Mobile Home & Energy

- **Understanding SEER Ratings for Mobile Home Cooling**
  Understanding SEER Ratings for Mobile Home Cooling Tracking Power Usage in Mobile Home Heating Systems Adapting Mobile Homes for High Efficiency HVAC Equipment Comparing SEER Values to Lower Energy Costs in Mobile Homes Evaluating ROI of Efficient Upgrades in Mobile Home Air Conditioning Minimizing Heat Loss with Insulation for Mobile Home HVAC Achieving Energy Savings with Variable Speed Motors in Mobile Homes Choosing Thermostat Controls for Better Mobile Home Efficiency Calculating Long Term Benefits of Efficient Mobile Home Furnaces Checking Duct Seal Quality for Improved Mobile Home SEER Performance Pinpointing Energy Loss in Mobile Home HVAC Installations Monitoring Seasonal Impacts on Mobile Home AC Efficiency
- **Exploring Common Certifications Required for Mobile Home HVAC Service**
  Exploring Common Certifications Required for Mobile Home HVAC Service Understanding EPA Regulations for Mobile Home Cooling Systems Evaluating Technician Training Programs for Mobile Home Heating Examining NATE Credentials and What They Mean for Mobile Home Repair Verifying Local Licensing for Mobile Home HVAC Professionals Assessing Safety Knowledge in Mobile Home Technician Work Matching Skill Levels to Complex Mobile Home AC Installations Identifying Gaps in Technical Training for Mobile Home HVAC Work Learning About Continuing Education for Mobile Home Furnace Repair Validating Experience Through Field Tests in Mobile Home HVAC Exploring Online Resources for Mobile Home Technician Readiness Collaborating with Certified Professionals for Mobile Home HVAC Projects
- **About Us**

Understanding EPA Regulations for Mobile Home Cooling Systems

How SEER Ratings Impact Energy Efficiency in Mobile Homes

Understanding the Environmental Protection Agency (EPA) regulations for mobile home cooling systems is crucial for ensuring compliance with environmental standards and promoting sustainable practices. The EPA, as a leading agency in environmental protection in the United States, has established several guidelines aimed at reducing the environmental impact of cooling systems, which are vital for maintaining comfortable living conditions in mobile homes.

One significant aspect of EPA regulations is the management of refrigerants used in cooling systems. Many traditional refrigerants contain chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs), which are known to deplete the ozone layer and contribute to global warming. In response, the EPA has mandated a phasedown of these substances under the Clean Air Act, encouraging manufacturers and homeowners to transition to more environmentally friendly alternatives such as hydrofluoroolefins (HFOs).

For mobile home owners, understanding these refrigerant regulations is essential not only for legal compliance but also for contributing to broader environmental goals. Drainage systems prevent moisture buildup around mobile home HVAC units **mobile home hvac replacement cost** crawl space. The shift towards greener refrigerants can lead to improved energy efficiency and reduced carbon emissions-a win-win scenario for both homeowners and the planet.

The EPA also emphasizes proper maintenance and disposal practices for cooling systems. Regular servicing by certified technicians can prevent leaks and ensure optimal performance, aligning with EPA's standards for reducing greenhouse gas emissions. Moreover, when a cooling system reaches the end of its lifecycle, it must be disposed of following specific guidelines to prevent harmful substances from being released into the

environment.

Additionally, new mobile home designs are increasingly incorporating energy-efficient technologies that meet or exceed EPA's Energy Star requirements. These innovations not only help reduce energy consumption but also lower utility bills for homeowners.

In summary, understanding and adhering to EPA regulations for mobile home cooling systems involves an awareness of current refrigerant policies, maintenance protocols, disposal procedures, and energy efficiency standards. By staying informed about these regulations, mobile home owners can play a critical role in fostering a healthier environment while enjoying enhanced comfort in their living spaces.

The Relationship Between SEER Ratings and Cooling Costs —

The Importance of Compliance with EPA Standards: Understanding Regulations for Mobile Home Cooling Systems

In the ever-evolving landscape of environmental regulations, the Environmental Protection Agency (EPA) plays a crucial role in safeguarding our natural resources and promoting sustainable practices. One area where the impact of these regulations is particularly significant is in mobile home cooling systems. As temperatures rise due to climate change, ensuring that these systems are both efficient and environmentally friendly becomes

paramount. Compliance with EPA standards is not just a legal obligation; it is a commitment to protecting our environment and enhancing public health.

Mobile homes, often more susceptible to temperature fluctuations due to their construction, rely heavily on effective cooling systems for comfort. However, traditional cooling methods can be energy-intensive and contribute significantly to greenhouse gas emissions. This is where the EPA's standards come into play. By establishing guidelines for energy efficiency and emissions reductions, the EPA ensures that manufacturers create cooling systems that minimize environmental impact while delivering optimal performance.

One key aspect of these regulations involves refrigerants used in air conditioning units. Historically, many refrigerants have been potent contributors to global warming when released into the atmosphere. The EPA's guidelines encourage the use of alternatives with lower environmental impact, such as hydrofluoroolefins (HFOs), which have a much lower global warming potential compared to older substances like hydrofluorocarbons (HFCs). Adopting such eco-friendly technologies not only helps mitigate climate change but also aligns with international efforts under agreements like the Kigali Amendment to phase out harmful refrigerants.

Moreover, compliance with EPA standards fosters innovation within the industry. Manufacturers are challenged to develop more efficient cooling technologies that meet regulatory requirements without compromising on quality or performance. This drive towards innovation can lead to advancements that benefit consumers through reduced energy bills and enhanced system longevity.

For mobile home residents and owners, understanding and adhering to these regulations provides tangible benefits beyond environmental stewardship. Efficient cooling systems translate into cost savings by reducing electricity consumption during hot seasons when air conditioning demand peaks. Furthermore, maintaining compliance ensures adherence to safety standards that protect users from potential hazards associated with faulty or outdated equipment.

In conclusion, compliance with EPA standards for mobile home cooling systems represents a vital intersection between regulatory adherence and environmental responsibility. It underscores an industry's dedication to sustainability while providing consumers with reliable solutions tailored for comfort and efficiency. As we continue facing challenges posed by climate change and resource scarcity, aligning our practices with established guidelines remains imperative - ensuring not only compliance but also contributing positively towards preserving our planet for future generations.

Posted by on

Posted by on

Posted by on

Choosing the Right SEER Rating for Your Mobile Home HVAC System

Understanding EPA Regulations for Mobile Home Cooling Systems

In the contemporary world, where environmental consciousness is more critical than ever, the efficient use of energy and reduction of emissions are at the forefront of regulatory focus. One

area where these concerns converge is in the cooling systems used in mobile homes. The Environmental Protection Agency (EPA) plays a significant role in shaping how these systems operate, ensuring they meet specific standards that align with broader environmental goals. Understanding these regulations is crucial not only for manufacturers but also for homeowners who seek to optimize their living environments while adhering to legal requirements.

Mobile home cooling systems are primarily affected by EPA regulations through their components, such as refrigerants, compressors, and overall system efficiency. Refrigerants are perhaps the most critical component regulated by the EPA due to their potential impact on both global warming and ozone depletion. Historically popular refrigerants like chlorofluorocarbons (CFCs) have been phased out due to their high ozone-depleting potential. In recent years, hydrochlorofluorocarbons (HCFCs) have also been targeted for phase-out under EPA guidelines. This has led to an industry-wide shift toward using hydrofluorocarbons (HFCs), which have a lower impact on ozone but still contribute significantly to global warming.

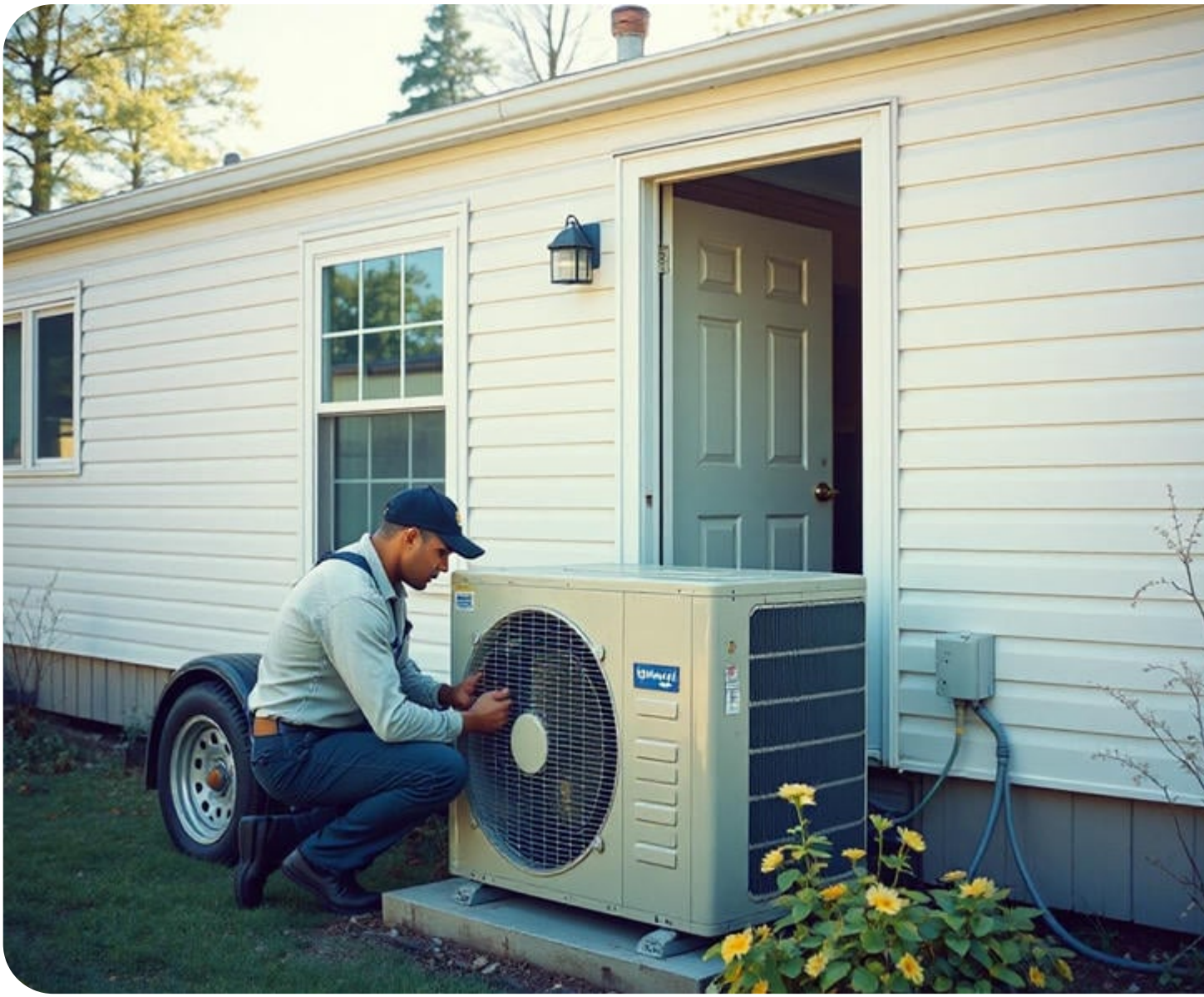
To further address this issue, newer alternatives like hydrofluoroolefins (HFOs) are being promoted due to their low global warming potential (GWP). The transition to these environmentally friendly refrigerants is a direct result of EPA regulations aimed at reducing greenhouse gas emissions from cooling systems. This regulatory push not only affects manufacturers who need to redesign products but also impacts homeowners who must ensure that any new installations or replacements comply with current standards.

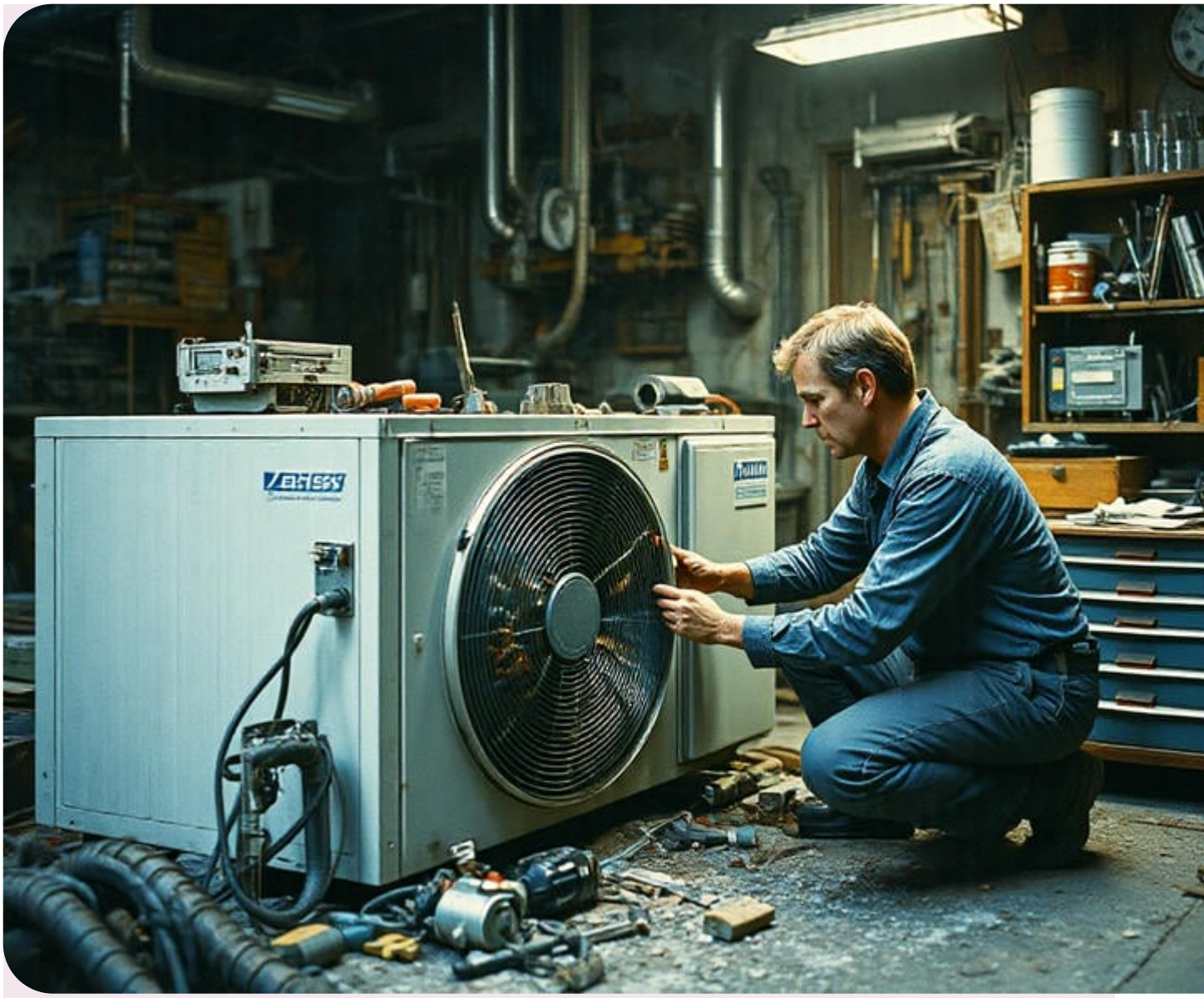
The compressor within a mobile home's cooling system is another vital component influenced by EPA regulations. Compressors must be designed for compatibility with the newer refrigerant types while maintaining energy efficiency. The emphasis on energy efficiency aligns with broader efforts by the EPA to reduce energy consumption across household appliances and systems. By promoting Energy Star-certified products, which meet stringent efficiency criteria set by the agency, homeowners can benefit from reduced utility costs and minimized environmental impact.

Overall system efficiency is another key area where EPA regulations play a pivotal role. Mobile home cooling systems must achieve specific Seasonal Energy Efficiency Ratio (SEER) ratings that indicate how efficiently they operate over an entire season of use. These ratings help consumers identify products that can effectively cool homes without excessive energy use or emissions.

In conclusion, understanding the key components of mobile home cooling systems affected by EPA regulations highlights an essential intersection between technology and environmental

policy. As we continue moving toward sustainable living practices, it becomes increasingly important for all stakeholders-manufacturers, regulators, and consumers-to collaborate in implementing solutions that are both effective and ecologically responsible. By staying informed about regulatory changes and opting for compliant technologies, we can all contribute to a healthier planet while enjoying comfortable living spaces within our mobile homes.





Factors Influencing SEER Rating Effectiveness in Mobile Homes

Ensuring that your mobile home cooling system meets EPA requirements is an essential step in maintaining both environmental responsibility and personal comfort. The Environmental Protection Agency (EPA) has established various regulations aimed at reducing energy consumption and minimizing the environmental impact of cooling systems. Understanding these regulations and implementing them in your mobile home cooling system can lead to significant benefits, including reduced energy bills, improved indoor air quality, and a lower carbon footprint.

The first step in ensuring compliance with EPA requirements is to familiarize yourself with the specific guidelines outlined by the agency. The EPA's Energy Star program provides detailed criteria for energy efficiency that apply to mobile home cooling systems. By choosing an Energy Star-certified system, you can be confident that it meets or exceeds federal standards for energy efficiency. Such systems are designed to use less electricity while providing effective cooling, which not only helps the environment but also saves money over time.

Proper installation of your cooling system is another critical step in meeting EPA requirements. An improperly installed system can lead to inefficient operation and increased energy usage, counteracting any potential benefits of having an Energy Star-certified unit. It is advisable to hire a professional technician who is familiar with both HVAC systems and EPA guidelines to ensure that your unit is installed correctly. This includes proper sealing of ducts, appropriate refrigerant levels, and correct sizing of the system based on your mobile home's specific needs.

Regular maintenance plays a vital role in keeping your mobile home cooling system aligned with EPA standards. Routine tasks such as cleaning or replacing air filters, checking refrigerant levels, and inspecting electrical connections help maintain optimal performance and efficiency. Scheduling annual inspections by certified professionals can further ensure that all components function as intended and comply with current regulations.

In addition to equipment-specific measures, homeowners should consider other actions that contribute to overall energy efficiency. For example, enhancing insulation within the mobile home reduces the workload on cooling systems by maintaining consistent indoor temperatures. Installing programmable thermostats allows for better control over temperature settings based on occupancy patterns, thereby reducing unnecessary energy consumption.

Finally, it's crucial for homeowners to stay informed about any changes or updates in EPA regulations concerning cooling systems. As technology evolves and new findings emerge regarding environmental impacts, the EPA may adjust its guidelines accordingly. Staying

updated ensures continued compliance and maximizes both environmental and economic benefits.

In summary, ensuring that your mobile home cooling system meets EPA requirements involves selecting an Energy Star-certified unit, ensuring proper installation and maintenance, enhancing overall energy efficiency through supplementary measures like improved insulation and smart thermostat use, and keeping abreast of regulatory changes. By following these steps diligently, homeowners can enjoy a comfortable living environment while contributing positively to broader environmental conservation efforts.

Comparing SEER Ratings Across Different Mobile Home Cooling Systems

Understanding and adhering to Environmental Protection Agency (EPA) guidelines for mobile home cooling systems presents a unique set of challenges. Mobile homes, often designed with compactness and cost-efficiency in mind, require specialized attention when it comes to environmental regulations. This essay explores the common challenges associated with complying with EPA standards, emphasizing the need for awareness and careful implementation.

One of the primary challenges is the limited space within mobile homes. Traditional HVAC systems may not fit or function effectively in these confined areas, necessitating alternative solutions that still meet EPA standards. Mobile homeowners often turn to smaller, more efficient cooling units or ductless mini-split systems. However, finding equipment that balances efficiency with compliance can be difficult because not all manufacturers clearly label their products' adherence to EPA guidelines.

Another significant challenge is financial constraints. Mobile home residents are frequently from lower-income brackets, making expensive retrofits or upgrades burdensome. The upfront costs of environmentally-friendly cooling systems can be prohibitive despite potential long-term savings on energy bills. Additionally, accessing state or federal incentives for upgrading to compliant systems can be complicated and time-consuming due to bureaucratic procedures.

The complexity of EPA regulations themselves poses another hurdle. Understanding technical jargon and navigating dense regulatory documents can be daunting for homeowners without a background in environmental science or engineering. This lack of clarity can lead to unintentional non-compliance as individuals struggle to interpret how general guidelines apply specifically to mobile homes.

Moreover, many mobile homes are older structures not originally built with modern energy efficiency standards in mind. Retrofitting these older models to comply with current EPA guidelines involves significant work-sometimes requiring structural modifications that are both costly and technically challenging.

Educational outreach and support from local governments or community organizations could alleviate some of these issues by providing clearer guidance tailored specifically for mobile home owners. Workshops or informational sessions about affordable compliance strategies could empower residents to make informed decisions about their cooling systems.

In conclusion, while adhering to EPA guidelines for mobile home cooling systems presents several challenges-including spatial limitations, financial barriers, complex regulations, and outdated infrastructure-these obstacles are not insurmountable. With increased awareness, education, and support mechanisms in place, mobile homeowners can successfully navigate these difficulties while contributing positively towards environmental sustainability.

Tips for Maintaining Optimal Performance of High-SEER Rated Systems

Understanding and adhering to the Environmental Protection Agency (EPA) regulations is crucial for mobile home occupants, especially when it comes to cooling systems. These regulations are designed to ensure both environmental protection and human health, offering a range of benefits that extend beyond mere compliance.

Firstly, following EPA regulations helps safeguard the environment. Mobile homes often rely on cooling systems that can emit harmful substances if not properly maintained or disposed of. The EPA sets standards to control these emissions, reducing pollutants like hydrochlorofluorocarbons (HCFCs), which contribute significantly to ozone layer depletion and climate change. By adhering to these guidelines, mobile home owners actively participate in global efforts to mitigate environmental damage and promote sustainability.

Moreover, the efficient operation of cooling systems as per EPA standards leads to energy conservation. Regulations encourage the use of energy-efficient technologies and practices that reduce electricity consumption. This not only lowers utility bills for mobile home occupants but also decreases overall demand on power grids, contributing positively to energy resource management.

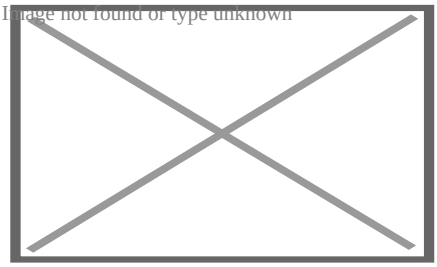
From a health perspective, compliance with EPA regulations ensures better indoor air quality for mobile home residents. Properly maintained cooling systems help prevent the circulation of pollutants and allergens within confined spaces, reducing risks associated with respiratory issues and other health problems. The EPA's focus on safe refrigerant handling and disposal further minimizes exposure to hazardous chemicals that could otherwise pose significant health risks.

Economically, aligning with EPA guidelines can lead to cost savings over time. While there might be initial investments required for upgrading systems or adopting new technologies compliant with current standards, these often result in long-term financial benefits through reduced maintenance costs and increased system longevity.

In conclusion, following EPA regulations regarding mobile home cooling systems is beneficial not only for the environment but also for the occupants themselves. Through protecting natural resources, enhancing energy efficiency, improving air quality, and offering economic advantages, these regulations play a pivotal role in fostering healthier living conditions while promoting environmental stewardship. It is essential for mobile home residents to stay informed about these regulations and implement them diligently for their own benefit as well as for future generations.

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

[edit]

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

[edit]

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

[edit]

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]
:Ãƒ Æ’Ã†â€™Ãƒâ€ Ã¢â‚¬â„¢Ã Æ’Ã¢â‚¬Â ÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢Ã Æ’Ã†â€™Ãƒ Â¢Ã¢â€šÂ¬Ã‚

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 $m^2 \cdot K/W$ (0.88 $°F \cdot ft^2 \cdot h/Btu$). 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

[edit]

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

[edit]

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

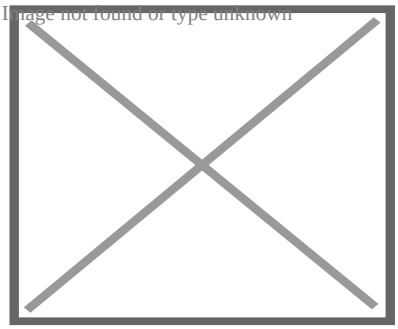
[edit]

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

PMV/PPD method

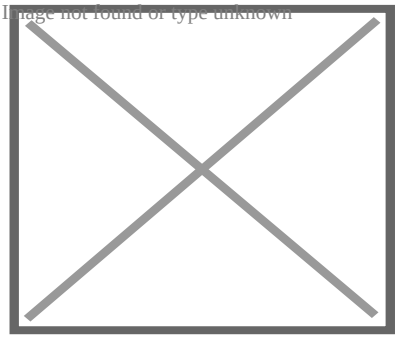
[edit]

Image not found or type unknown



Psychrometric Chart

Image not found or type unknown



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]

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

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

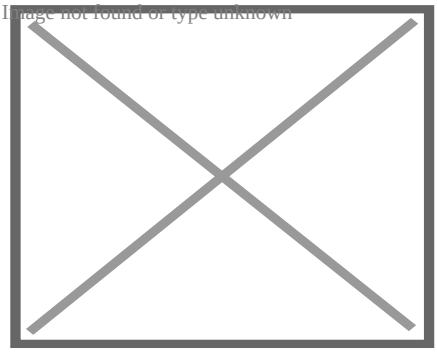
two-node method to represent human physiology in measuring skin temperature and skin wettedness.[48]

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 needed*]

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]

This section **relies largely or entirely on a single source**. Relevant discussion may be found on the talk page. Please help improve this article by introducing citations to additional sources.
Find sources: "Thermal comfort" – news · newspapers · books · scholar · JSTOR *(June 2016)*

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

References

[edit]

1. ^ ***a b c d e f g h i j k l m n o p q r s*** ANSI/ASHRAE Standard 55-2017, Thermal Environmental Conditions for Human Occupancy
2. **^** *Çengel, Yunus A.; Boles, Michael A. (2015). Thermodynamics: An Engineering Approach (8th ed.). New York, NY: McGraw-Hill Education. ISBN 978-0-07-339817-4.*
3. ^ ***a b c d e f g h i*** *de Dear, Richard; Brager, Gail (1998). "Developing an adaptive model of thermal comfort and preference". ASHRAE Transactions.* ***104*** *(1): 145–67.*
4. **^** *Battistel, Laura; Vilardi, Andrea; Zampini, Massimiliano; Parin, Riccardo (2023). "An investigation on humans' sensitivity to environmental temperature". Scientific Reports.* ***13*** *(1). doi:10.1038/s41598-023-47880-5. ISSN 2045-2322. PMC 10695924. PMID 38049468.*
5. ^ ***a b c*** *Fanger, P Ole (1970). Thermal Comfort: Analysis and applications in environmental engineering. Danish Technical Press. ISBN 8757103410.*[*page needed*]
6. **^** *Nicol, Fergus; Humphreys, Michael (2002). "Adaptive thermal comfort and sustainable thermal standards for buildings" (PDF). Energy and Buildings.* ***34*** *(6): 563–572. doi:10.1016/S0378-7788(02)00006-3. S2CID 17571584.*[*permanent dead link*]
7. **^** ISO, 2005. ISO 7730 - Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.

8. **^** CEN, 2019. EN 16798-1 - Energy performance of buildings - Ventilation for buildings. Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
9. ^ ***a b c*** *Tartarini, Federico; Schiavon, Stefano; Cheung, Toby; Hoyt, Tyler (2020). "CBE Thermal Comfort Tool: Online tool for thermal comfort calculations and visualizations". SoftwareX.* ***12****: 100563. Bibcode:2020SoftX..1200563T. doi: 10.1016/j.softx.2020.100563. S2CID 225631918.*
10. ^ ***a b c*** *Tartarini, Federico; Schiavon, Stefano (2020-07-01). "pythermalcomfort: A Python package for thermal comfort research". SoftwareX.* ***12****: 100578. Bibcode:2020SoftX..1200578T. doi:10.1016/j.softx.2020.100578. ISSN 2352-7110. S2CID 225618628.*
11. **^** *Axelrod, Yekaterina K.; Diringer, Michael N. (2008). "Temperature Management in Acute Neurologic Disorders". Neurologic Clinics.* ***26*** *(2): 585–603. doi:10.1016/j.ncl.2008.02.005. ISSN 0733-8619. PMID 18514828.*
12. **^** *Laupland, Kevin B. (2009). "Fever in the critically ill medical patient". Critical Care Medicine.* ***37*** *(Supplement): S273–S278. doi:10.1097/ccm.0b013e3181aa6117. ISSN 0090-3493. PMID 19535958. S2CID 21002774.*
13. **^** *Brown, Douglas J.A.; Brugger, Hermann; Boyd, Jeff; Paal, Peter (2012-11-15). "Accidental Hypothermia". New England Journal of Medicine.* ***367*** *(20): 1930–1938. doi:10.1056/nejmra1114208. ISSN 0028-4793. PMID 23150960. S2CID 205116341.*
14. **^** *Vitruvius, Marcus (2001). The Ten Books of Architecture. Cambridge University Press. ISBN 978-1-107-71733-6.*
15. **^** *Linden, David J. (1961). Touch: the science of hand, heart, and mind. New York. ISBN 9780670014873. OCLC 881888093.*cite book: CS1 maint: location missing publisher (link)
16. **^** *Lisa., Heschong (1979). Thermal delight in architecture. Cambridge, Mass.: MIT Press. ISBN 978-0262081016. OCLC 5353303.*
17. **^** Wargocki, Pawel, and Olli A. Seppänen, et al. (2006) "Indoor Climate and Productivity in Offices". Vol. 6. *REHVA Guidebooks 6*. Brussels, Belgium: REHVA, Federation of European Heating and Air-conditioning Associations.
18. **^** *Wyon, D.P.; Andersen, I.; Lundqvist, G.R. (1981), "Effects of Moderate Heat Stress on Mental Performance", Studies in Environmental Science, vol. 5, no. 4, Elsevier, pp. 251–267, doi:10.1016/s0166-1116(08)71093-8, ISBN 9780444997616, PMID 538426*
19. **^** *Fang, L; Wyon, DP; Clausen, G; Fanger, PO (2004). "Impact of indoor air temperature and humidity in an office on perceived air quality, SBS symptoms and performance". Indoor Air.* ***14*** *(Suppl 7): 74–81. doi:10.1111/j.1600-0668.2004.00276.x. PMID 15330775.*
20. **^** *Cabanac, Michel (1971). "Physiological role of pleasure". Science.* ***173*** *(4002): 1103–7. Bibcode:1971Sci...173.1103C. doi:10.1126/science.173.4002.1103. PMID 5098954. S2CID 38234571.*

21. **^** *Parkinson, Thomas; de Dear, Richard (2014-12-15). "Thermal pleasure in built environments: physiology of alliesthesia". Building Research & Information.* ***43*** *(3): 288–301. doi:10.1080/09613218.2015.989662. ISSN 0961-3218. S2CID 109419103.*
22. **^** *Hitchings, Russell; Shu Jun Lee (2008). "Air Conditioning and the Material Culture of Routine Human Encasement". Journal of Material Culture.* ***13*** *(3): 251–265. doi:10.1177/1359183508095495. ISSN 1359-1835. S2CID 144084245.*
23. **^** *Toftum, J. (2005). "Thermal Comfort Indices". Handbook of Human Factors and Ergonomics Methods. Boca Raton, FL, USA: 63.CRC Press.*[*page needed*]
24. **^** *Smolander, J. (2002). "Effect of Cold Exposure on Older Humans". International Journal of Sports Medicine.* ***23*** *(2): 86–92. doi:10.1055/s-2002-20137. PMID 11842354. S2CID 26072420.*
25. **^** *Khodakarami, J. (2009). Achieving thermal comfort. VDM Verlag. ISBN 978-3-639-18292-7.*[*page needed*]
26. **^** Thermal Comfort chapter, Fundamentals volume of the ASHRAE Handbook, ASHRAE, Inc., Atlanta, GA, 2005[*page needed*]
27. **^** *Ainsworth, BE; Haskell, WL; Whitt, MC; Irwin, ML; Swartz, AM; Strath, SJ; O'Brien, WL; Bassett Jr, DR; Schmitz, KH; Emplaincourt, PO; Jacobs Jr, DR; Leon, AS (2000). "Compendium of physical activities: An update of activity codes and MET intensities". Medicine & Science in Sports & Exercise.* ***32*** *(9 Suppl): S498–504. CiteSeerX 10.1.1.524.3133. doi:10.1097/00005768-200009001-00009. PMID 10993420.*
28. ^ ***a b*** *Szokolay, Steven V. (2010). Introduction to Architectural Science: The Basis of Sustainable Design (2nd ed.). pp. 16–22.*
29. **^** *Havenith, G (1999). "Heat balance when wearing protective clothing". The Annals of Occupational Hygiene.* ***43*** *(5): 289–96. CiteSeerX 10.1.1.566.3967. doi:10.1016/S0003-4878(99)00051-4. PMID 10481628.*
30. **^** *McCullough, Elizabeth A.; Eckels, Steve; Harms, Craig (2009). "Determining temperature ratings for children's cold weather clothing". Applied Ergonomics.* ***40*** *(5): 870–7. doi:10.1016/j.apergo.2008.12.004. PMID 19272588.*
31. **^** *Frank C. Mooren, ed. (2012). "Skin Wettedness". Encyclopedia of Exercise Medicine in Health and Disease. p. 790. doi:10.1007/978-3-540-29807-6_3041. ISBN 978-3-540-36065-0.*
32. **^** *Fukazawa, Takako; Havenith, George (2009). "Differences in comfort perception in relation to local and whole-body skin wetness". European Journal of Applied Physiology.* ***106*** *(1): 15–24. doi:10.1007/s00421-009-0983-z. PMID 19159949. S2CID 9932558.*
33. ^ ***a b*** ANSI, ASHRAE, 2020. Standard - 55 Thermal environmental conditions for human occupancy.
34. **^** *Balaras, Constantinos A.; Dascalaki, Elena; Gaglia, Athina (2007). "HVAC and indoor thermal conditions in hospital operating rooms". Energy and Buildings.* ***39*** *(4): 454. doi:10.1016/j.enbuild.2006.09.004.*
35. **^** *Wolkoff, Peder; Kjaergaard, Søren K. (2007). "The dichotomy of relative humidity on indoor air quality". Environment International.* ***33*** *(6): 850–7.*

doi:10.1016/j.envint.2007.04.004. PMID 17499853.

36. **^** *Hashiguchi, Nobuko; Tochihara, Yutaka (2009). "Effects of low humidity and high air velocity in a heated room on physiological responses and thermal comfort after bathing: An experimental study". International Journal of Nursing Studies.* ***46*** *(2): 172–80. doi:10.1016/j.ijnurstu.2008.09.014. PMID 19004439.*
37. **^** *McMullan, Randall (2012). Environmental Science in Building. Macmillan International Higher Education. p. 25. ISBN 9780230390355.*[*permanent dead link*]
38. **^** *"Humidity". Humidity. The Columbia Electronic Encyclopedia (6th ed.). Columbia University Press. 2012.*
39. **^** *"How the weather makes you hot and cold". Popular Mechanics. Hearst Magazines. July 1935. p. 36.*
40. **^** *Morris, Nathan B.; English, Timothy; Hospers, Lily; Capon, Anthony; Jay, Ollie (2019-08-06). "The Effects of Electric Fan Use Under Differing Resting Heat Index Conditions: A Clinical Trial". Annals of Internal Medicine.* ***171*** *(9). American College of Physicians: 675–677. doi:10.7326/m19-0512. ISSN 0003-4819. PMID 31382270. S2CID 199447588.*
41. **^** *"Radiation and Thermal Comfort for Indoor Spaces | SimScale Blog". SimScale. 2019-06-27. Retrieved 2019-10-14.*
42. **^** *Humphreys, Michael A.; Nicol, J. Fergus; Raja, Iftikhar A. (2007). "Field Studies of Indoor Thermal Comfort and the Progress of the Adaptive Approach". Advances in Building Energy Research.* ***1*** *(1): 55–88. doi:10.1080/17512549.2007.9687269. ISSN 1751-2549. S2CID 109030483.*
43. **^** *Brager, Gail S.; de Dear, Richard J. (1998). "Thermal adaptation in the built environment: a literature review". Energy and Buildings.* ***27*** *(1): 83–96. doi:10.1016/S0378-7788(97)00053-4. ISSN 0378-7788. S2CID 114893272.*
44. **^** *Hoyt, Tyler; Schiavon, Stefano; Piccioli, Alberto; Moon, Dustin; Steinfeld, Kyle (2013). "CBE Thermal Comfort Tool". Center for the Built Environment, University of California, Berkeley. Retrieved 21 November 2013.*
45. ^ ***a b*** *Cheung, Toby; Schiavon, Stefano; Parkinson, Thomas; Li, Peixian; Brager, Gail (2019-04-15). "Analysis of the accuracy on PMV – PPD model using the ASHRAE Global Thermal Comfort Database II". Building and Environment.* ***153****: 205–217. doi:10.1016/j.buildenv.2019.01.055. ISSN 0360-1323. S2CID 115526743.*
46. **^** *Földváry LiÃƒÆ'Ã†â€™Ãƒâ€ Ã¢â‚¬â„¢ÃƒÆ'Ã¢â‚¬Â ÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ÃƒÆ'Ã†â€™ÃƒÂ¢Ã¢â€ Veronika; Cheung, Toby; Zhang, Hui; de Dear, Richard; Parkinson, Thomas; Arens, Edward; Chun, Chungyoon; Schiavon, Stefano; Luo, Maohui (2018-09-01). "Development of the ASHRAE Global Thermal Comfort Database II". Building and Environment.* ***142****: 502–512. doi:10.1016/j.buildenv.2018.06.022. hdl: 11311/1063927. ISSN 0360-1323. S2CID 115289014.*
47. **^** *WC16 Saberi (PDF). p. 1329 (p. 5 in the PDF). Archived from the original (PDF) on 23 June 2016. Retrieved 31 May 2017.*
48. ^ ***a b c*** *Gagge, AP; Fobelets, AP; Berglund, LG (1986). "A standard predictive index of human response to the thermal environment". ASHRAE Transactions.* ***92*** *(2nd ed.): 709–31.*

49. ^ ***a b*** *Doherty, TJ; Arens, E.A. (1988). "Evaluation of the physiological bases of thermal comfort models". ASHRAE Transactions.* ***94*** *(1): 15.*
50. **^** *Berglund, Larry (1978). "Mathematical models for predicting the thermal comfort response of building occupants". ASHRAE Transactions.* ***84****.*
51. **^** *Fountain, Mark; Huizenga, Charlie (1997). "A thermal sensation prediction software tool for use by the profession". ASHRAE Transactions.* ***103*** *(2).*
52. **^** La Roche, P. (2011). *Carbon-neutral architectural design*. CRC Press.[*page needed*]
53. **^** EN 15251 Standard 2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics
54. ^ ***a b*** *Rohles, Frederick H. (February 2007). "Temperature & Temperament - A Psychologist Looks at Comfort". ASHRAE Journal: 14–22.*
55. ^ ***a b c*** *Szokolay, Steven V. (2010). Introduction to Architectural Science: The Basis of Sustainable Design (2nd ed.). p. 19.*
56. ^ ***a b*** *Nicol, J Fergus (2001). "Characterising Occupant Behaviour in Buildings" (PDF). Proceedings of the Seventh International IBPSA Conference. Rio de Janeiro, Brazil. pp. 1073–1078.*
57. **^** *Haldi, Frédéric; Robinson, Darren (2008). "On the behaviour and adaptation of office occupants". Building and Environment.* ***43*** *(12): 2163. doi:10.1016/j.buildenv.2008.01.003.*
58. ^ ***a b c*** *Lenzuni, P.; Freda, D.; Del Gaudio, M. (2009). "Classification of Thermal Environments for Comfort Assessment". Annals of Occupational Hygiene.* ***53*** *(4): 325–32. doi:10.1093/annhyg/mep012. PMID 19299555.*
59. **^** *Wyon, D.P.; Andersen, I.; Lundqvist, G.R. (2009). "Spontaneous magnitude estimation of thermal discomfort during changes in the ambient temperature*". Journal of Hygiene.* ***70*** *(2): 203–21. doi:10.1017/S0022172400022269. PMC 2130040. PMID 4503865.*
60. **^** *Karjalainen, Sami (2007). "Biological sex differences in thermal comfort and use of thermostats in everyday thermal environments". Building and Environment.* ***42*** *(4): 1594–1603. doi:10.1016/j.buildenv.2006.01.009.*
61. **^** *Lan, Li; Lian, Zhiwei; Liu, Weiwei; Liu, Yuanmou (2007). "Investigation of biological sex difference in thermal comfort for Chinese people". European Journal of Applied Physiology.* ***102*** *(4): 471–80. doi:10.1007/s00421-007-0609-2. PMID 17994246. S2CID 26541128.*
62. **^** *Harimi Djamila; Chi Chu Ming; Sivakumar Kumaresan (6–7 November 2012), "Assessment of Gender Differences in Their Thermal Sensations to the Indoor Thermal Environment", Engineering Goes Green, 7th CUTSE Conference, Sarawak Malaysia: School of Engineering & Science, Curtin University, pp. 262–266, ISBN 978-983-44482-3-3*.
63. **^** *Yu, Jinghua; Yang, Changzhi; Tian, Liwei; Liao, Dan (2009). "Evaluation on energy and thermal performance for residential envelopes in hot summer and cold winter zone of China". Applied Energy.* ***86*** *(10): 1970. doi:10.1016/j.apenergy.2009.01.012.*

64. **^** *Silva, Vicente de Paulo Rodrigues; De Azevedo, Pedro Vieira; Brito, Robson Souto; Campos, João Hugo Baracuy (2009). "Evaluating the urban climate of a typically tropical city of northeastern Brazil". Environmental Monitoring and Assessment.* ***161*** *(1–4): 45–59. doi:10.1007/s10661-008-0726-3. PMID 19184489. S2CID 23126235.*.
65. **^** United States Environmental Protection Agency. Office of Air and Radiation. Office of the Administrator.; Smart Growth Network (2003). *Smart Growth and Urban Heat Islands*. (EPA-content)
66. **^** *Shmaefsky, Brian R. (2006). "One Hot Demonstration: The Urban Heat Island Effect" (PDF). Journal of College Science Teaching.* ***35*** *(7): 52–54. Archived (PDF) from the original on 2022-03-16.*
67. **^** *Al-Homoud, Mohammad S.; Abdou, Adel A.; Budaiwi, Ismail M. (2009). "Assessment of monitored energy use and thermal comfort conditions in mosques in hot-humid climates". Energy and Buildings.* ***41*** *(6): 607. doi:10.1016/j.enbuild.2008.12.005.*
68. **^** Nasrollahi, N. (2009). *Thermal environments and occupant thermal comfort*. VDM Verlag, 2009, ISBN 978-3-639-16978-2.[*page needed*]
69. **^** *"About the WBGT and Apparent Temperature Indices".*
70. **^** *Hancock, P. A.; Ross, Jennifer M.; Szalma, James L. (2007). "A Meta-Analysis of Performance Response Under Thermal Stressors". Human Factors: The Journal of the Human Factors and Ergonomics Society.* ***49*** *(5): 851–77. doi:10.1518/001872007X230226. PMID 17915603. S2CID 17379285.*
71. **^** *Leon, Lisa R. (2008). "Thermoregulatory responses to environmental toxicants: The interaction of thermal stress and toxicant exposure". Toxicology and Applied Pharmacology.* ***233*** *(1): 146–61. doi:10.1016/j.taap.2008.01.012. PMID 18313713.*
72. **^** ISO, 2004. ISO 7933 - Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain.
73. **^** *"OSHA Technical Manual (OTM) Section III: Chapter 4". osha.gov. September 15, 2017. Retrieved January 11, 2024.*
74. **^** *Peeters, Leen; Dear, Richard de; Hensen, Jan; d'Haeseleer, William (2009). "Thermal comfort in residential buildings: Comfort values and scales for building energy simulation". Applied Energy.* ***86*** *(5): 772. doi:10.1016/j.apenergy.2008.07.011.*
75. **^** *Barwood, Martin J.; Newton, Phillip S.; Tipton, Michael J. (2009). "Ventilated Vest and Tolerance for Intermittent Exercise in Hot, Dry Conditions with Military Clothing". Aviation, Space, and Environmental Medicine.* ***80*** *(4): 353–9. doi:10.3357/ASEM.2411.2009. PMID 19378904.*
76. **^** *Zhang, Hui; Arens, Edward; Huizenga, Charlie; Han, Taeyoung (2010). "Thermal sensation and comfort models for non-uniform and transient environments: Part I: Local sensation of individual body parts". Building and Environment.* ***45*** *(2): 380. doi:10.1016/j.buildenv.2009.06.018. S2CID 220973362.*
77. **^** *Zhang, Hui; Arens, Edward; Huizenga, Charlie; Han, Taeyoung (2010). "Thermal sensation and comfort models for non-uniform and transient environments, part II:*

Local comfort of individual body parts". Building and Environment. ***45*** *(2): 389. doi:10.1016/j.buildenv.2009.06.015.*
78. **^** *Zhang, Hui; Arens, Edward; Huizenga, Charlie; Han, Taeyoung (2010). "Thermal sensation and comfort models for non-uniform and transient environments, part III: Whole-body sensation and comfort". Building and Environment.* ***45*** *(2): 399. doi:10.1016/j.buildenv.2009.06.020.*
79. **^** *Tsushima, Yoshiaki; Okada, Sho; Kawai, Yuka; Sumita, Akio; Ando, Hiroshi; Miki, Mitsunori (10 August 2020). "Effect of illumination on perceived temperature". PLOS ONE.* ***15*** *(8): e0236321. Bibcode:2020PLoSO..1536321T. doi: 10.1371/journal.pone.0236321. PMC 7416916. PMID 32776987.*
80. **^** *Ziat, Mounia; Balcer, Carrie Anne; Shirtz, Andrew; Rolison, Taylor (2016). "A Century Later, the Hue-Heat Hypothesis: Does Color Truly Affect Temperature Perception?". Haptics: Perception, Devices, Control, and Applications. Lecture Notes in Computer Science. Vol. 9774. pp. 273–280. doi:10.1007/978-3-319-42321-0_25. ISBN 978-3-319-42320-3.*
81. **^** *"Hue Heat". Medium. 10 April 2022. Retrieved 15 May 2023.*
82. **^** *Toftum, Jørn; Thorseth, Anders; Markvart, Jakob; Logadóttir, Ásta (October 2018). "Occupant response to different correlated colour temperatures of white LED lighting" (PDF). Building and Environment.* ***143****: 258–268. doi:10.1016/j.buildenv.2018.07.013. S2CID 115803800.*
83. **^** *"Temperature - Colour - National 5 Art and Design Revision". BBC Bitesize. Retrieved 15 May 2023.*
84. **^** *Khodakarami, Jamal; Nasrollahi, Nazanin (2012). "Thermal comfort in hospitals – A literature review". Renewable and Sustainable Energy Reviews.* ***16*** *(6): 4071. doi:10.1016/j.rser.2012.03.054.*
85. ^ ***a b*** *Zhang, H.; Arens, E.; Zhai, Y. (2015). "A review of the corrective power of personal comfort systems in non-neutral ambient environments". Building and Environment.* ***91****: 15–41. doi:10.1016/j.buildenv.2015.03.013.*
86. **^** *Andersen, M.; Fiero, G.; Kumar, S. (21–26 August 2016). "Well-Connected Microzones for Increased Building Efficiency and Occupant Comfort". Proceedings of ACEEE Summer Study on Energy Efficiency in Buildings.*

Further reading

[edit]

- *Thermal Comfort*, Fanger, P. O, Danish Technical Press, 1970 (Republished by McGraw-Hill, New York, 1973).
- Thermal Comfort chapter, Fundamentals volume of the *ASHRAE Handbook*, ASHRAE, Inc., Atlanta, GA, 2005.
- *Weiss, Hal (1998). Secrets of Warmth: For Comfort or Survival. Seattle, WA: Mountaineers Books. ISBN 978-0-89886-643-8. OCLC 40999076.*
- Godish, T. Indoor Environmental Quality. Boca Raton: CRC Press, 2001.
- Bessoudo, M. *Building Facades and Thermal Comfort: The impacts of climate, solar shading, and glazing on the indoor thermal environment.* VDM Verlag, 2008

- *Nicol, Fergus (2012). Adaptive thermal comfort : principles and practice. London New York: Routledge. ISBN 978-0415691598.*
- *Humphreys, Michael (2016). Adaptive thermal comfort : foundations and analysis. Abingdon, U.K. New York, NY: Routledge. ISBN 978-0415691611.*
- Communications in development and assembly of textile products, Open Access Journal, ISSN 2701-939X
- Heat Stress, National Institute for Occupational Safety and Health.
- Cold Stress, National Institute for Occupational Safety and Health.

- v
- t
- e

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
- Solar heating

- 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

Components

- Grille

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

Authority control databases: National Image not found or type unknown **Germany** **Edit this at Wikidata**

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

Image not found or type unknown

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

References

[edit]

1. **^** *"Energy consumption definition and meaning - Collins English Dictionary". www.collinsdictionary.com.*
2. **^** *"Human energy requirements: Principles and Definitions". Report of a Joint FAO/WHO/UNU Expert Consultation. Food and Agriculture Organization of the United Nations. 2004. Retrieved 2009-10-15.*

External links

[edit]

Image not found or type unknown

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

- Image not found or type unknown Media related to Energy consumption at Wikimedia Commons
- World energy consumption per capita per country
- v
- t
- e

  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
- 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

Energy system components

Use and supply	○ Efficient energy use ○ Agriculture ○ Computing ○ Transport ○ Energy conservation ○ Energy consumption ○ Energy policy ○ Energy development ○ Energy security ○ Energy storage ○ Renewable energy ○ Sustainable energy ○ World energy supply and consumption ○ Africa ○ Asia ○ Australia ○ Canada ○ Europe ○ Mexico ○ South America ○ United States
Misc.	○ Carbon footprint ○ Energy democracy ○ Energy recovery ○ Energy recycling ○ Jevons paradox ○ Waste-to-energy ○ Waste-to-energy plant

- Image not found or type unknown **Category**
- Image not found or type unknown **Commons**
- Image not found or type unknown **Portal**
- Image not found or type unknown **WikiProject**

Authority control databases: National Image not found or type unknown **Edit this at Wikidata**

- Czech Republic
- Latvia

About Durham Supply Inc

Photo

Image not found or type unknown

Photo

Image not found or type unknown

Photo

Image not found or type unknown

Photo

Image not found or type unknown

Photo

Image not found or type unknown

Photo

Image not found or type unknown

Things To Do in Oklahoma County

Photo

Image not found or type unknown

Science Museum Oklahoma

4.7 (2305)

Photo

Image not found or type unknown

Lighthouse

4.7 (993)

Photo

Image not found or type unknown

USS Oklahoma Anchor Memorial

5 (15)

Photo

Image not found or type unknown

Stockyards City Main Street

4.6 (256)

Photo

National Cowboy & Western Heritage Museum

4.8 (5474)

Photo

Image not found or type unknown

Centennial Land Run Monument

4.8 (811)

Driving Directions in Oklahoma County

Driving Directions From Residence Inn Oklahoma City South to Durham Supply Inc

Driving Directions From Santa Fe South High School to Durham Supply Inc

Driving Directions From Blazers Ice Centre to Durham Supply Inc

Driving Directions From Central Oklahoma City to Durham Supply Inc

Driving Directions From Oklahoma City to Durham Supply Inc

Driving Directions From Burger King to Durham Supply Inc

**https://www.google.com/maps/dir/Helmerich+%26+Payne/Durham+Supply+Inc/@35.
97.489937,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJ714Z1i8UsocRphJjY9iB9I
97.489937!2d35.410201!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e0**

**https://www.google.com/maps/dir/Burger+King/Durham+Supply+Inc/@35.3986553,-
97.4941094,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJLfaFHGgYsocR_KJOjeK
97.4941094!2d35.3986553!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e2**

**https://www.google.com/maps/dir/Residence+Inn+Oklahoma+City+South/Durham+S
97.4927159,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJay7C7kUUsocR-
KWMu3Zkx4U!2m2!1d-
97.4927159!2d35.3926643!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e1**

**https://www.google.com/maps/dir/Subway/Durham+Supply+Inc/@35.420449,-
97.4922233,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJlQ9TACgUsocRafY1sp5
FM!2m2!1d-
97.4922233!2d35.420449!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e3**

**https://www.google.com/maps/dir/Burlington/Durham+Supply+Inc/@35.3932991,-
97.5096817,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJpZ837WsUsocRoduRUD
97.5096817!2d35.3932991!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e0**

**https://www.google.com/maps/dir/Oakwood+Homes/Durham+Supply+Inc/@35.3969
97.507498,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJlxa_QmsUsocROKaMBK
97.507498!2d35.396903!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e2**

Driving Directions From Oklahoma City Zoo to Durham Supply Inc

Driving Directions From Science Museum Oklahoma to Durham Supply Inc

Driving Directions From Centennial Land Run Monument to Durham Supply Inc

Driving Directions From Science Museum Oklahoma to Durham Supply Inc

Driving Directions From Sanctuary Asia to Durham Supply Inc

Driving Directions From Bricktown Water Taxi to Durham Supply Inc

https://www.google.com/maps/dir/Oklahoma+City+National+Memorial+%26+Museum
97.5170593,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-
97.5170593!2d35.4731496!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e0

https://www.google.com/maps/dir/Oklahoma+City+Zoo/Durham+Supply+Inc/@35.523
97.4724932,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-
97.4724932!2d35.5238895!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e2

https://www.google.com/maps/dir/Oklahoma+National+Guard+Museum/Durham+Sup
97.4737378,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-
97.4737378!2d35.5081012!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e1

https://www.google.com/maps/dir/Oklahoma+Railway+Museum/Durham+Supply+Inc
97.4671897,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-
97.4671897!2d35.5051862!1m5!1m1!1sChIJCUnZ1UoUsocRpJXqm8cX514!2m2!1d-
97.4774449!2d35.3963954!3e3

Reviews for Durham Supply Inc

Durham Supply Inc

Image not found or type unknown

K Moore

(1)

No service after the sale. I purchased a sliding patio door and was given the wrong size sliding screen door. After speaking with the salesman and manager several times the issue is still not resolved and, I was charged full price for an incomplete door. They blamed the supplier for all the issues…and have offered me nothing to resolve this.

Durham Supply Inc

Image not found or type unknown

Crystal Dawn

(1)

I would give 0 stars. This isnTHE WORST company for heating and air. I purchased a home less than one year ago and my ac has gone out twice and these people refuse to repair it although I AM UNDER WARRANTY!!!! They say it’s an environmental issue and they can’t fix it or even try to or replace my warrantied air conditioning system.

Durham Supply Inc

Image not found or type unknown

Salest

(5)

Had to make a quick run for 2 sets of ?? door locks for front and back door.. In/ out in a quick minute! They helped me right away. ?? Made sure the 2 sets had the same ? keys. The ? bathroom was clean and had everything I needed. ? ?. Made a quick inquiry about a random item... they quickly looked it up and gave me pricing. Great ? job ?

Durham Supply Inc

Image not found or type unknown

Jennifer Williamson

(5)

First we would like to thank you for installing our air conditioning unit! I’d like to really brag about our technician, Mack, that came to our home to install our unit in our new home. Mack was here for most of the day and throughly explained everything we had a question about. By the late afternoon, we had cold air pumping through our vents and we couldn’t have been more thankful. I can tell you, I would be very lucky to have a technician like Mack if this were my company. He was very very professional, kind, and courteous. Please give Mack a pat on the back and stay rest assured that Mack is doing a great job and upholding your company name! Mack, if you see this, great job!! Thanks for everything you did!! We now have a new HVAC company in the event we need one. We will also spread the word to others!!

Durham Supply Inc

Image not found or type unknown

Noel Vandy

(5)

Thanks to the hard work of Randy our AC finally got the service it needed. These 100 degree days definitely feel long when your house isn't getting cool anymore. We were so glad when Randy came to work on the unit, he had all the tools and products he needed with him and it was all good and running well when he left. With a long drive to get here and only few opportunities to do so, we are glad he got it done in 1 visit. Now let us hope it will keep running well for a good while.

Understanding EPA Regulations for Mobile Home Cooling Systems**View GBP**

Check our other pages :

- **Verifying Local Licensing for Mobile Home HVAC Professionals**
- **Calculating Long Term Benefits of Efficient Mobile Home Furnaces**
- **Achieving Energy Savings with Variable Speed Motors in Mobile Homes**
- **Checking Duct Seal Quality for Improved Mobile Home SEER Performance**

Frequently Asked Questions

What are the key EPA regulations that apply to mobile home cooling systems?

The key EPA regulations for mobile home cooling systems primarily involve the use of refrigerants. The EPA enforces rules under the Clean Air Act, which mandate that only certified technicians handle the repair and maintenance of HVAC systems containing ozone-depleting substances. Additionally, there are specific guidelines on leak repair and disposal of refrigerants to minimize environmental impact.

How do these EPA regulations affect the installation process of a new cooling system in a mobile home?

During installation, contractors must ensure compliance with EPA standards regarding refrigerant handling. This means using approved equipment and techniques to avoid leaks or emissions during setup. Installers need proper certification to legally work with certain types of refrigerants, ensuring that installations do not harm the environment or violate legal requirements.

Are there any exemptions or special considerations for older mobile homes under EPA regulations?

Older mobile homes may face different challenges due to outdated HVAC systems potentially using phased-out refrigerants like R-22. While there might be no direct exemptions from current regulations, owners may need to upgrade their systems to meet modern standards. Retrofitting can often be necessary when older units require parts that comply with newer environmental guidelines set by the EPA.

Royal Supply Inc

Phone : +16362969959

City : Oklahoma City

State : OK

Zip : 73149

Address : Unknown Address

Google Business Profile

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

Follow us