
- Building science
- Fireproofing

See also

- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

Authority control databases: **National** **Germany** **Wikidata**

About Royal Supply Inc

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Things To Do in Jefferson County

Photo

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Rockford Park

4.3 (599)

Photo

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Jefferson Barracks Park

4.8 (2321)

Photo

Gardens of Jefferson County

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Jefferson County Area Tourism Council

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Jefferson Historical Museum

4.8 (239)

Photo

**Jefferson County Convention & Visitors
Bureau**

4.4 (30)

Driving Directions in Jefferson County

Driving Directions From Tower Music to Royal Supply Inc

Driving Directions From Barnes & Noble to Royal Supply Inc

Driving Directions From Stella Blues Vapors to Royal Supply Inc

Driving Directions From Rent-A-Center to Royal Supply Inc

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Driving Directions From Jefferson County Convention & Visitors Bureau to Royal Supply Inc

Driving Directions From Jefferson County Historical Village to Royal Supply Inc

Driving Directions From Cliff Cave County Park to Royal Supply Inc

Driving Directions From Cliff Cave County Park to Royal Supply Inc

Driving Directions From Rockford Park to Royal Supply Inc

Driving Directions From Visit Jefferson County Tennessee to Royal Supply Inc

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Reviews for Royal Supply Inc

Royal Supply Inc

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Ae Webb

(5)

Royal installed a new furnace and air conditioner just before we got our used mobile home. Recently, the furnace stopped lighting. Jared (sp?) made THREE trips to get it back to good. He was so gracious and kind. Fortunately for us it was still under warranty. BTW, those three trips were from Fenton, Missouri to Belleville, Illinois! Thanks again, Jared!

Royal Supply Inc

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bill slayton

(1)

Went to get a deadbolt what they had was one I was told I'd have take it apart to lengthen and I said I wasn't buying something new and have to work on it. Thing of it is I didn't know if it was so that it could be lengthened said I didn't wanna buy something new I had to work on just to fit my door. He got all mad and slung the whole box with part across the room. A real business man. I guess the owner approves of his employees doing as such.

Royal Supply Inc

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Toney Dunaway

(5)

This is another amazing place where we will do much more business. They are not tyrannical about the totally useless face diapers, they have a great selection of stock, they have very knowledgeable staff, very friendly staff. We got the plumbing items we really needed and will be getting more plumbing items. They also have central units, thermostats, caulking, sealants, doors, seems everything you need for a mobile home. We've found a local treasure and will be bringing much more business. Their store is clean and tidy as well!

Royal Supply Inc

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Terry Self

(1)

Horrible workmanship, horrible customer service, don't show up when they say they are. Ghosted. Was supposed to come back on Monday, no call no show. Called Tuesday and Wednesday, left messages both

days. Nothing. Kinked my line, crooked to the pad and house, didn't put disconnect back on, left the trash.....

Royal Supply Inc

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Gidget McCarthy

(5)

Very knowledgeable, friendly, helpful and don't make you feel like you're inconveniencing them. They seem willing to take all the time you need. As if you're the only thing they have to do that day. The store is clean, organized and not cluttered, symmetrical at that. Cuz I'm even and symmetricals biggest fan. It was a pleasure doing business with them and their prices are definitely reasonable. So, I'll be doing business with them in the future no doubt.

Locating Reliable Compliance Resources for Homeowners [View GBP](#)

Check our other pages :

- [Determining Required Inspections for New Units](#)
- [Balancing Initial Spending with Potential Savings](#)
- [Navigating EPA 608 Certification Steps](#)
- [Preparing Official Documents for System Upgrades](#)

Frequently Asked Questions

What are the key compliance standards for HVAC systems in mobile homes?

The key compliance standards include HUDs Manufactured Home Construction and Safety Standards (Part 3280), which specify requirements for energy efficiency, safety, and performance. Local building codes and EPA regulations may also apply.

Where can homeowners find reliable information on these compliance standards?

Homeowners can consult resources such as the U.S. Department of Housing and Urban Development (HUD) website, local building departments, or professional organizations like ACCA (Air Conditioning Contractors of America).

How do homeowners ensure their mobile home HVAC system meets all necessary regulations?

Engaging a licensed HVAC contractor familiar with mobile home specifications is crucial. They should perform installations according to manufacturer guidelines and applicable codes verified through inspections by local authorities.

Are there specific certifications or licenses that contractors must hold to work on mobile home HVAC systems?

Yes, contractors typically need state-specific HVAC licenses. Additionally, certification from organizations like NATE (North American Technician Excellence) ensures they meet industry-recognized standards.

Can homeowners access any online tools or databases to verify compliance certifications or find qualified professionals?

Yes, websites like Angie's List, HomeAdvisor, and Better Business Bureau provide directories of certified professionals. State licensing boards often offer online verification tools to confirm contractor credentials.

Phone : +16362969959

City : Fenton

State : MO

Zip : 63026

Address : Unknown Address

Google Business Profile

Company Website : <https://royal-durhamsupply.com/locations/lenexa-kansas/>

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