Air Quality

- Mapping Duct Layouts for Cleaner Airflow in Mobile Homes
  Mapping Duct Layouts for Cleaner Airflow in Mobile Homes Inspecting Vent Connections for Improved Air Quality Minimizing Drafts Through Sealed Mobile Home Duct Systems Scheduling Regular Cleanings for Mobile Home Ventilation Evaluating Filter Efficiency for Enhanced Mobile Home Air Quality Addressing Mold Risks in Mobile Home Ductwork Installing Air Purification Systems in Mobile Homes Checking Air Pressure to Reduce Allergens in Mobile Home Interiors Identifying Common Leaks in Flexible Mobile Home Ducts Balancing Humidity Levels for Healthier Mobile Home Air Considering UV Technology for Mobile Home Air Treatment Using Diagnostic Tools to Assess Air Quality in Mobile Homes
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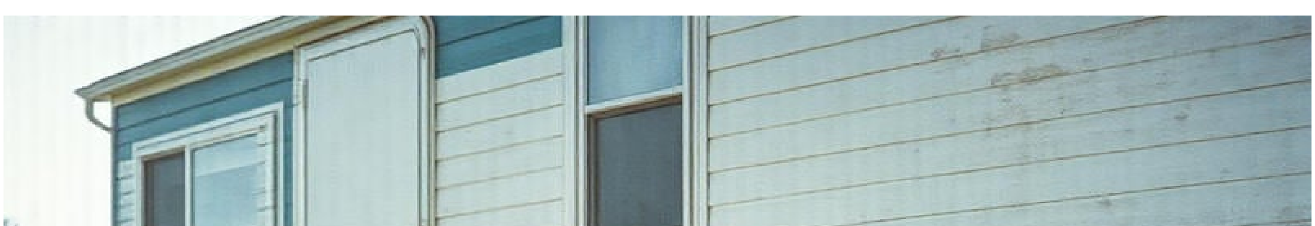

Minimizing Drafts Through Sealed Mobile Home Duct Systems

Importance of Efficient Duct Layouts for Airflow

Maintaining efficient HVAC systems in mobile homes presents a unique set of challenges, particularly when it comes to minimizing drafts through sealed duct systems. Unlike traditional houses, mobile homes often have less space for HVAC components and are constructed with materials that make them more susceptible to air leaks. These factors contribute to the complexity of ensuring energy efficiency and comfort within these living spaces.

One of the primary challenges is the limited structural space available in mobile homes. The compact nature of these homes means that HVAC systems must be efficiently designed to fit into smaller areas without compromising performance. This often results in ductwork being placed in cramped conditions, making it difficult to access for maintenance or sealing purposes. Ensuring that ducts are properly sealed is crucial because any gaps or leaks can lead to significant energy loss, increased utility bills, and uncomfortable indoor environments.

Moreover, the construction materials commonly used in mobile homes can exacerbate draft issues. Space constraints in mobile homes require innovative HVAC installation techniques **mobile home hvac repair** attention. Many mobile homes are built with lighter materials that may not provide as robust a barrier against external elements as those used in traditional housing. As a result, even minor inefficiencies in the duct system can lead to noticeable drafts, impacting both heating and cooling effectiveness. This requires homeowners and technicians alike to pay close attention to sealing techniques and insulation quality.

Sealing ductwork is an essential step in minimizing drafts and enhancing HVAC efficiency in mobile homes. The use of high-quality sealants and insulation materials can significantly reduce air leakage, thereby improving system performance. Additionally, regular inspections are vital for identifying potential issues before they escalate into larger problems. Technicians must be adept at navigating the tight spaces within mobile homes to inspect and repair ductwork effectively.

Another challenge lies in the mobility aspect of these homes themselves. Mobile homes may be relocated from time to time, which can put stress on their structural components, including the HVAC system. During such moves, ducts can become dislodged or damaged if not properly secured beforehand. It's important for owners planning a move to engage professionals who understand how to prepare an HVAC system for transport.

In conclusion, maintaining efficient HVAC systems in mobile homes involves navigating several unique challenges related primarily to size constraints and material vulnerabilities. By focusing on proper sealing practices and regular maintenance checks, homeowners can minimize drafts through their duct systems while also optimizing energy usage. With careful attention paid to these aspects, it's possible for mobile home residents to enjoy comfortable living conditions year-round despite the inherent limitations of their dwellings' design.

The comfort and energy efficiency of mobile homes are significantly influenced by the design and maintenance of their duct systems. A critical aspect of this is ensuring that these systems are properly sealed. The importance of sealed duct systems in mobile homes cannot be overstated, particularly when it comes to minimizing drafts-a common issue that can lead to uncomfortable living conditions and increased utility bills.

Duct systems are responsible for distributing heated or cooled air throughout a home. In mobile homes, which often face unique structural challenges compared to traditional houses, the integrity of these ducts plays a crucial role in maintaining consistent indoor temperatures. Unsealed or poorly sealed ducts can result in significant air leakage. This not only leads to drafts but also forces heating and cooling systems to work harder, consuming more energy and driving up costs.

By sealing duct systems effectively, homeowners can mitigate these issues. Sealed ducts ensure that conditioned air reaches its intended destination without escaping into unconditioned spaces like attics or crawl spaces. This enhances the overall efficiency of heating and cooling appliances, potentially reducing energy consumption by as much as 20%. Furthermore, it directly addresses the problem of drafts, creating a more stable and comfortable indoor environment.

In addition to improving energy efficiency and comfort levels, sealed duct systems contribute positively to indoor air quality. Leaky ducts can draw dust, allergens, and pollutants from unconditioned areas into the living space. Properly sealing these ducts prevents such contaminants from infiltrating the home's interior environment, thereby promoting healthier air for occupants.

Furthermore, addressing duct leaks early on through proper sealing helps extend the lifespan of HVAC equipment by reducing unnecessary strain on these systems. This preventative measure can save homeowners significant repair or replacement costs over time.

In conclusion, investing in well-sealed duct systems is essential for any mobile home owner seeking to minimize drafts effectively while enhancing energy efficiency and indoor air quality. By prioritizing this often-overlooked aspect of home maintenance, residents can enjoy more consistent temperatures year-round with reduced utility expenses-a win-win scenario for both comfort and cost savings.

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Techniques for Mapping Duct Layouts

In mobile homes, controlling drafts and optimizing energy efficiency are crucial for maintaining a comfortable living environment. One of the most effective ways to achieve this is through the implementation of sealed duct systems. Sealed duct systems play a pivotal role in minimizing drafts, which not only enhances comfort but also contributes significantly to reducing energy consumption.

Mobile homes often face unique challenges when it comes to heating and cooling due to their construction and materials. The ductwork in these homes serves as the main pathway for distributing conditioned air throughout the space. However, if these ducts are not properly sealed, they can become major sources of air leaks. Such leaks allow conditioned air to escape into unconditioned spaces like attics or crawl spaces, leading to inefficiencies in the heating and cooling process.

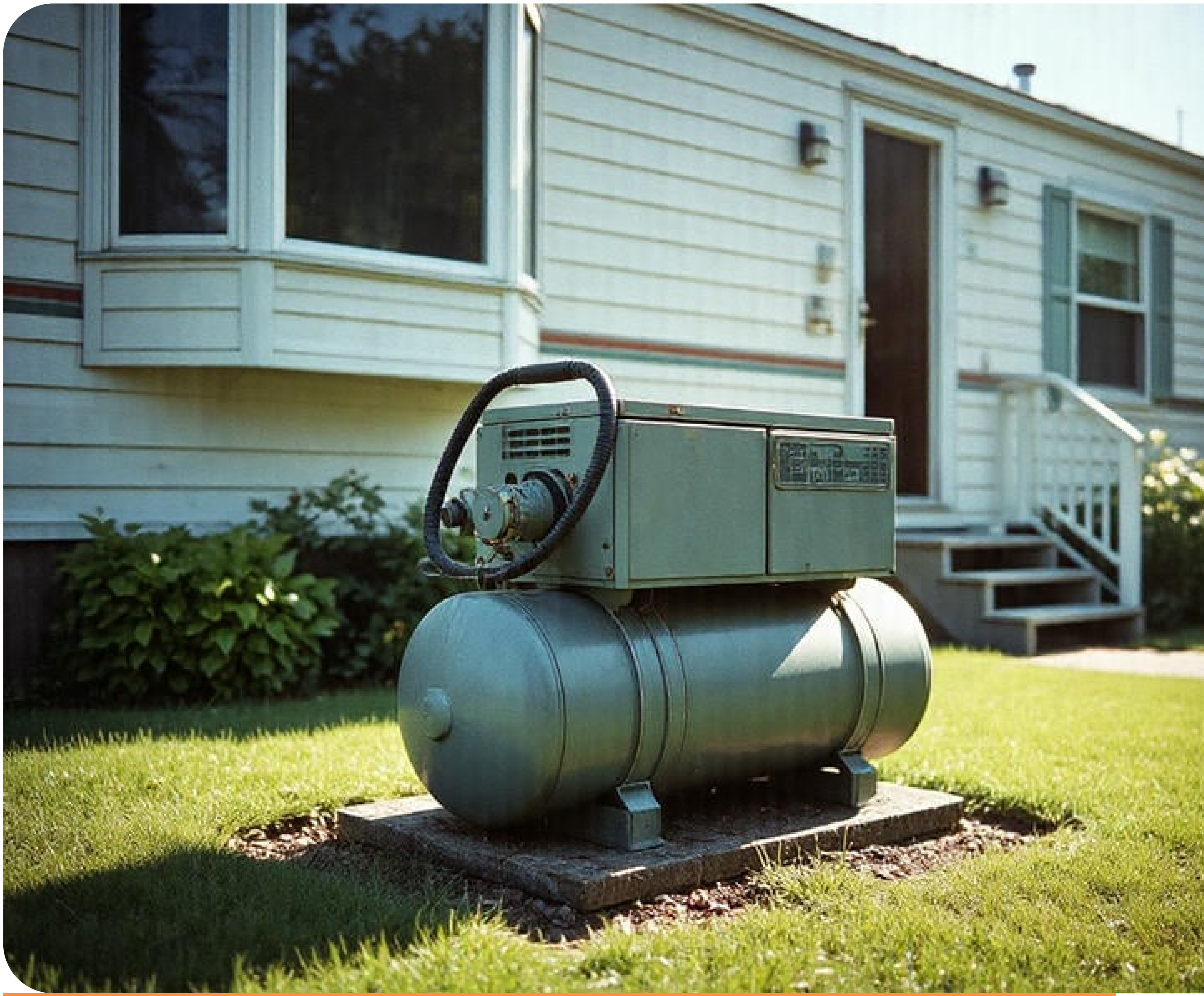
Sealing duct systems involves applying mastic sealant or metal tape specifically designed for HVAC applications along all joints, seams, and connections within the ductwork. This prevents air from escaping at any point along its journey from the HVAC unit to the various rooms in the home. By ensuring that all parts of the duct system are airtight, homeowners can prevent unwanted infiltration of outside air into their living spaces.

One of the primary benefits of a sealed duct system is its ability to minimize drafts. Drafts occur when there is an imbalance between indoor and outdoor air pressures, often exacerbated by leaky ducts allowing cold or hot external air into interior spaces. When ducts are tightly sealed, they help maintain consistent indoor temperatures by effectively containing conditioned air until it reaches its intended destination. This uniform distribution results in fewer cold spots during winter and less overheating during summer months.

Moreover, improving energy efficiency is another significant advantage associated with sealed duct systems. In many cases, up to 30% of heated or cooled air can be lost due to leaks in unsealed ducts, leading to increased energy usage as HVAC systems work harder to compensate for these losses. By sealing ducts properly, homeowners can reduce this wasted energy expenditure-resulting in lower utility bills and a smaller carbon footprint.

Furthermore, sealed ducts enhance overall indoor air quality by preventing pollutants such as dust, allergens, and fumes from infiltrating through gaps in the ductwork. This creates a healthier living environment for occupants while ensuring that ventilation systems operate more effectively.

In conclusion, investing in a sealed duct system offers numerous benefits for mobile home owners seeking to minimize drafts and improve energy efficiency. Not only does it lead to more consistent indoor temperatures and reduced energy costs, but it also fosters better indoor air quality-making it an essential consideration for anyone looking to optimize comfort within their mobile home environment. Through careful attention to sealing practices within their ductwork systems, residents can enjoy both immediate improvements in comfort levels as well as long-term savings on their energy expenses.



Tools and Technologies for Accurate Duct Mapping

In the quest for energy efficiency and comfort, one of the often-overlooked aspects of mobile home maintenance is the duct system. Unsealed ducts can pose a variety of issues that not only affect the indoor environment but also lead to increased energy costs. Understanding these common problems is crucial for anyone looking to minimize drafts through sealed mobile home duct systems.

One of the primary issues with unsealed ducts is air leakage. Ducts are responsible for distributing heated or cooled air throughout a home, and any leaks along this system can result in significant energy loss. When ducts are not properly sealed, conditioned air escapes into areas like crawl spaces or attics instead of reaching living spaces. This leakage forces HVAC systems to work harder and longer to maintain desired temperatures, leading to higher utility bills and unnecessary wear on equipment.

Another concern with unsealed ducts is uneven temperature distribution across different rooms. Drafts can form when some parts of a home receive less heating or cooling than others due to escaped air. This inconsistency not only creates discomfort but also encourages occupants to adjust thermostats frequently, which further compounds energy inefficiency.

Moreover, unsealed ducts can become conduits for dust, dirt, and allergens entering the indoor air supply. As gaps in ductwork allow external elements to infiltrate, indoor air quality may suffer significantly. This can pose health risks, particularly for individuals with respiratory conditions or allergies.

Moisture intrusion is yet another problem linked with unsealed ducts. Gaps in ductwork can let moisture enter from humid environments such as basements or crawl spaces. Over time, this moisture can foster mold growth within the ducts themselves-an issue that poses both structural risks and health hazards.

Addressing these issues requires sealing the ductwork effectively using materials such as mastic sealant or metal tape designed specifically for HVAC systems. Sealing prevents air loss by closing off potential escape routes within the duct system while also protecting against pollution infiltration and moisture ingress.

By investing in sealing mobile home ducts properly, homeowners benefit from improved thermal control throughout their homes alongside reduced operational demands on their HVAC systems-resulting in lower utility expenses over time coupled with enhanced occupant comfort levels year-round without worrying about inconsistent room climates due to leaks causing drafts!

Ultimately addressing these common issues through effective sealing techniques ensures an efficient airflow management strategy tailored towards minimizing drafts while maximizing performance outcomes overall!

Best Practices for Cleaner Airflow

In the quest to create more energy-efficient homes, particularly mobile homes, one of the critical areas often overlooked is the ductwork system. Mobile home duct systems are pivotal in maintaining a comfortable indoor environment, yet when they remain unsealed, they become susceptible to a range of problems that can compromise both comfort and efficiency. Among these issues, air leaks and increased energy costs are perhaps the most significant.

Air leaks in unsealed ducts represent a persistent problem that can have multiple repercussions. When ducts are not properly sealed, conditioned air intended to heat or cool living spaces escapes into unconditioned areas such as attics or crawl spaces. This leakage leads to uneven temperature distribution within the home, resulting in certain rooms being too hot or too cold while others remain uncomfortable. Moreover, air leaks allow dust and other pollutants to infiltrate the duct system and circulate throughout the home, negatively impacting indoor air quality. Consequently, residents may experience discomfort and health issues such as allergies or respiratory problems.

The financial implications of unsealed ducts cannot be understated. Air leaks force heating and cooling systems to work harder than necessary to maintain desired temperatures, leading to increased energy consumption. According to studies by various energy organizations, homes with leaky ducts can lose up to 30% of their conditioned air-an inefficiency that directly translates into higher utility bills. In today's climate-conscious world where every kilowatt-hour counts towards sustainability goals and household budgets alike, such waste represents an unnecessary burden.

Sealing mobile home duct systems is therefore not just about addressing air leaks; it is an investment in reducing energy costs. Properly sealed ducts ensure that heated or cooled air reaches its intended destination without loss along the way. This improvement allows HVAC systems to operate at peak efficiency, thereby lowering overall energy consumption and associated costs. Additionally, minimizing drafts through well-sealed ducts contributes significantly to environmental conservation efforts by reducing a home's carbon footprint.

Furthermore, sealing ducts improves overall comfort levels within mobile homes by maintaining consistent temperatures across all rooms-a crucial factor for any dwelling but especially important for smaller spaces like mobile homes where temperature variations are more noticeable.

In conclusion, addressing typical problems associated with unsealed ducts is essential for enhancing both comfort and cost-effectiveness in mobile homes. Through diligent attention to sealing these vital pathways for air distribution, homeowners can enjoy numerous benefits: reduced drafts leading to better temperature control; improved indoor air quality; decreased strain on HVAC systems resulting in lower maintenance needs; and ultimately substantial savings on energy bills-all while contributing positively towards environmental preservation efforts. Sealing mobile home duct systems thus emerges as an indispensable strategy for anyone looking forward not only toward immediate comfort but also long-term economic and ecological sustainability.

Case Studies of Improved Air Quality in Mobile Homes

In mobile homes, maintaining a comfortable and energy-efficient environment is often a challenge due to the unique construction of these dwellings. One critical area that can significantly impact both comfort and energy efficiency is the duct system. Leaky ducts can lead to drafts, resulting in uneven heating or cooling and increased energy bills. Therefore, sealing ducts in mobile homes is essential in minimizing drafts and ensuring the efficient operation of HVAC systems.

First and foremost, understanding the common issues associated with ductwork in mobile homes is crucial. Unlike traditional homes, mobile homes typically have ducts running under the floor or within narrow spaces, making them more susceptible to leaks. These leaks often occur at joints or seams where sections of ductwork are connected. Over time, normal wear and tear or shifting of the home can exacerbate these issues, leading to significant air loss.

To address these challenges, various techniques can be employed to effectively seal duct systems in mobile homes. One widely-used method is mastic sealing. Mastic is a thick paste that can be applied around seams and joints using a brush or gloved hand. Once cured, it forms a flexible yet durable seal that prevents air leakage even under pressure changes within the system. This technique is particularly effective because mastic remains pliable over time, accommodating any slight movements or vibrations without cracking.

Another popular option for sealing ducts involves using foil-backed tape specifically designed for HVAC applications. Unlike standard duct tape-which tends to deteriorate quickly-foil tape adheres well to metal surfaces and provides a long-lasting seal when applied correctly. For best results, it should be applied smoothly over clean surfaces with sufficient pressure to eliminate any air gaps.

In addition to these methods, homeowners might consider employing aerosol-based sealants known as "duct sprays." These products are sprayed inside the duct system where they adhere to leak sites as they exit through holes or cracks during operation-effectively sealing them from within without requiring direct access.

Regardless of the chosen technique, preparation plays a pivotal role in ensuring successful outcomes when sealing ducts. Before applying any sealant, it's important to thoroughly clean all surfaces involved; this ensures optimal adhesion and performance over time by removing dust or debris that could otherwise compromise integrity upon application.

Furthermore-and perhaps most importantly-it's worth noting that while some DIY enthusiasts may feel confident tackling basic tasks themselves after conducting thorough research on best practices related specifically towards their situation (and exercising appropriate caution); many individuals would benefit greatly from enlisting professional assistance instead: experienced technicians possess specialized knowledge/tools necessary not only diagnosing but also addressing complex problems efficiently/safely-all helping guarantee peace-of-mind knowing job done right first-time round!

In conclusion then: investing effort/resources into properly sealed/maintained mobile home-duct-systems pays dividends far beyond simply reducing drafts alone! Indeed-not-only does doing so contribute towards lowering utility expenses directly-but also indirectly enhances overall quality-life enjoyed therein too via improved indoor climate-control year-round regardless prevailing outdoor conditions encountered outside at any given moment!

Minimizing drafts in mobile homes is crucial for maintaining energy efficiency and comfort, especially during extreme weather conditions. A key component of achieving an airtight environment is effectively sealing the ductwork. Mobile home duct systems often differ from those in traditional houses due to their unique construction and space constraints, necessitating specialized methods and materials for sealing.

One of the primary methods used to seal ductwork in mobile homes is applying mastic sealant. Mastic is a thick, paste-like material that can be brushed onto joints and seams within the duct system. Its pliable nature allows it to adhere well to various surfaces, creating a long-lasting seal that remains flexible over time. This flexibility is particularly important in mobile homes, where movement may cause less adaptable materials to crack or break away.

Another effective method involves using metal-backed tape or foil tape. Unlike standard duct tape, which can degrade quickly under temperature fluctuations, metal-backed tape provides a durable solution that withstands the demanding conditions found within HVAC systems. When applied correctly, this type of tape forms a strong bond with the duct surfaces, preventing air leaks at connections and junctions.

For areas where ducts are joined or there are gaps too wide for mastic alone to seal effectively, preformed rubber gaskets or neoprene seals can be employed. These materials offer excellent resistance against environmental factors such as moisture and temperature changes while providing a robust barrier against air leakage.

Additionally, insulating wraps can be applied around ducts to further enhance sealing efforts by minimizing heat loss or gain through conduction. These wraps often consist of fiberglass insulation encased in a reflective foil barrier designed to reflect radiant heat away from the ducts themselves.

When these methods are combined-mastic sealant for seams, metal-backed tape for joints, rubber gaskets for wider gaps, and insulation wraps for thermal protection-they create a comprehensive approach that significantly reduces drafts throughout the mobile home's HVAC system.

Proper preparation before applying any sealing materials is paramount; ensuring that all surfaces are clean and dry maximizes adhesion. Furthermore, regular inspections should be conducted post-sealing to address any wear or damage promptly-this helps maintain optimal performance of the sealed system over time.

In conclusion, effectively sealing ductwork in mobile homes requires an understanding of both the specific challenges posed by these dwellings and the appropriate use of modern sealing technologies. By adopting a multifaceted approach tailored to their unique needs-employing mastic sealants, metal-backed tapes, rubber gaskets, and insulating wraps-homeowners can ensure their living spaces remain comfortable while reducing energy consumption caused by drafts.

In the realm of mobile home living, comfort is often a paramount concern. Mobile homes, with their unique construction and design, can sometimes present challenges in maintaining consistent indoor temperatures. One significant factor contributing to this issue is the duct system used for heating and cooling. A sealed duct system can offer remarkable benefits, particularly when it comes to minimizing drafts, thereby enhancing the overall comfort and energy efficiency of a mobile home.

Drafts are unwelcome guests in any household, but they can be particularly intrusive in mobile homes where insulation might not be as robust as in traditional houses. These drafts often originate from poorly sealed ducts where air escapes or enters through gaps and leaks. This not only leads to uncomfortable temperature fluctuations but also results in higher energy bills as heating and cooling systems work overtime to compensate for the lost air.

By implementing a sealed duct system, homeowners can significantly reduce these drafts. Sealing ducts involves using mastic sealant or metal-backed tape to close up any seams or joints that could potentially leak air. This process ensures that conditioned air reaches its intended destination without escaping into unheated spaces like attics or crawl spaces. As a result, rooms maintain a more consistent temperature, reducing cold spots and increasing overall comfort.

Moreover, a sealed duct system contributes to improved energy efficiency-a crucial benefit for those living in mobile homes who are mindful of utility costs. When ducts are properly sealed, HVAC systems do not have to work as hard to heat or cool the space, which can lead to noticeable savings on energy bills over time. Additionally, this increased efficiency translates into reduced wear and tear on heating and cooling units, potentially extending their lifespan and reducing maintenance costs.

Another significant advantage of sealing ducts is the improvement of indoor air quality. Leaky ducts can draw in dust, mold spores, and other pollutants from unconditioned areas such as basements or attics. By sealing these leaks, homeowners reduce the risk of contaminants entering the living environment, leading to healthier indoor air quality for residents.

Finally, investing in a sealed duct system enhances the overall value of a mobile home. Prospective buyers are increasingly aware of energy efficiency and comfort factors when making purchasing decisions. Demonstrating that your home has an efficient HVAC system with well-sealed ducts can be an attractive selling point.

In conclusion, sealing mobile home duct systems offers numerous benefits beyond merely minimizing drafts; it improves comfort levels by maintaining consistent temperatures throughout the space while simultaneously lowering energy costs through enhanced efficiency. Furthermore, it promotes better indoor air quality and adds value to the property itself-making it a wise investment for any mobile homeowner seeking improved living conditions and cost savings over time.

Minimizing drafts in mobile homes through sealed duct systems presents a compelling case for homeowners seeking to enhance their living environments. The advantages of this approach are manifold, encompassing improved comfort, energy savings, and enhanced system performance.

First and foremost, sealing duct systems significantly enhances the comfort level within a mobile home. Drafts can create uncomfortable temperature variations that make certain areas of a home less habitable, especially during extreme weather conditions. By minimizing these drafts, sealed duct systems help maintain a consistent temperature throughout the living space. This uniformity not only ensures that every room is cozy but also reduces the need for constant thermostat adjustments, allowing residents to enjoy a more stable and pleasant indoor climate.

Energy savings represent another significant benefit of sealed duct systems. Leaky ducts can lead to substantial energy losses as heated or cooled air escapes before reaching its intended destination. This inefficiency forces heating and cooling systems to work harder and longer to compensate for lost air, resulting in higher energy consumption and increased utility bills. By sealing these leaks, homeowners can drastically reduce wasted energy. The improved efficiency means that HVAC systems require less power to maintain desired temperatures, translating into tangible cost savings over time.

Moreover, enhanced system performance is a noteworthy advantage of utilizing sealed ductwork in mobile homes. When ducts are properly sealed, the entire HVAC system operates more effectively and reliably. With minimal air leakage, the system can better distribute conditioned air throughout the home without overexerting itself. This reduction in strain not only prolongs the lifespan of HVAC components but also decreases the likelihood of breakdowns or costly repairs. Consequently, homeowners experience fewer interruptions in service and enjoy peace of mind knowing their system is running optimally.

In conclusion, investing in sealed duct systems for mobile homes offers numerous benefits that contribute to an improved quality of life. From providing consistent comfort levels and achieving significant energy savings to ensuring robust system performance, sealing ducts addresses common issues associated with drafty environments efficiently. As homeowners increasingly seek sustainable solutions that enhance living conditions while reducing costs, adopting sealed ductwork emerges as a practical and advantageous choice for modern mobile home living.

Minimizing drafts in mobile homes has long been a challenge for homeowners who seek both comfort and energy efficiency. Mobile homes, often characterized by their lightweight construction, are particularly susceptible to air leaks, especially through duct systems. Sealing these ducts is a crucial step towards achieving a more controlled and efficient indoor environment. This essay will explore various case studies and examples that highlight successful strategies for minimizing drafts through sealed mobile home duct systems.

One compelling case study comes from the state of Florida, where a community of mobile home residents collaborated with local energy efficiency experts to address their persistent draft issues. The project began with an extensive audit of the homes' HVAC systems. Technicians identified that the primary source of drafts was poorly sealed ductwork, which allowed conditioned air to escape and unconditioned air to infiltrate the living spaces.

The solution involved sealing all joints and seams in the ductwork using mastic sealant-a thick paste that hardens to create an airtight barrier. Additionally, technicians installed flexible insulated duct sleeves to further reduce heat loss and prevent condensation buildup. After completing these upgrades, residents reported not only a noticeable reduction in drafts but also significant savings on their energy bills.

Similarly, in a rural community in Texas, another project demonstrated the potential benefits of integrating modern sealing technologies into older mobile homes. Here, infrared cameras were used during inspections to pinpoint areas of heat loss within the duct system. The use of advanced diagnostic tools allowed for precise targeting of problem areas without unnecessary disruption or expense.

The Texas initiative employed aerosol-based sealants-an innovative approach wherein tiny particles are sprayed into the ducts while they are pressurized from within. As air escapes through leaks, it carries these particles directly to trouble spots where they accumulate and form durable seals. This technology proved highly effective; post-intervention tests showed a dramatic decrease in airflow leakage rates.

Moreover, educational workshops were held alongside these technical interventions to empower homeowners with knowledge about maintaining their newly sealed systems. By understanding how ducts function and recognizing signs of wear or damage early on, residents could proactively manage future issues before they escalated into significant problems.

In conclusion, these case studies emphasize the profound impact that properly sealed duct systems can have on reducing drafts in mobile homes. Through strategic application of both traditional methods like mastic sealant and cutting-edge solutions like aerosol-based technology, communities across diverse climates have successfully enhanced comfort levels while lowering energy costs. Furthermore, by involving residents throughout the process-from initial audits to maintenance education-these projects fostered a sense of ownership and empowerment among homeowners that extends beyond mere technical fixes. Collectively, these examples offer valuable insights for anyone seeking effective ways to improve indoor environments within mobile homes worldwide.

Minimizing drafts in mobile homes is a critical aspect of enhancing comfort and energy efficiency. One effective strategy to achieve this is through the implementation of sealed duct systems. By examining real-life examples and case studies, we can gain valuable insights into how these systems operate successfully in practice.

Consider the case of Green Meadows Mobile Home Park, a community that faced significant challenges with energy inefficiency and occupant discomfort due to drafty conditions. The park management decided to undertake a comprehensive project focused on sealing the duct systems across all their units. This initiative was spearheaded by a team of HVAC professionals who meticulously assessed each mobile home to identify leaks and inefficiencies within the ductwork.

The transformation was remarkable. After sealing the ducts, residents reported a noticeable reduction in drafts throughout their homes. Furthermore, energy bills decreased significantly, with some households experiencing savings of up to 20% on their monthly utility costs. This not only improved the living conditions for residents but also bolstered the overall value of properties in Green Meadows.

Another compelling case study can be found in Sunny Acres Mobile Homes, where an innovative approach was taken to retrofit older models with sealed duct systems. Here, engineers utilized advanced diagnostic tools such as blower door tests and thermal imaging to pinpoint problem areas within the ducts. By addressing these issues with precision sealing techniques, Sunny Acres saw an immediate impact on indoor air quality and thermal comfort.

Residents at Sunny Acres shared positive feedback about how their homes felt warmer during winter months and cooler in summer without excessive reliance on heating or cooling appliances. These improvements were not just anecdotal; data collected over six months post-implementation showed a consistent decrease in energy consumption across the board.

These examples illustrate that sealed duct systems are more than just a technical upgrade; they represent a practical solution for minimizing drafts and improving mobile home living standards. The success stories from Green Meadows and Sunny Acres underscore the potential benefits of such initiatives-enhanced comfort, reduced energy costs, and increased property values-all contributing to more sustainable living environments.

In conclusion, real-life implementations of sealed duct systems in mobile homes demonstrate their effectiveness in minimizing drafts while offering economic advantages for residents and property owners alike. As awareness grows around these benefits, it is likely that more communities will follow suit, further showcasing how targeted interventions can lead to substantial improvements in residential quality of life.

Title: Maintenance Tips for Sealed Duct Systems: Minimizing Drafts in Mobile Homes

Sealed duct systems play a crucial role in maintaining the comfort and energy efficiency of mobile homes. Proper maintenance of these systems can significantly reduce drafts, ensuring that your living space remains cozy and your utility bills manageable. Here are some essential tips to help you maintain sealed duct systems effectively and minimize drafts in your mobile home.

Firstly, regular inspection is key to identifying potential issues before they escalate. At least twice a year, conduct a thorough examination of your ductwork for any signs of damage or leaks. Look out for cracks, holes, or loose joints that might compromise the system's integrity. If you're unsure about what to look for, consider hiring a professional to perform an inspection.

Another important aspect of maintaining sealed duct systems is keeping them clean. Dust and debris accumulation can obstruct airflow and lead to inefficiencies. Use a vacuum cleaner with a hose attachment to remove dust from vents and grilles regularly. Additionally, consider scheduling professional cleaning every few years to ensure deeper parts of the ducts remain free from buildup.

Sealing leaks promptly is vital in minimizing drafts through your duct system. If you detect any leaks during your inspections, seal them immediately using mastic sealant or metal-backed tape designed specifically for ductwork. Avoid using generic tapes like duct tape as they tend not to withstand temperature fluctuations over time.

Insulation also plays an essential role in reducing energy loss through ducts, thus minimizing drafts. Ensure that all accessible parts of your duct system are well-insulated, especially those running through unconditioned spaces such as attics or crawl spaces. Insulating ducts helps maintain consistent temperature levels throughout the home by preventing heat transfer between conditioned air inside the ducts and the surrounding environment.

Furthermore, it's crucial to pay attention to airflow management within the home itself. Check that furniture or other obstructions do not block air vents or registers which could disrupt efficient air distribution throughout your mobile home.

In addition to these practical measures, upgrading outdated equipment can enhance overall efficiency and draft reduction efforts considerably over time-consider replacing old thermostats with programmable models that automatically adjust temperatures based on occupancy patterns while reducing strain on HVAC systems linked directly via sealed ducts.

Lastly but importantly are routine check-ups; schedule annual professional servicing sessions where technicians examine both heating/cooling equipment along with connected ventilation infrastructure-ensuring everything functions optimally without hidden faults contributing towards unwanted draughts within household environments!

In conclusion: Maintaining mobile homes' sealed duct systems involves diligent inspections alongside proper cleaning routines coupled alongside proactive leak sealing practices-all aiding significantly toward minimizing pesky draughts affecting interior comfort levels whilst promoting enhanced energy efficiencies thereby lowering associated costs!

Maintaining sealed duct systems in mobile homes is crucial for ensuring both long-term effectiveness and energy efficiency. Mobile homes, often characterized by their unique construction and design, require special attention to their heating and cooling systems to minimize drafts and enhance comfort. Properly sealing ductwork not only helps in maintaining a consistent indoor temperature but also contributes significantly to energy savings.

The first step in maintaining a sealed duct system is regular inspection. Over time, ducts can develop leaks due to natural wear and tear or poor installation practices. These leaks allow conditioned air to escape into unconditioned spaces, such as crawl spaces or attics, which results in increased energy consumption as heating or cooling units work harder to maintain desired temperatures. By conducting routine checks for visible cracks or separations at joints and connections, homeowners can identify potential problem areas before they worsen.

Once leaks are identified, sealing them effectively is essential. Using mastic sealant or metal-backed tape specifically designed for ductwork can provide a robust solution that withstands the pressures of airflow and temperature changes better than conventional duct tape. These materials can be applied easily around seams and joints where leaks are most likely to occur, creating a durable barrier against air escape.

In addition to sealing existing ducts, proper insulation plays a critical role in maintaining efficiency. Insulating ducts that run through unconditioned spaces helps prevent heat loss during colder months and heat gain during warmer months. This step is especially important in mobile homes where space constraints might lead ducts through less protected areas.

Moreover, it's vital to consider the overall design and layout of the duct system when aiming for long-term performance. A well-designed system ensures balanced airflow throughout the home without placing undue strain on HVAC components. Consulting with HVAC professionals during installation or renovation projects can help ensure the system's layout promotes efficient air distribution while reducing any chances of future drafts.

Finally, regular maintenance of HVAC equipment complements efforts made toward sealing ducts. Changing air filters frequently ensures unobstructed airflow within the system while keeping dust and debris from accumulating inside ducts-a common cause of pressure imbalances that could exacerbate leakage issues.

In conclusion, minimizing drafts through sealed mobile home duct systems requires a comprehensive approach that includes routine inspections, effective sealing techniques using quality materials, proper insulation practices, thoughtful system design considerations, and ongoing HVAC maintenance. By addressing these factors proactively, homeowners can enjoy enhanced comfort levels within their homes while benefiting from reduced energy bills-an investment in both environmental sustainability and personal well-being that pays dividends over time.

In the evolving landscape of mobile home living, there is a growing emphasis on comfort and energy efficiency. One of the most promising avenues for enhancing HVAC efficiency in these homes lies in minimizing drafts through sealed duct systems. As we look to future trends, it becomes clear that addressing this issue not only improves comfort but also significantly reduces energy consumption.

Mobile homes, by their nature, are highly susceptible to air leaks and drafts due to their construction methods and materials. These drafts can lead to uneven heating or cooling, causing HVAC systems to work harder than necessary, thereby increasing energy costs and reducing system longevity. The solution? Sealed duct systems designed specifically for mobile homes.

Sealing ductwork effectively prevents conditioned air from escaping before it reaches its intended destination. This approach ensures that the HVAC system operates at peak efficiency by delivering air precisely where it's needed without unnecessary loss. Innovative sealing technologies such as advanced mastic sealants and specialized adhesive tapes are being tailored for the unique challenges presented by mobile home environments.

Furthermore, the integration of smart technologies into HVAC systems provides an additional layer of efficiency. Smart thermostats and sensors can detect temperature variations caused by leaks or poorly insulated areas and adjust settings accordingly. By utilizing data analytics, these systems predict potential draft issues before they become significant problems, allowing homeowners to address them proactively.

As awareness around environmental impact grows, so does the demand for sustainable living solutions. Sealing duct systems aligns with this trend by contributing to reduced carbon footprints through decreased energy usage. Moreover, government incentives and rebates increasingly encourage homeowners to adopt energy-efficient measures like duct sealing.

Looking ahead, we anticipate advancements in materials science leading to even more effective sealing products that are both durable and easy to install in mobile homes. Additionally, increased collaboration between manufacturers and builders will likely result in standardized practices for ductwork installation that prioritize airtightness from the outset.

In conclusion, minimizing drafts through sealed mobile home duct systems represents a crucial step forward in improving HVAC efficiency. As technology advances and societal priorities shift towards sustainability, such innovations promise not only enhanced comfort but also significant environmental benefits for future generations of mobile homeowners.

In recent years, there has been a burgeoning interest in the exploration of emerging technologies and practices that enhance the efficiency of HVAC systems in mobile homes. This focus is not just a nod to environmental sustainability, but also an acknowledgment of the significant energy costs associated with heating and cooling these compact living spaces. One particularly promising area within this realm is minimizing drafts through sealed mobile home duct systems.

Mobile homes, by their very nature, are more susceptible to energy inefficiency compared to traditional houses. This susceptibility arises mainly from their construction methods and materials, which often do not provide the same level of insulation or barrier against external elements. The ductwork in these homes is typically less robust, leading to increased potential for air leaks which can significantly impact the effectiveness of HVAC systems.

Sealing duct systems provides a direct and impactful way to combat this issue. By ensuring that ducts are properly sealed, homeowners can drastically reduce air loss, thereby enhancing HVAC efficiency and maintaining consistent indoor temperatures. This practice involves using innovative sealing products such as mastic sealant or high-quality metal tape designed specifically for ductwork applications. These materials help close gaps and joints where air might escape, ensuring that heated or cooled air reaches its intended destination without unnecessary loss.

Technological advancements have further augmented this approach with tools like aerosol-based sealants that allow for precise application even in hard-to-reach areas within a mobile home's duct system. These innovations make it possible to address leaks more comprehensively than ever before.

Beyond just sealing ducts, integrating smart home technology can provide an additional layer of efficiency enhancement. Smart thermostats offer real-time feedback on energy use and enable remote adjustments, ensuring optimal operation that aligns with user habits while minimizing wasteful practices.

The benefits of investing time and resources into sealing duct systems extend beyond immediate energy savings; they also contribute to improved indoor air quality by reducing the infiltration of dust and allergens through leaky ducts. Moreover, when combined with other energy-efficient practices-such as upgrading insulation or installing new windows-sealing ducts can form part of a holistic strategy aimed at making mobile homes more comfortable year-round while lowering utility bills.

In conclusion, exploring these emerging technologies and practices represents not just an opportunity for cost savings but also a step towards greater environmental responsibility. As we continue to advance our understanding and application of these techniques, sealed duct systems stand out as a vital component in the quest for enhanced HVAC efficiency in mobile homes-a move that promises comfort without compromise for residents across diverse climates.

About Air conditioning

This article is about cooling of air. For the Curved Air album, see Air Conditioning (album). For a similar device capable of both cooling and heating, see heat pump. "a/c" redirects here. For the abbreviation used in banking and book-keeping, see Account (disambiguation). For other uses, see AC.

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There are various types of air conditioners. Popular examples include: Window-mounted air conditioner (Suriname, 1955); Ceiling-mounted cassette air conditioner (China, 2023); Wall-mounted air conditioner (Japan, 2020); Ceiling-mounted console (Also called ceiling suspended) air conditioner (China, 2023); and portable air conditioner (Vatican City, 2018).

Air conditioning, often abbreviated as **A/C** (US) or **air con** (UK),[1] is the process of removing heat from an enclosed space to achieve a more comfortable interior temperature (sometimes referred to as 'comfort cooling') and in some cases also strictly controlling the humidity of internal air. Air conditioning can be achieved using a mechanical 'air conditioner' or by other methods, including passive cooling and ventilative cooling.[2][3] Air conditioning is a member of a family of systems and techniques that provide heating, ventilation, and air conditioning (HVAC).[4] Heat pumps are similar in many ways to air conditioners, but use a reversing valve to allow them both to heat and to cool an enclosed space.[5]

Air conditioners, which typically use vapor-compression refrigeration, range in size from small units used in vehicles or single rooms to massive units that can cool large buildings.[6] Air source heat pumps, which can be used for heating as well as cooling, are becoming increasingly common in cooler climates.

Air conditioners can reduce mortality rates due to higher temperature.[7] According to the International Energy Agency (IEA) 1.6 billion air conditioning units were used globally in 2016.[8] The United Nations called for the technology to be made more sustainable to mitigate climate change and for the use of alternatives, like passive cooling, evaporative cooling, selective shading, windcatchers, and better thermal insulation.

History

[edit]

Air conditioning dates back to prehistory.[9] Double-walled living quarters, with a gap between the two walls to encourage air flow, were found in the ancient city of Hamoukar, in modern Syria.[10] Ancient Egyptian buildings also used a wide variety of passive air-conditioning techniques.[11] These became widespread from the Iberian Peninsula through North Africa, the Middle East, and Northern India.[12

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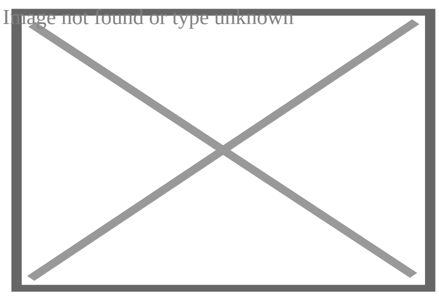
Passive techniques remained widespread until the 20th century when they fell out of fashion and were replaced by powered air conditioning. Using information from engineering studies of traditional buildings, passive techniques are being revived and modified for 21st-century architectural designs.[13][12]



An array of air conditioner condenser units outside a commercial office building

Air conditioners allow the building's indoor environment to remain relatively constant, largely independent of changes in external weather conditions and internal heat loads. They also enable deep plan buildings to be created and have allowed people to live comfortably in hotter parts of the world.[14]

Development

[edit]

Preceding discoveries

[edit]

In 1558, Giambattista della Porta described a method of chilling ice to temperatures far below its freezing point by mixing it with potassium nitrate (then called "nitre") in his popular science book *Natural Magic*.[15][16][17] In 1620, Cornelis Drebbel demonstrated "Turning Summer into Winter" for James I of England, chilling part of the Great Hall of Westminster Abbey with an apparatus of troughs and vats.[18] Drebbel's contemporary Francis Bacon, like della Porta a believer in science communication, may not have been present at the demonstration, but in a book published later the same year, he described it as "experiment of artificial freezing" and said that "Nitre (or rather its spirit) is very cold, and hence nitre or salt when added to snow or ice intensifies the cold of the latter, the nitre by adding to its cold, but the salt by supplying activity to the cold of the snow."[15]

In 1758, Benjamin Franklin and John Hadley, a chemistry professor at the University of Cambridge, conducted experiments applying the principle of evaporation as a means to cool an object rapidly. Franklin and Hadley confirmed that the evaporation of highly volatile liquids (such as alcohol and ether) could be used to drive down the temperature of an object past the freezing point of water. They experimented with the bulb of a mercury-in-glass thermometer as their object. They used a bellows to speed up the evaporation. They lowered the temperature of the thermometer bulb down to −14 °C (7 °F) while the ambient temperature was 18 °C (64 °F). Franklin noted that soon after they passed the freezing point of water 0 °C (32 °F), a thin film of ice formed on the surface of the thermometer's bulb and that the ice mass was about 6 mm (1⁄4 in) thick when they stopped the experiment upon reaching −14 °C (7 °F). Franklin concluded: "From this experiment, one may see the possibility of freezing a man to death on a warm summer's day."[19]

The 19th century included many developments in compression technology. In 1820, English scientist and inventor Michael Faraday discovered that compressing and liquefying ammonia could chill air when the liquefied ammonia was allowed to evaporate.[20] In 1842, Florida physician John Gorrie used compressor technology to create ice, which he used to cool air for his patients in his hospital in Apalachicola, Florida. He hoped to eventually use his ice-making machine to regulate the temperature of buildings.[20][21] He envisioned centralized air conditioning that could cool entire cities. Gorrie was granted a patent in 1851,[22] but following the death of his main backer, he was not able to realize his invention.

[23] In 1851, James Harrison created the first mechanical ice-making machine in Geelong, Australia, and was granted a patent for an ether vapor-compression refrigeration system in 1855 that produced three tons of ice per day.[24] In 1860, Harrison established a second ice company. He later entered the debate over competing against the American advantage of ice-refrigerated beef sales to the United Kingdom.[24]

First devices

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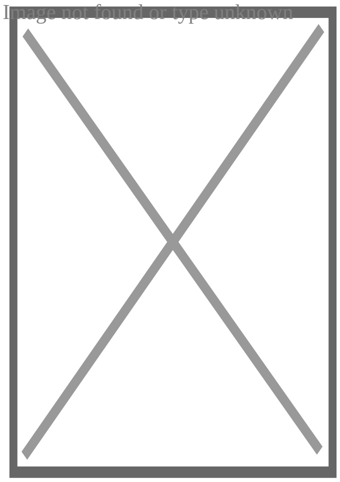


Willis Carrier, who is credited with building the first modern electrical air conditioning unit

Electricity made the development of effective units possible. In 1901, American inventor Willis H. Carrier built what is considered the first modern electrical air conditioning unit.[25][26][27][28] In 1902, he installed his first air-conditioning system, in the Sackett-Wilhelms Lithographing & Publishing Company in Brooklyn, New York.[29] His invention controlled both the temperature and humidity, which helped maintain consistent paper dimensions and ink alignment at the printing plant. Later, together with six other employees, Carrier formed The Carrier Air Conditioning Company of America, a business that in 2020 employed 53,000 people and was valued at $18.6 billion.[30][31]

In 1906, Stuart W. Cramer of Charlotte, North Carolina, was exploring ways to add moisture to the air in his textile mill. Cramer coined the term "air conditioning" in a patent claim which he filed that year, where he suggested that air conditioning was analogous to "water conditioning", then a well-known process for making textiles easier to process.[32] He combined moisture with ventilation to "condition" and change the air in the factories; thus, controlling the humidity that is necessary in textile plants. Willis Carrier adopted the term and incorporated it into the name of his company.[33]

Domestic air conditioning soon took off. In 1914, the first domestic air conditioning was installed in Minneapolis in the home of Charles Gilbert Gates. It is, however, possible that the considerable device (c. 2.1 m × 1.8 m × 6.1 m; 7 ft × 6 ft × 20 ft) was never used, as the house remained uninhabited[20] (Gates had already died in October 1913.)

In 1931, H.H. Schultz and J.Q. Sherman developed what would become the most common type of individual room air conditioner: one designed to sit on a window ledge. The units went on sale in 1932 at US$10,000 to $50,000 (the equivalent of $200,000 to $1,100,000 in 2023.)[20] A year later, the first air conditioning systems for cars were offered for sale.[34] Chrysler Motors introduced the first practical semi-portable air conditioning unit in 1935,[35] and Packard became the first automobile manufacturer to offer an air conditioning unit in its cars in 1939.[36]

Further development

[edit]

Innovations in the latter half of the 20th century allowed more ubiquitous air conditioner use. In 1945, Robert Sherman of Lynn, Massachusetts, invented a portable, in-window air conditioner that cooled, heated, humidified, dehumidified, and filtered the air.[37] The first inverter air conditioners were released in 1980–1981.[38][39]

In 1954, Ned Cole, a 1939 architecture graduate from the University of Texas at Austin, developed the first experimental "suburb" with inbuilt air conditioning in each house. 22 homes were developed on a flat, treeless track in northwest Austin, Texas, and the community was christened the 'Austin Air-Conditioned Village.' The residents were subjected to a year-long study of the effects of air conditioning led by the nation's premier air conditioning companies, builders, and social scientists. In addition, researchers from UT's Health Service and Psychology Department studied the effects on the "artificially cooled humans." One of the more amusing discoveries was that each family reported being troubled with scorpions, the leading theory being that scorpions sought cool, shady places. Other reported changes in lifestyle were that mothers baked more, families ate heavier foods, and they were more apt to choose hot drinks.[40][41]

Air conditioner adoption tends to increase above around $10,000 annual household income in warmer areas.[42] Global GDP growth explains around 85% of increased air condition adoption by 2050, while the remaining 15% can be explained by climate change.[42]

As of 2016 an estimated 1.6 billion air conditioning units were used worldwide, with over half of them in China and USA, and a total cooling capacity of 11,675 gigawatts.[8][43] The International Energy Agency predicted in 2018 that the number of air conditioning units would grow to around 4 billion units by 2050 and that the total cooling capacity would grow to around 23,000 GW, with the biggest increases in India and China.[8] Between 1995 and 2004, the proportion of urban households in China with air conditioners increased from 8% to 70%.[44] As of 2015, nearly 100 million homes, or about 87% of US households, had air conditioning systems.[45] In 2019, it was estimated that 90% of new single-family homes constructed in the US included air conditioning (ranging from 99% in the South to 62% in the West).[46][47]

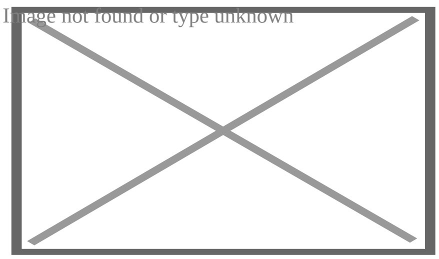
Operation

[edit]

Operating principles

[edit]

Main article: Vapor-compression refrigeration



A simple stylized diagram of the refrigeration cycle: 1) condensing coil, 2) expansion valve, 3) evaporator coil, 4) compressor

Cooling in traditional air conditioner systems is accomplished using the vapor-compression cycle, which uses a refrigerant's forced circulation and phase change between gas and liquid to transfer heat.[48][49] The vapor-compression cycle can occur within a unitary, or packaged piece of equipment; or within a chiller that is connected to terminal cooling equipment (such as a fan coil unit in an air handler) on its evaporator side and heat rejection equipment such as a cooling tower on its condenser side. An air source heat pump shares many components with an air conditioning system, but includes a reversing valve, which allows the unit to be used to heat as well as cool a space.[50]

Air conditioning equipment will reduce the absolute humidity of the air processed by the system if the surface of the evaporator coil is significantly cooler than the dew point of the surrounding air. An air conditioner designed for an occupied space will typically achieve a 30% to 60% relative humidity in the occupied space.[51]

Most modern air-conditioning systems feature a dehumidification cycle during which the compressor runs. At the same time, the fan is slowed to reduce the evaporator temperature and condense more water. A dehumidifier uses the same refrigeration cycle but incorporates both the evaporator and the condenser into the same air path; the air first passes over the evaporator coil, where it is cooled[52] and dehumidified before passing over the condenser coil, where it is warmed again before it is released back into the room.[*citation needed*]

Free cooling can sometimes be selected when the external air is cooler than the internal air. Therefore, the compressor does not need to be used, resulting in high cooling efficiencies for these times. This may also be combined with seasonal thermal energy storage.[53]

Heating

[edit]
Main article: Heat pump

Some air conditioning systems can reverse the refrigeration cycle and act as an air source heat pump, thus heating instead of cooling the indoor environment. They are also commonly referred to as "reverse cycle air conditioners". The heat pump is significantly more energy-efficient than electric resistance heating, because it moves energy from air or groundwater to the heated space and the heat from purchased electrical energy. When the heat pump is in heating mode, the indoor evaporator coil switches roles and becomes the condenser coil, producing heat. The outdoor condenser unit also switches roles to serve as the evaporator and discharges cold air (colder than the ambient outdoor air).

Most air source heat pumps become less efficient in outdoor temperatures lower than 4 °C or 40 °F.[54] This is partly because ice forms on the outdoor unit's heat exchanger coil, which blocks air flow over the coil. To compensate for this, the heat pump system must temporarily switch back into the regular air conditioning mode to switch the outdoor evaporator coil *back* to the condenser coil, to heat up and defrost. Therefore, some heat pump systems will have electric resistance heating in the indoor air path that is activated only in this mode to compensate for the temporary indoor air cooling, which would otherwise be uncomfortable in the winter.

Newer models have improved cold-weather performance, with efficient heating capacity down to −14 °F (−26 °C).[55][54][56] However, there is always a chance that the humidity that condenses on the heat exchanger of the outdoor unit could freeze, even in models that have improved cold-weather performance, requiring a defrosting cycle to be performed.

The icing problem becomes much more severe with lower outdoor temperatures, so heat pumps are sometimes installed in tandem with a more conventional form of heating, such as an electrical heater, a natural gas, heating oil, or wood-burning fireplace or central heating, which is used instead of or in addition to the heat pump during harsher winter temperatures. In this case, the heat pump is used efficiently during milder temperatures, and the system is switched to the conventional heat source when the outdoor temperature is lower.

Performance

[edit]

Main articles: coefficient of performance, Seasonal energy efficiency ratio, and European seasonal energy efficiency ratio

The coefficient of performance (COP) of an air conditioning system is a ratio of useful heating or cooling provided to the work required.[57][58] Higher COPs equate to lower operating costs. The COP usually exceeds 1; however, the exact value is highly dependent on operating conditions, especially absolute temperature and relative temperature between sink and system, and is often graphed or averaged against expected conditions.[59] Air conditioner equipment power in the U.S. is often described in terms of "tons of refrigeration", with each approximately equal to the cooling power of one short ton (2,000 pounds (910 kg) of ice melting in a 24–hour period. The value is equal to 12,000 BTU_{IT} per hour, or 3,517 watts.[60] Residential central air systems are usually from 1 to 5 tons (3.5 to 18 kW) in capacity.[*citation needed*]

The efficiency of air conditioners is often rated by the seasonal energy efficiency ratio (SEER), which is defined by the Air Conditioning, Heating and Refrigeration Institute in its 2008 standard AHRI 210/240, *Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment*.[61] A similar standard is the European seasonal energy efficiency ratio (ESEER).[*citation needed*]

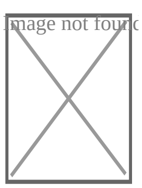
Efficiency is strongly affected by the humidity of the air to be cooled. Dehumidifying the air before attempting to cool it can reduce subsequent cooling costs by as much as 90 percent. Thus, reducing dehumidifying costs can materially affect overall air conditioning costs.[62]

Control system

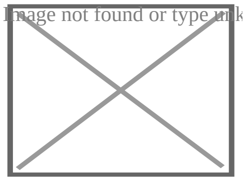
[edit]

Wireless remote control

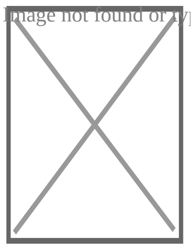
[edit]
Main articles: Remote control and Infrared blaster

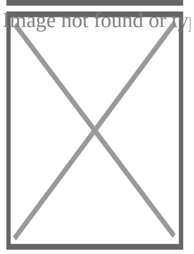


A
wireless
remote
controller



The infrared transmitting LED on the remote





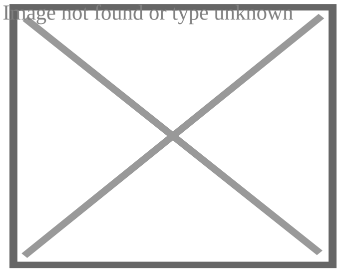
The infrared receiver on the air conditioner

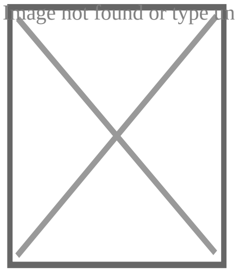
This type of controller uses an infrared LED to relay commands from a remote control to the air conditioner. The output of the infrared LED (like that of any infrared remote) is invisible to the human eye because its wavelength is beyond the range of visible light (940 nm). This system is commonly used on mini-split air conditioners because it is simple and portable. Some window and ducted central air conditioners uses it as well.

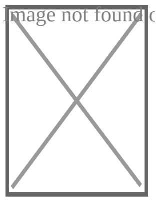
Wired controller

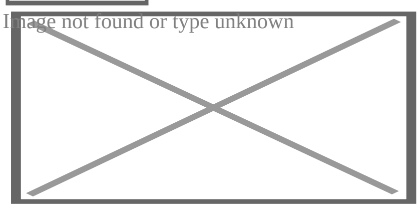
[edit]

Main article: Thermostat









Several wired controllers (Indonesia, 2024)

A wired controller, also called a "wired thermostat," is a device that controls an air conditioner by switching heating or cooling on or off. It uses different sensors to measure temperatures and actuate control operations. Mechanical thermostats commonly use bimetallic strips, converting a temperature change into mechanical displacement, to actuate control of the air conditioner. Electronic thermostats, instead, use a thermistor or other semiconductor sensor, processing temperature change as electronic signals to control the air conditioner.

These controllers are usually used in hotel rooms because they are permanently installed into a wall and hard-wired directly into the air conditioner unit, eliminating the need for batteries.

Types

[edit]

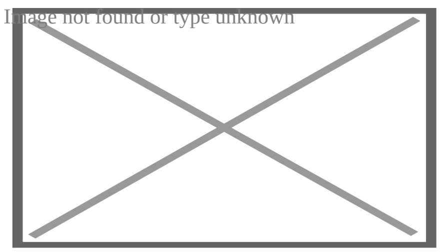
Types	Typical Capacity*	Air supply	Mounting	Typical application
Mini-split	small – large	Direct	Wall	Residential
Window	very small – small	Direct	Window	Residential
Portable	very small – small	Direct / Ducted	Floor	Residential, remote areas
Ducted (individual)	small – very large	Ducted	Ceiling	Residential, commercial
Ducted (central)	medium – very large	Ducted	Ceiling	Residential, commercial
Ceiling suspended	medium – large	Direct	Ceiling	Commercial
Cassette	medium – large	Direct / Ducted	Ceiling	Commercial
Floor standing	medium – large	Direct / Ducted	Floor	Commercial
Packaged	very large	Direct / Ducted	Floor	Commercial
Packaged RTU (Rooftop Unit)	very large	Ducted	Rooftop	Commercial

* where the typical capacity is in kilowatt as follows:

- very small: <1.5 kW
- small: 1.5–3.5 kW
- medium: 4.2–7.1 kW
- large: 7.2–14 kW
- very large: >14 kW

Mini-split and multi-split systems

[edit]



Evaporator, indoor unit, or terminal, side of a ductless split-type air conditioner

Ductless systems (often mini-split, though there are now ducted mini-split) typically supply conditioned and heated air to a single or a few rooms of a building, without ducts and in a decentralized manner.[63] Multi-zone or multi-split systems are a common application of ductless systems and allow up to eight rooms (zones or locations) to be conditioned independently from each other, each with its indoor unit and simultaneously from a single outdoor unit.

The first mini-split system was sold in 1961 by Toshiba in Japan, and the first wall-mounted mini-split air conditioner was sold in 1968 in Japan by Mitsubishi Electric, where small home sizes motivated their development. The Mitsubishi model was the first air conditioner with a cross-flow fan.[64][65][66] In 1969, the first mini-split air conditioner was sold in the US.[67] Multi-zone ductless systems were invented by Daikin in 1973, and variable refrigerant flow systems (which can be thought of as larger multi-split systems) were also invented by Daikin in 1982. Both were first sold in Japan.[68] Variable refrigerant flow systems when compared with central plant cooling from an air handler, eliminate the need for large cool air ducts, air handlers, and chillers; instead cool refrigerant is transported through much smaller pipes to the indoor units in the spaces to be conditioned, thus allowing for less space above dropped ceilings and a lower structural impact, while also allowing for more individual and independent temperature control of spaces. The outdoor and indoor units can be spread across the building.[69] Variable refrigerant flow indoor units can also be turned off individually in unused spaces.[*citation needed*] The lower start-up power of VRF's DC inverter compressors and their inherent DC power requirements also allow VRF solar-powered heat pumps to be run using DC-providing solar panels.

Ducted central systems

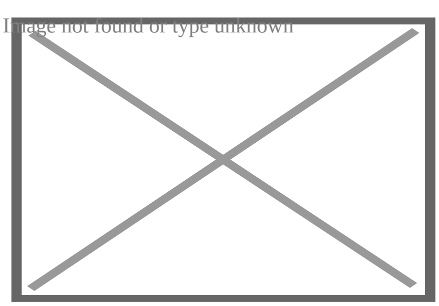
[edit]

Split-system central air conditioners consist of two heat exchangers, an outside unit (the condenser) from which heat is rejected to the environment and an internal heat exchanger (the evaporator, or Fan Coil Unit, FCU) with the piped refrigerant being circulated between the two. The FCU is then connected to the spaces to be cooled by ventilation ducts.[70] Floor standing air conditioners are similar to this type of air conditioner but sit within spaces that need cooling.

Central plant cooling

[edit]

See also: Chiller



Industrial air conditioners on top of the shopping mall *Passage* in Linz, Austria

Large central cooling plants may use intermediate coolant such as chilled water pumped into air handlers or fan coil units near or in the spaces to be cooled which then duct or deliver cold air into the spaces to be conditioned, rather than ducting cold air directly to these spaces from the plant, which is not done due to the low density and heat capacity of air, which would require impractically large ducts. The chilled water is cooled by chillers in the plant, which uses a refrigeration cycle to cool water, often transferring its heat to the atmosphere even in liquid-cooled chillers through the use of cooling towers. Chillers may be air- or liquid-cooled.[71][72]

Portable units

[edit]

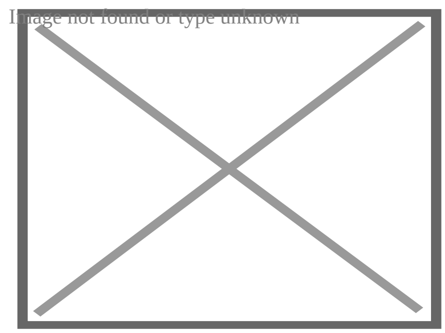
A portable system has an indoor unit on wheels connected to an outdoor unit via flexible pipes, similar to a permanently fixed installed unit (such as a ductless split air conditioner).

Hose systems, which can be *monoblock* or *air-to-air*, are vented to the outside via air ducts. The *monoblock* type collects the water in a bucket or tray and stops when full. The *air-to-air* type re-evaporates the water, discharges it through the ducted hose, and can run continuously. Many but not all portable units draw indoor air and expel it outdoors through a single duct, negatively impacting their overall cooling efficiency.

Many portable air conditioners come with heat as well as a dehumidification function.[73]

Window unit and packaged terminal

[edit]



Through-the-wall PTAC units, University Motor Inn, Philadelphia

Main article: Packaged terminal air conditioner

The packaged terminal air conditioner (PTAC), through-the-wall, and window air conditioners are similar. These units are installed on a window frame or on a wall opening. The unit usually has an internal partition separating its indoor and outdoor sides, which contain the unit's condenser and evaporator, respectively. PTAC systems may be adapted to provide heating in cold weather, either directly by using an electric strip, gas, or other heaters, or by reversing the refrigerant flow to heat the interior and draw heat from the exterior air, converting the air conditioner into a heat pump. They may be installed in a wall opening with the help of a special sleeve on the wall and a custom grill that is flush with the wall and window air conditioners can also be installed in a window, but without a custom grill.[74]

Packaged air conditioner

[edit]

Packaged air conditioners (also known as self-contained units)[75][76] are central systems that integrate into a single housing all the components of a split central system, and deliver air, possibly through ducts, to the spaces to be cooled. Depending on their construction they may be outdoors or indoors, on roofs (rooftop units),[77][78] draw the air to be conditioned from inside or outside a building and be water or air-cooled. Often, outdoor units are air-cooled while indoor units are liquid-cooled using a cooling tower.[70][79][80][81][82][83]

Types of compressors

[edit]

Compressor types	Common applications	Typical capacity	Efficiency	Durability	Repairability
Reciprocating	Refrigerator, Walk-in freezer, portable air conditioners	small – large	very low (small capacity) medium (large capacity)	very low	medium
Rotary vane	Residential mini splits	small	low	low	easy
Scroll	Commercial and central systems, VRF	medium	medium	medium	easy
Rotary screw	Commercial chiller	medium – large	medium	medium	hard
Centrifugal	Commercial chiller	very large	medium	high	hard

Maglev Centrifugal	Commercial chiller	very large	high	very high	very hard

Reciprocating

[edit]

Main article: Reciprocating compressor

This compressor consists of a crankcase, crankshaft, piston rod, piston, piston ring, cylinder head and valves. [*citation needed*]

Scroll

[edit]

Main article: Scroll compressor

This compressor uses two interleaving scrolls to compress the refrigerant.[84] it consists of one fixed and one orbiting scrolls. This type of compressor is more efficient because it has 70 percent less moving parts than a reciprocating compressor. [*citation needed*]

Screw

[edit]

Main article: Rotary-screw compressor

This compressor use two very closely meshing spiral rotors to compress the gas. The gas enters at the suction side and moves through the threads as the screws rotate. The meshing rotors force the gas through the compressor, and the gas exits at the end of the screws. The working area is the inter-lobe volume between the male and female rotors. It is larger at the intake end, and decreases along the length of the rotors until the exhaust port. This change in volume is the compression. [*citation needed*]

Capacity modulation technologies

[edit]

There are several ways to modulate the cooling capacity in refrigeration or air conditioning and heating systems. The most common in air conditioning are: on-off cycling, hot gas bypass, use or not of liquid injection, manifold configurations of multiple compressors, mechanical modulation (also called digital), and inverter technology. [*citation needed*]

Hot gas bypass

[edit]

Hot gas bypass involves injecting a quantity of gas from discharge to the suction side. The compressor will keep operating at the same speed, but due to the bypass, the refrigerant mass flow circulating with the system is reduced, and thus the cooling capacity. This naturally causes the compressor to run uselessly during the periods when the bypass is operating. The turn down capacity varies between 0 and 100%.[85]

Manifold configurations

[edit]

Several compressors can be installed in the system to provide the peak cooling capacity. Each compressor can run or not in order to stage the cooling capacity of the unit. The turn down capacity is either 0/33/66 or 100% for a trio configuration and either 0/50 or 100% for a tandem.[*citation needed*]

Mechanically modulated compressor

[edit]

This internal mechanical capacity modulation is based on periodic compression process with a control valve, the two scroll set move apart stopping the compression for a given time period. This method varies refrigerant flow by changing the average time of compression, but not the actual speed of the motor. Despite an excellent turndown ratio – from 10 to 100% of the cooling capacity, mechanically modulated scrolls have high energy consumption as the motor continuously runs.[*citation needed*]

Variable-speed compressor

[edit]

Main article: Inverter compressor

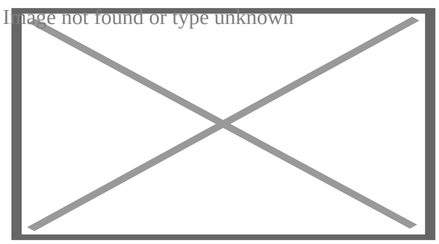
This system uses a variable-frequency drive (also called an Inverter) to control the speed of the compressor. The refrigerant flow rate is changed by the change in the speed of the compressor. The turn down ratio depends on the system configuration and manufacturer. It modulates from 15 or 25% up to 100% at full capacity with a single inverter from 12 to 100% with a hybrid tandem. This method is the most efficient way to modulate an air conditioner's capacity. It is up to 58% more efficient than a fixed speed system.[*citation needed*]

Impact

[edit]

Health effects

[edit]



Rooftop condenser unit fitted on top of an Osaka Municipal Subway 10 series subway carriage. Air conditioning has become increasingly prevalent on public transport vehicles as a form of climate control, and to ensure passenger comfort and drivers' occupational safety and health.

In hot weather, air conditioning can prevent heat stroke, dehydration due to excessive sweating, electrolyte imbalance, kidney failure, and other issues due to hyperthermia.[8][86] Heat waves are the most lethal type of weather phenomenon in the United States.[87][88] A 2020 study found that areas with lower use of air conditioning correlated with higher rates of heat-related mortality and hospitalizations.[89] The August 2003 France heatwave resulted in approximately 15,000 deaths, where 80% of the victims were over 75 years old. In response, the French government required all retirement homes to have at least one air-conditioned room at 25 °C (77 °F) per floor during heatwaves.[8]

Air conditioning (including filtration, humidification, cooling and disinfection) can be used to provide a clean, safe, hypoallergenic atmosphere in hospital operating rooms and other environments where proper atmosphere is critical to patient safety and well-being. It is sometimes recommended for home use by people with allergies, especially mold.[90][91] However, poorly maintained water cooling towers can promote the growth and spread of microorganisms such as *Legionella pneumophila*, the infectious agent responsible for Legionnaires' disease. As long as the cooling tower is kept clean (usually by means of a chlorine treatment), these health hazards can be avoided or reduced. The state of New York has codified requirements for registration, maintenance, and testing of cooling towers to protect against Legionella.[92]

Economic effects

[edit]

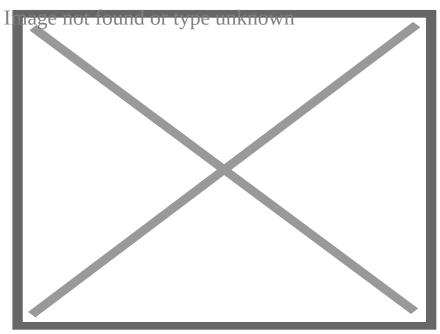
First designed to benefit targeted industries such as the press as well as large factories, the invention quickly spread to public agencies and administrations with studies with claims of increased productivity close to 24% in places equipped with air conditioning.[93]

Air conditioning caused various shifts in demography, notably that of the United States starting from the 1970s. In the US, the birth rate was lower in the spring than during other seasons until the 1970s but this difference then declined since then.[94] As of 2007, the Sun Belt contained 30% of the total US population while it was inhabited by 24% of Americans at the beginning of the 20th century.[95] Moreover, the summer mortality rate in the US, which had been higher in regions subject to a heat wave during the summer, also evened out.[7]

The spread of the use of air conditioning acts as a main driver for the growth of global demand of electricity.[96] According to a 2018 report from the International Energy Agency (IEA), it was revealed that the energy consumption for cooling in the United States, involving 328 million Americans, surpasses the combined energy consumption of 4.4 billion people in Africa, Latin America, the Middle East, and Asia (excluding China).[8] A 2020 survey found that an estimated 88% of all US households use AC, increasing to 93% when solely looking at homes built between 2010 and 2020.[97]

Environmental effects

[edit]



Air conditioner farm in the facade of a building in Singapore

Space cooling including air conditioning accounted globally for 2021 terawatt-hours of energy usage in 2016 with around 99% in the form of electricity, according to a 2018 report on air-conditioning efficiency by the International Energy Agency.[8] The report predicts an increase of electricity usage due to space cooling to around 6200 TWh by 2050,[8][98] and that with the progress currently seen, greenhouse gas emissions attributable to space cooling will double: 1,135 million tons (2016) to 2,070 million tons.[8] There is some push to increase the energy efficiency of air conditioners. United Nations Environment Programme (UNEP) and the IEA found that if air conditioners could be twice as effective as now, 460 billion tons of GHG could be cut over 40 years.[99] The UNEP and IEA also recommended legislation to decrease the use of hydrofluorocarbons, better building insulation, and more sustainable temperature-controlled food supply chains going forward.[99]

Refrigerants have also caused and continue to cause serious environmental issues, including ozone depletion and climate change, as several countries have not yet ratified the Kigali Amendment to reduce the consumption and production of hydrofluorocarbons.[100] CFCs and HCFCs refrigerants such as R-12 and R-22, respectively, used within air conditioners have caused damage to the ozone layer,[101] and hydrofluorocarbon refrigerants such as R-410A and R-404A, which were designed to replace CFCs and HCFCs, are instead exacerbating climate change.[102] Both issues happen due to the venting of refrigerant to the atmosphere, such as during repairs. HFO refrigerants, used in some if not most new equipment, solve both issues with an ozone damage potential (ODP) of zero and a much lower global warming potential (GWP) in the single or double digits vs. the three or four digits of hydrofluorocarbons.[103]

Hydrofluorocarbons would have raised global temperatures by around 0.3–0.5 °C (0.5–0.9 °F) by 2100 without the Kigali Amendment. With the Kigali Amendment, the increase of global temperatures by 2100 due to hydrofluorocarbons is predicted to be around 0.06 °C (0.1 °F).[104]

Alternatives to continual air conditioning include passive cooling, passive solar cooling, natural ventilation, operating shades to reduce solar gain, using trees, architectural shades, windows (and using window coatings) to reduce solar gain.[*citation ne*

Social effects

[edit]

Socioeconomic groups with a household income below around $10,000 tend to have a low air conditioning adoption,[42] which worsens heat-related mortality.[7] The lack of cooling can be hazardous, as areas with lower use of air conditioning correlate with higher rates of heat-related mortality and hospitalizations.[89] Premature mortality in NYC is projected to grow between 47% and 95% in 30 years, with lower-income and vulnerable populations most at risk.[89] Studies on the correlation between heat-related mortality and hospitalizations and living in low socioeconomic locations can be traced in Phoenix, Arizona,[105] Hong Kong,[106] China,[106] Japan,[107] and Italy.[108][109] Additionally, costs concerning health care can act as another barrier, as the lack of private health insurance during a 2009 heat wave in Australia, was associated with heat-related hospitalization.[109]

Disparities in socioeconomic status and access to air conditioning are connected by some to institutionalized racism, which leads to the association of specific marginalized communities with lower economic status, poorer health, residing in hotter neighborhoods, engaging in physically demanding labor, and experiencing limited access to cooling technologies such as air conditioning.[109] A study overlooking Chicago, Illinois, Detroit, and Michigan found that black households were half as likely to have central air conditioning units when compared to their white counterparts.[110] Especially in cities, Redlining creates heat islands, increasing temperatures in certain parts of the city.[109] This is due to materials heat-absorbing building materials and pavements and lack of vegetation and shade coverage.[111] There have been initiatives that provide cooling solutions to low-income communities, such as public cooling spaces.[8][111]

Other techniques

[edit]

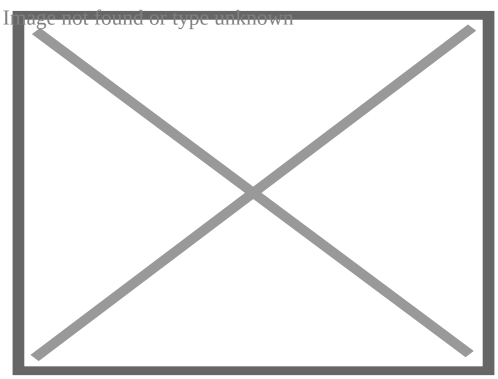
Buildings designed with passive air conditioning are generally less expensive to construct and maintain than buildings with conventional HVAC systems with lower energy demands.[112] While tens of air changes per hour, and cooling of tens of degrees, can be achieved with passive methods, site-specific microclimate must be taken into account, complicating building design.[12]

Many techniques can be used to increase comfort and reduce the temperature in buildings. These include evaporative cooling, selective shading, wind, thermal convection, and heat storage.[113]

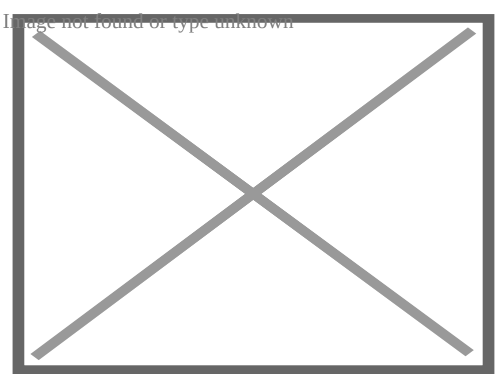
Passive ventilation

[edit]

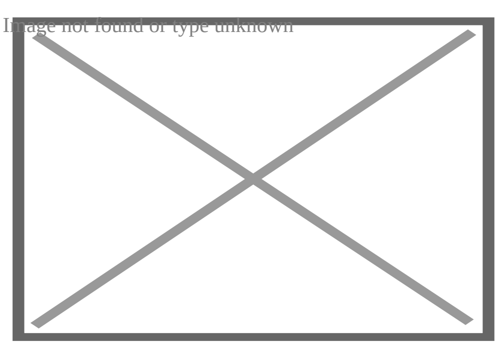
This section is an excerpt from Passive ventilation.[edit]



The ventilation system of a regular earthship



Dogtrot houses are designed to maximise natural ventilation.



A roof turbine ventilator, colloquially known as a 'Whirly Bird' is an application of wind driven ventilation.

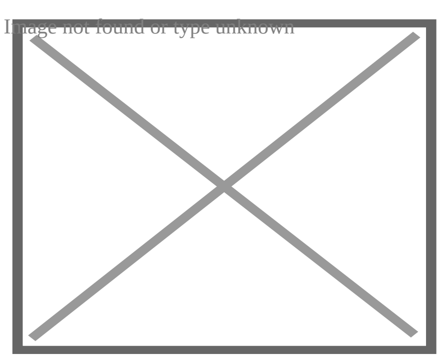
Passive ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces.

There are two types of natural ventilation occurring in buildings: *wind driven ventilation* and *buoyancy-driven ventilation*. Wind driven ventilation arises from the different pressures created by wind around a building or structure, and openings being formed on the perimeter which then permit flow through the building. Buoyancy-driven ventilation occurs as a result of the directional buoyancy force that results from temperature differences between the interior and exterior.[114] Since the internal heat gains which create temperature differences between the interior and exterior are created by natural processes, including the heat from people, and wind effects are variable, naturally ventilated buildings are sometimes called "breathing buildings".

Passive cooling

[edit]

This section is an excerpt from Passive cooling.[edit]



A traditional Iranian solar cooling design using a wind tower

Passive cooling is a building design approach that focuses on heat gain control and heat dissipation in a building in order to improve the indoor thermal comfort with low or no energy consumption.[115][116] This approach works either by preventing heat from entering the interior (heat gain prevention) or by removing heat from the building (natural cooling).[117]

Natural cooling utilizes on-site energy, available from the natural environment, combined with the architectural design of building components (e.g. building envelope), rather than mechanical systems to dissipate heat.[118] Therefore, natural cooling depends not only on the architectural design of the building but on how the site's natural resources are used as heat sinks (i.e. everything that absorbs or dissipates heat). Examples of on-site heat sinks are the upper atmosphere (night sky), the outdoor air (wind), and the earth/soil.

Passive cooling is an important tool for design of buildings for climate change adaptation – reducing dependency on energy-intensive air conditioning in warming environments.[119][120]

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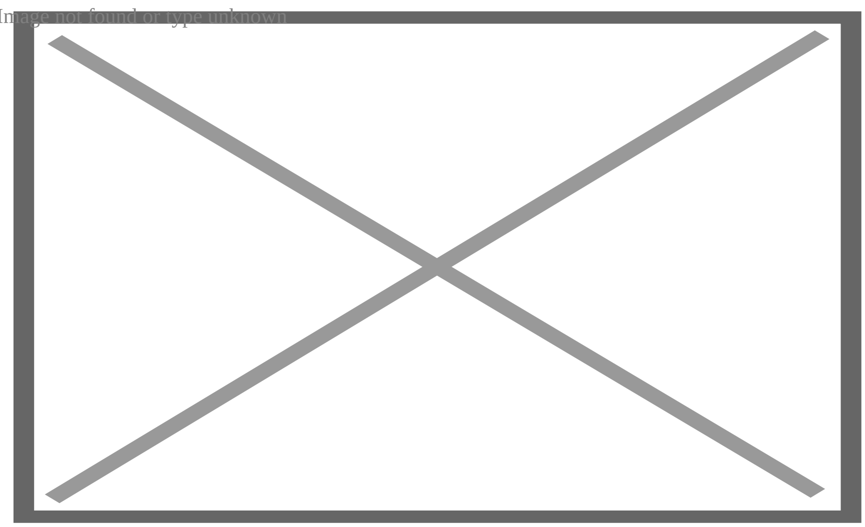
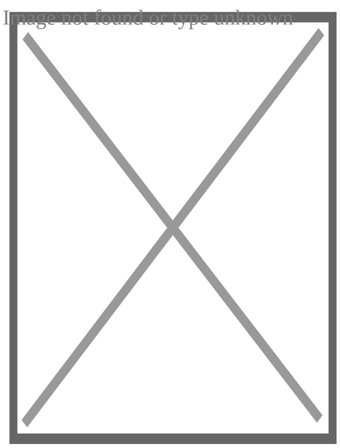


A pair of short windcatchers (*malqaf*) used in traditional architecture; wind is forced down on the windward side and leaves on the leeward side (*cross-ventilation*). In the absence of wind, the circulation can be driven with evaporative cooling in the inlet (which is also designed to catch dust). In the center, a *shuksheika* (roof lantern vent), used to shade the qa'a below while allowing hot air rise out of it (*stack effect*).[11]

Daytime radiative cooling

[edit]



Passive daytime radiative cooling (PDRC) surfaces are high in solar reflectance and heat emittance, cooling with zero energy use or pollution.[121]

Passive daytime radiative cooling (PDRC) surfaces reflect incoming solar radiation and heat back into outer space through the infrared window for cooling during the daytime. Daytime radiative cooling became possible with the ability to suppress solar heating using photonic structures, which emerged through a study by Raman et al. (2014).[122] PDRCs can come in a variety of forms, including paint coatings and films, that are designed to be high in solar reflectance and thermal emittance.[121][123]

PDRC applications on building roofs and envelopes have demonstrated significant decreases in energy consumption and costs.[123] In suburban single-family residential areas, PDRC application on roofs can potentially lower energy costs by 26% to 46%.[124] PDRCs are predicted to show a market size of ~$27 billion for indoor space cooling by 2025 and have undergone a surge in research and development since the 2010s.[125][126]

Fans

[edit]
Main article: Ceiling fan

Hand fans have existed since prehistory. Large human-powered fans built into buildings include the punkah.

The 2nd-century Chinese inventor Ding Huan of the Han dynasty invented a rotary fan for air conditioning, with seven wheels 3 m (10 ft) in diameter and manually powered by prisoners.[127]
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In 747, Emperor Xuanzong (r. 712–762) of the Tang dynasty (618–907) had the Cool Hall (*Liang Dian*
ÃƒÆ’Ã¢â‚¬Å¡Ã‚Â Ã¢â€šÂ¬Ã¢â€žÂ¢ÃƒÆ’Ã¢â€šÂ¬Ã‚Â Ã¢Ã¢â€šÂ¬Ã‚Â¬Ã¢â€šÂ¢ÃƒÆ’Ã¢â‚¬Å¡Ã‚Â¢Ã¢â€šÂ¬
) built in the imperial palace, which the *Tang Yulin* describes as having water-powered fan wheels for air conditioning as well as rising jet streams of water from fountains. During the subsequent Song dynasty (960–1279), written sources mentioned the air conditioning rotary fan as even more widely used.[127]
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Thermal buffering

[edit]

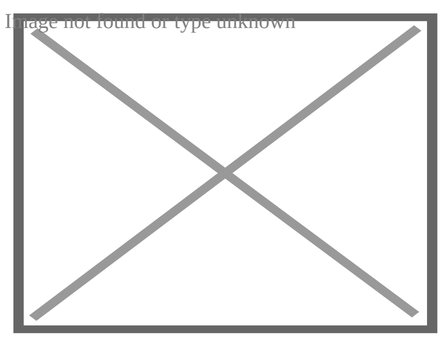
In areas that are cold at night or in winter, heat storage is used. Heat may be stored in earth or masonry; air is drawn past the masonry to heat or cool it.[13]

In areas that are below freezing at night in winter, snow and ice can be collected and stored in ice houses for later use in cooling.[13] This technique is over 3,700 years old in the Middle East.[128] Harvesting outdoor ice during winter and transporting and storing for use in summer was practiced by wealthy Europeans in the early 1600s,[15] and became popular in Europe and the Americas towards the end of the 1600s.[129] This practice was replaced by mechanical compression-cycle icemakers.

Evaporative cooling

[edit]

Main article: Evaporative cooler



An evaporative cooler

In dry, hot climates, the evaporative cooling effect may be used by placing water at the air intake, such that the draft draws air over water and then into the house. For this reason, it is sometimes said that the fountain, in the architecture of hot, arid climates, is like the fireplace in the architecture of cold climates.[11] Evaporative cooling also makes the air more humid, which can be beneficial in a dry desert climate.[130]

Evaporative coolers tend to feel as if they are not working during times of high humidity, when there is not much dry air with which the coolers can work to make the air as cool as possible for dwelling occupants. Unlike other types of air conditioners, evaporative coolers rely on the outside air to be channeled through cooler pads that cool the air before it reaches the inside of a house through its air duct system; this cooled outside air must be allowed to push the warmer air within the house out through an exhaust opening such as an open door or window.[131]

See also

[edit]

- Air filter
- Air purifier
- Cleanroom
- Crankcase heater
- Energy recovery ventilation
- Indoor air quality
- Particulates

References

[edit]

1. **^** *"Air Con". Cambridge Dictionary. Archived from the original on May 3, 2022. Retrieved January 6, 2023.*
2. **^** *Dissertation Abstracts International: The humanities and social sciences. A. University Microfilms. 2005. p. 3600.*
3. **^** *1993 ASHRAE Handbook: Fundamentals. ASHRAE. 1993. ISBN 978-0-910110-97-6.*
4. **^** *Enteria, Napoleon; Sawachi, Takao; Saito, Kiyoshi (January 31, 2023). Variable Refrigerant Flow Systems: Advances and Applications of VRF. Springer Nature. p. 46. ISBN 978-981-19-6833-4.*
5. **^** *Agencies, United States Congress House Committee on Appropriations Subcommittee on Dept of the Interior and Related (1988). Department of the Interior and Related Agencies Appropriations for 1989: Testimony of public witnesses, energy programs, Institute of Museum Services, National Endowment for the Arts, National Endowment for the Humanities. U.S. Government Printing Office. p. 629.*
6. **^** *"Earth Tubes: Providing the freshest possible air to your building". Earth Rangers Centre for Sustainable Technology Showcase. Archived from the*

original on January 28, 2021. Retrieved May 12, 2021.

7. ^ ***a b c*** *Barreca, Alan; Clay, Karen; Deschenes, Olivier; Greenstone, Michael; Shapiro, Joseph S. (February 2016). "Adapting to Climate Change: The Remarkable Decline in the US Temperature-Mortality Relationship over the Twentieth Century". Journal of Political Economy.* ***124*** *(1): 105–159. doi:10.1086/684582.*
8. ^ ***a b c d e f g h i j*** *International Energy Agency (May 15, 2018). The Future of Cooling - Opportunities for energy-efficient air conditioning (PDF) (Report). Archived (PDF) from the original on June 26, 2024. Retrieved July 1, 2024.*
9. **^** *Laub, Julian M. (1963). Air Conditioning & Heating Practice. Holt, Rinehart and Winston. p. 367. ISBN 978-0-03-011225-6.*
10. **^** *"Air-conditioning found at 'oldest city in the world'". The Independent. June 24, 2000. Archived from the original on December 8, 2023. Retrieved December 9, 2023.*
11. ^ ***a b c*** *Mohamed, Mady A.A. (January 2010). Lehmann, S.; Waer, H.A.; Al-Qawasmi, J. (eds.). Traditional Ways of Dealing with Climate in Egypt. The Seventh International Conference of Sustainable Architecture and Urban Development (SAUD 2010). Amman, Jordan: The Center for the Study of Architecture in Arab Region (CSAAR Press). pp. 247–266. Archived from the original on May 13, 2021. Retrieved May 12, 2021.*
12. ^ ***a b c*** *Ford, Brian (September 2001). "Passive downdraught evaporative cooling: principles and practice". Architectural Research Quarterly.* ***5*** *(3): 271–280. doi:10.1017/S1359135501001312.*
13. ^ ***a b c*** *Attia, Shady; Herde, André de (June 22–24, 2009). Designing the Malqaf for Summer Cooling in Low-Rise Housing, an Experimental Study. 26th Conference on Passive and Low Energy Architecture (PLEA2009). Quebec City. Archived from the original on May 13, 2021. Retrieved May 12, 2021.*
14. **^** *US EPA, OAR (October 17, 2014). "Heating, Ventilation and Air-Conditioning Systems, Part of Indoor Air Quality Design Tools for Schools". epa.gov. Archived from the original on July 5, 2022. Retrieved July 5, 2022.*
15. ^ ***a b c*** *Shachtman, Tom (1999). "Winter in Summer". Absolute zero and the conquest of cold. Boston: Houghton Mifflin Harcourt. ISBN 978-0395938881. OCLC 421754998. Archived from the original on May 13, 2021. Retrieved May 12, 2021.*
16. **^** *Porta, Giambattista Della (1584). Magiae naturalis (PDF). London. LCCN 09023451. Archived (PDF) from the original on May 13, 2021. Retrieved May 12, 2021. "In our method I shall observe what our ancestors have said; then I shall show by my own experience, whether they be true or false"*

17. **^** *Beck, Leonard D. (October 1974). "Things Magical in the collections of the Rare Book and Special Collections Division" (PDF). Library of Congress Quarterly Journal.* ***31****: 208–234. Archived (PDF) from the original on March 24, 2021. Retrieved May 12, 2021.*
18. **^** *Laszlo, Pierre (2001). Salt: Grain of Life. Columbia University Press. p. 117. ISBN 978-0231121989. OCLC 785781471. "Cornelius Drebbel air conditioning."*
19. **^** *Franklin, Benjamin (June 17, 1758). "Archived copy". Letter to John Lining. Archived from the original on February 25, 2021. Retrieved May 12, 2021.*cite press release: CS1 maint: archived copy as title (link)
20. ^ ***a b c d*** *Green, Amanda (January 1, 2015). "The Cool History of the Air Conditioner". Popular Mechanics. Archived from the original on April 10, 2021. Retrieved May 12, 2021.*
21. **^** *"John Gorrie". Encyclopædia Britannica. September 29, 2020. Archived from the original on March 13, 2021. Retrieved May 12, 2021.*
22. **^** Gorrie, John "Improved process for the artificial production of ice" U.S. Patent no. 8080 (Issued: May 6, 1851).
23. **^** *Wright, E. Lynne (2009). It Happened in Florida: Remarkable Events That Shaped History. Rowman & Littlefield. pp. 13–. ISBN 978-0762761692.*
24. ^ ***a b*** *Bruce-Wallace, L. G. (1966). "Harrison, James (1816–1893)". Australian Dictionary of Biography. Vol. 1. Canberra: National Centre of Biography, Australian National University. ISBN 978-0-522-84459-7. ISSN 1833-7538. OCLC 70677943. Retrieved May 12, 2021.*
25. **^** *Palermo, Elizabeth (May 1, 2014). "Who Invented Air Conditioning?". livescience.com. Archived from the original on January 16, 2021. Retrieved May 12, 2021.*
26. **^** *Varrasi, John (June 6, 2011). "Global Cooling: The History of Air Conditioning". American Society of Mechanical Engineers. Archived from the original on March 8, 2021. Retrieved May 12, 2021.*
27. **^** *Simha, R. V. (February 2012). "Willis H Carrier". Resonance.* ***17*** *(2): 117–138. doi:10.1007/s12045-012-0014-y. ISSN 0971-8044. S2CID 116582893.*
28. **^** *Gulledge III, Charles; Knight, Dennis (February 11, 2016). "Heating, Ventilating, Air-Conditioning, And Refrigerating Engineering". National Institute of Building Sciences. Archived from the original on April 20, 2021. Retrieved May 12, 2021. " Though he did not actually invent air-conditioning nor did he take the first documented scientific approach to applying it, Willis Carrier is credited with integrating the scientific method, engineering, and business of this developing technology and creating the industry we know today as air-conditioning."*

29. ^ *"Willis Carrier – 1876–1902". Carrier Global. Archived from the original on February 27, 2021. Retrieved May 12, 2021.*
30. ^ *"Carrier Reports First Quarter 2020 Earnings". Carrier Global (Press release). May 8, 2020. Archived from the original on January 24, 2021. Retrieved May 12, 2021.*
31. ^ *"Carrier Becomes Independent, Publicly Traded Company, Begins Trading on New York Stock Exchange". Carrier Global (Press release). April 3, 2020. Archived from the original on February 25, 2021. Retrieved May 12, 2021.*
32. ^ Cramer, Stuart W. "Humidifying and air conditioning apparatus" U.S. Patent no. 852,823 (filed: April 18, 1906; issued: May 7, 1907).
    - See also: Cramer, Stuart W. (1906) "Recent development in air conditioning" in: *Proceedings of the Tenth Annual Convention of the American Cotton Manufacturers Association Held at Asheville, North Carolina May 16–17, 1906*. Charlotte, North Carolina, USA: Queen City Publishing Co. pp. 182–211.
33. ^ US patent US808897A, Carrier, Willis H., "Apparatus for treating air", published January 2, 1906, issued January 2, 1906 and Buffalo Forge Company *"Archived copy" (PDF). Archived from the original on December 5, 2019. Retrieved May 12, 2021.*cite web: CS1 maint: archived copy as title (link) CS1 maint: bot: original URL status unknown (link)
34. ^ *"First Air-Conditioned Auto". Popular Science. Vol. 123, no. 5. November 1933. p. 30. ISSN 0161-7370. Archived from the original on April 26, 2021. Retrieved May 12, 2021.*
35. ^ *"Room-size air conditioner fits under window sill". Popular Mechanics. Vol. 63, no. 6. June 1935. p. 885. ISSN 0032-4558. Archived from the original on November 22, 2016. Retrieved May 12, 2021.*
36. ^ *"Michigan Fast Facts and Trivia". 50states.com. Archived from the original on June 18, 2017. Retrieved May 12, 2021.*
37. ^ US patent US2433960A, Sherman, Robert S., "Air conditioning apparatus", published January 6, 1948, issued January 6, 1948
38. ^ *"IEEE milestones (39) Inverter Air Conditioners, 1980–1981" (PDF). March 2021. Archived (PDF) from the original on January 21, 2024. Retrieved February 9, 2024.*
39. ^ *"Inverter Air Conditioners, 1980–1981 IEEE Milestone Celebration Ceremony" (PDF). March 16, 2021. Archived (PDF) from the original on January 21, 2024. Retrieved February 9, 2024.*

40. **^** *Seale, Avrel (August 7, 2023). "Texas alumnus and his alma mater central to air-conditioned homes". UT News. Retrieved November 13, 2024.*
41. **^** *"Air Conditioned Village". Atlas Obscura. Retrieved November 13, 2024.*
42. ^ ***a b c*** *Davis, Lucas; Gertler, Paul; Jarvis, Stephen; Wolfram, Catherine (July 2021). "Air conditioning and global inequality". Global Environmental Change.* ***69****: 102299. Bibcode:2021GEC....6902299D. doi:10.1016/j.gloenvcha.2021.102299.*
43. **^** *Pierre-Louis, Kendra (May 15, 2018). "The World Wants Air-Conditioning. That Could Warm the World". The New York Times. Archived from the original on February 16, 2021. Retrieved May 12, 2021.*
44. **^** *Carroll, Rory (October 26, 2015). "How America became addicted to air conditioning". The Guardian. Los Angeles. Archived from the original on March 13, 2021. Retrieved May 12, 2021.*
45. **^** *Lester, Paul (July 20, 2015). "History of Air Conditioning". United States Department of Energy. Archived from the original on June 5, 2020. Retrieved May 12, 2021.*
46. **^** *Cornish, Cheryl; Cooper, Stephen; Jenkins, Salima. Characteristics of New Housing (Report). United States Census Bureau. Archived from the original on April 11, 2021. Retrieved May 12, 2021.*
47. **^** *"Central Air Conditioning Buying Guide". Consumer Reports. March 3, 2021. Archived from the original on May 9, 2021. Retrieved May 12, 2021.*
48. **^** *Petchers, Neil (2003). Combined Heating, Cooling & Power Handbook: Technologies & Applications : an Integrated Approach to Energy Resource Optimization. The Fairmont Press. p. 737. ISBN 978-0-88173-433-1.*
49. **^** *Krarti, Moncef (December 1, 2020). Energy Audit of Building Systems: An Engineering Approach, Third Edition. CRC Press. p. 370. ISBN 978-1-000-25967-4.*
50. **^** *"What is a Reversing Valve". Samsung India. Archived from the original on February 22, 2019. Retrieved May 12, 2021.*
51. **^** *"Humidity and Comfort" (PDF). DriSteem. Archived from the original (PDF) on May 16, 2018. Retrieved May 12, 2021.*
52. **^** *Perryman, Oliver (April 19, 2021). "Dehumidifier vs Air Conditioning". Dehumidifier Critic. Archived from the original on May 13, 2021. Retrieved May 12, 2021.*
53. **^** *Snijders, Aart L. (July 30, 2008). "Aquifer Thermal Energy Storage (ATES) Technology Development and Major Applications in Europe" (PDF). Toronto and Region Conservation Authority. Arnhem: IFTech International. Archived (PDF) from the original on March 8, 2021. Retrieved May 12, 2021.*

54. ^ ***a*** ***b*** *"Cold Climate Air Source Heat Pump" (PDF). Minnesota Department of Commerce, Division of Energy Resources. Archived (PDF) from the original on January 2, 2022. Retrieved March 29, 2022.*
55. **^** *"Even in Frigid Temperatures, Air-Source Heat Pumps Keep Homes Warm From Alaska Coast to U.S. Mass Market". nrel.gov. Archived from the original on April 10, 2022. Retrieved March 29, 2022.*
56. **^** *"Heat Pumps: A Practical Solution for Cold Climates". RMI. December 10, 2020. Archived from the original on March 31, 2022. Retrieved March 28, 2022.*
57. **^** *"TEM Instruction Sheet" (PDF). TE Technology. March 14, 2012. Archived from the original (PDF) on January 24, 2013. Retrieved May 12, 2021.*
58. **^** *"Coefficient of Performance (COP) heat pumps". Grundfos. November 18, 2020. Archived from the original on May 3, 2021. Retrieved May 12, 2021.*
59. **^** *"Unpotted HP-199-1.4-0.8 at a hot-side temperature of 25 °C" (PDF). TE Technology. Archived from the original (PDF) on January 7, 2009. Retrieved February 9, 2024.*
60. **^** *Newell, David B.; Tiesinga, Eite, eds. (August 2019). The International System of Units (SI) (PDF). National Institute of Standards and Technology. doi: 10.6028/NIST.SP.330-2019. Archived (PDF) from the original on April 22, 2021. Retrieved May 13, 2021.*
61. **^** *ANSI/AHRI 210/240-2008: 2008 Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment (PDF). Air Conditioning, Heating and Refrigeration Institute. 2012. Archived from the original on March 29, 2018. Retrieved May 13, 2021.*
62. **^** *Baraniuk, Chris. "Cutting-Edge Technology Could Massively Reduce the Amount of Energy Used for Air Conditioning". Wired. ISSN 1059-1028. Retrieved July 18, 2024.*
63. **^** *"M-Series Contractor Guide" (PDF). Mitsubishipro.com. p. 19. Archived (PDF) from the original on March 18, 2021. Retrieved May 12, 2021.*
64. **^**
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shouene-kaden.net. Archived from the original on September 7, 2022. Retrieved January 21, 2024.

65. **^** *"Air conditioner | History". Toshiba Carrier. April 2016. Archived from the original on March 9, 2021. Retrieved May 12, 2021.*
66. **^** *"1920s–1970s | History". Mitsubishi Electric. Archived from the original on March 8, 2021. Retrieved May 12, 2021.*
67. **^** *Wagner, Gerry (November 30, 2021). "The Duct Free Zone: History of the Mini Split". HPAC Magazine. Retrieved February 9, 2024.*
68. **^** *"History of Daikin Innovation". Daikin. Archived from the original on June 5, 2020. Retrieved May 12, 2021.*
69. **^** *Feit, Justin (December 20, 2017). "The Emergence of VRF as a Viable HVAC Option". buildings.com. Archived from the original on December 3, 2020. Retrieved May 12, 2021.*
70. ^ ***a b*** *"Central Air Conditioning". United States Department of Energy. Archived from the original on January 30, 2021. Retrieved May 12, 2021.*
71. **^** *Kreith, Frank; Wang, Shan K.; Norton, Paul (April 20, 2018). Air Conditioning and Refrigeration Engineering. CRC Press. ISBN 978-1-351-46783-4.*
72. **^** *Wang, Shan K. (November 7, 2000). Handbook of Air Conditioning and Refrigeration. McGraw-Hill Education. ISBN 978-0-07-068167-5.*
73. **^** *Hleborodova, Veronika (August 14, 2018). "Portable Vs Split System Air Conditioning | Pros & Cons". Canstar Blue. Archived from the original on March 9, 2021. Retrieved May 12, 2021.*
74. **^** *Kamins, Toni L. (July 15, 2013). "Through-the-Wall Versus PTAC Air Conditioners: A Guide for New Yorkers". Brick Underground. Archived from the original on January 15, 2021. Retrieved May 12, 2021.*
75. **^** *"Self-Contained Air Conditioning Systems". Daikin Applied Americas. 2015. Archived from the original on October 30, 2020. Retrieved May 12, 2021.*
76. **^** *"LSWU/LSWD Vertical Water-Cooled Self-Contained Unit Engineering Guide" (PDF). Johnson Controls. April 6, 2018. Archived (PDF) from the original on May 13, 2021. Retrieved May 12, 2021.*
77. **^** *"Packaged Rooftop Unit" (PDF). Carrier Global. 2016. Archived (PDF) from the original on May 13, 2021. Retrieved May 12, 2021.*
78. **^** *"Packaged Rooftop Air Conditioners" (PDF). Trane Technologies. November 2006. Archived (PDF) from the original on May 13, 2021. Retrieved May 12, 2021*

.

79. ^ *"What is Packaged Air Conditioner? Types of Packged Air Condtioners". Bright Hub Engineering. January 13, 2010. Archived from the original on February 22, 2018. Retrieved May 12, 2021.*
80. ^ *Evans, Paul (November 11, 2018). "RTU Rooftop Units explained". The Engineering Mindset. Archived from the original on January 15, 2021. Retrieved May 12, 2021.*
81. ^ *"water-cooled – Johnson Supply". studylib.net. 2000. Archived from the original on May 13, 2021. Retrieved May 12, 2021.*
82. ^ *"Water Cooled Packaged Air Conditioners" (PDF). Japan: Daikin. May 2, 2003. Archived (PDF) from the original on June 19, 2018. Retrieved May 12, 2021.*
83. ^ *"Water Cooled Packaged Unit" (PDF). Daikin. Archived (PDF) from the original on May 13, 2021. Retrieved May 12, 2021.*
84. ^ *Lun, Y. H. Venus; Tung, S. L. Dennis (November 13, 2019). Heat Pumps for Sustainable Heating and Cooling. Springer Nature. p. 25. ISBN 978-3-030-31387-6.*
85. ^ *Ghanbariannaeeni, Ali; Ghazanfarihashemi, Ghazalehsadat (June 2012). "Bypass Method For Recip Compressor Capacity Control". Pipeline and Gas Journal.* ***239*** *(6). Archived from the original on August 12, 2014. Retrieved February 9, 2024.*
86. ^ *"Heat Stroke (Hyperthermia)". Harvard Health. January 2, 2019. Archived from the original on January 29, 2021. Retrieved May 13, 2021.*
87. ^ *"Weather Related Fatality and Injury Statistics". National Weather Service. 2021. Archived from the original on August 24, 2022. Retrieved August 24, 2022.*
88. ^ *"Extreme Weather: A Guide to Surviving Flash Floods, Tornadoes, Hurricanes, Heat Waves, Snowstorms Tsunamis and Other Natural Disasters". Reference Reviews.* ***26*** *(8): 41. October 19, 2012. doi:10.1108/09504121211278322. ISSN 0950-4125. Archived from the original on January 21, 2024. Retrieved December 9, 2023.*
89. ^ ***a b c*** *Gamarro, Harold; Ortiz, Luis; González, Jorge E. (August 1, 2020). "Adapting to Extreme Heat: Social, Atmospheric, and Infrastructure Impacts of Air-Conditioning in Megacities—The Case of New York City". ASME Journal of Engineering for Sustainable Buildings and Cities.* ***1*** *(3). doi:10.1115/1.4048175. ISSN 2642-6641. S2CID 222121944.*
90. ^ *Spiegelman, Jay; Friedman, Herman; Blumstein, George I. (September 1, 1963). "The effects of central air conditioning on pollen, mold, and bacterial concentrations". Journal of Allergy.* ***34*** *(5): 426–431. doi:10.1016/0021-8707(63)90007-8. ISSN 0021-8707. PMID 14066385.*

91. **^** *Portnoy, Jay M.; Jara, David (February 1, 2015). "Mold allergy revisited". Annals of Allergy, Asthma & Immunology.* ***114*** *(2): 83–89. doi: 10.1016/j.anai.2014.10.004. ISSN 1081-1206. PMID 25624128.*
92. **^** *"Subpart 4-1 – Cooling Towers". New York Codes, Rules and Regulations. June 7, 2016. Archived from the original on May 13, 2021. Retrieved May 13, 2021.*
93. **^** *Nordhaus, William D. (February 10, 2010). "Geography and macroeconomics: New data and new findings". Proceedings of the National Academy of Sciences.* ***103*** *(10): 3510–3517. doi:10.1073/pnas.0509842103. ISSN 0027-8424. PMC 1363683. PMID 16473945.*
94. **^** *Barreca, Alan; Deschenes, Olivier; Guldi, Melanie (2018). "Maybe next month? Temperature shocks and dynamic adjustments in birth rates". Demography.* ***55*** *(4): 1269–1293. doi:10.1007/s13524-018-0690-7. PMC 7457515. PMID 29968058.*
95. **^** *Glaeser, Edward L.; Tobio, Kristina (January 2008). "The Rise of the Sunbelt". Southern Economic Journal.* ***74*** *(3): 609–643. doi:10.1002/j.2325-8012.2008.tb00856.x.*
96. **^** *Sherman, Peter; Lin, Haiyang; McElroy, Michael (2018). "Projected global demand for air conditioning associated with extreme heat and implications for electricity grids in poorer countries". Energy and Buildings.* ***268****: 112198. doi: 10.1016/j.enbuild.2022.112198. ISSN 0378-7788. S2CID 248979815.*
97. **^** *Air Filters Used in Air Conditioning and General Ventilation Part 1: Methods of Test for Atmospheric Dust Spot Efficiency and Synthetic Dust Weight Arrestance (Withdrawn Standard). British Standards Institution. March 29, 1985. BS 6540-1:1985.*
98. **^** *Mutschler, Robin; Rüdisüli, Martin; Heer, Philipp; Eggimann, Sven (April 15, 2021). "Benchmarking cooling and heating energy demands considering climate change, population growth and cooling device uptake". Applied Energy.* ***288****: 116636. Bibcode:2021ApEn..28816636M. doi:10.1016/j.apenergy.2021.116636. ISSN 0306-2619.*
99. ^ ***a b*** *"Climate-friendly cooling could cut years of Greenhouse Gas Emissions and save US$ trillions: UN". doi:10.1163/9789004322714_cclc_2020-0252-0973.* cite journal: Cite journal requires |journal= (help)
100. **^** *Gerretsen, Isabelle (December 8, 2020). "How your fridge is heating up the planet". BBC Future. Archived from the original on May 10, 2021. Retrieved May 13, 2021.*
101. **^** *Encyclopedia of Energy: Ph-S. Elsevier. 2004. ISBN 978-0121764821.*

102. **^** *Corberan, J.M. (2016). "New trends and developments in ground-source heat pumps". Advances in Ground-Source Heat Pump Systems. pp. 359–385. doi:10.1016/B978-0-08-100311-4.00013-3. ISBN 978-0-08-100311-4.*
103. **^** *Roselli, Carlo; Sasso, Maurizio (2021). Geothermal Energy Utilization and Technologies 2020. MDPI. ISBN 978-3036507040.*
104. **^** *"Cooling Emissions and Policy Synthesis Report: Benefits of cooling efficiency and the Kigali Amendment, United Nations Environment Programme - International Energy Agency, 2020" (PDF).*
105. **^** *Harlan, Sharon L.; Declet-Barreto, Juan H.; Stefanov, William L.; Petitti, Diana B. (February 2013). "Neighborhood Effects on Heat Deaths: Social and Environmental Predictors of Vulnerability in Maricopa County, Arizona". Environmental Health Perspectives.* ***121*** *(2): 197–204. Bibcode:2013EnvHP.121..197H. doi:10.1289/ehp.1104625. ISSN 0091-6765. PMC 3569676. PMID 23164621.*
106. ^ ***a b*** *Chan, Emily Ying Yang; Goggins, William B; Kim, Jacqueline Jakyoung; Griffiths, Sian M (April 2012). "A study of intracity variation of temperature-related mortality and socioeconomic status among the Chinese population in Hong Kong". Journal of Epidemiology and Community Health.* ***66*** *(4): 322–327. doi:10.1136/jech.2008.085167. ISSN 0143-005X. PMC 3292716. PMID 20974839.*
107. **^** *Ng, Chris Fook Sheng; Ueda, Kayo; Takeuchi, Ayano; Nitta, Hiroshi; Konishi, Shoko; Bagrowicz, Rinako; Watanabe, Chiho; Takami, Akinori (2014). "Sociogeographic Variation in the Effects of Heat and Cold on Daily Mortality in Japan". Journal of Epidemiology.* ***24*** *(1): 15–24. doi:10.2188/jea.JE20130051. PMC 3872520. PMID 24317342.*
108. **^** *Stafoggia, Massimo; Forastiere, Francesco; Agostini, Daniele; Biggeri, Annibale; Bisanti, Luigi; Cadum, Ennio; Caranci, Nicola; de'Donato, Francesca; De Lisio, Sara; De Maria, Moreno; Michelozzi, Paola; Miglio, Rossella; Pandolfi, Paolo; Picciotto, Sally; Rognoni, Magda (2006). "Vulnerability to Heat-Related Mortality: A Multicity, Population-Based, Case-Crossover Analysis". Epidemiology.* ***17*** *(3): 315–323. doi:10.1097/01.ede.0000208477.36665.34. ISSN 1044-3983. JSTOR 20486220. PMID 16570026. S2CID 20283342.*
109. ^ ***a b c d*** *Gronlund, Carina J. (September 2014). "Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: a Review". Current Epidemiology Reports.* ***1*** *(3): 165–173. doi:10.1007/s40471-014-0014-4. PMC 4264980. PMID 25512891.*
110. **^** *O'Neill, M. S. (May 11, 2005). "Disparities by Race in Heat-Related Mortality in Four US Cities: The Role of Air Conditioning Prevalence". Journal of Urban Health: Bulletin of the New York Academy of Medicine.* ***82*** *(2): 191–197.*

doi:10.1093/jurban/jti043. PMC 3456567. PMID 15888640.

111. ^ ***a b*** *Sampson, Natalie R.; Gronlund, Carina J.; Buxton, Miatta A.; Catalano, Linda; White-Newsome, Jalonne L.; Conlon, Kathryn C.; O'Neill, Marie S.; McCormick, Sabrina; Parker, Edith A. (April 1, 2013). "Staying cool in a changing climate: Reaching vulnerable populations during heat events". Global Environmental Change.* ***23*** *(2): 475–484. Bibcode:2013GEC....23..475S. doi:10.1016/j.gloenvcha.2012.12.011. ISSN 0959-3780. PMC 5784212. PMID 29375195.*
112. **^** *Niktash, Amirreza; Huynh, B. Phuoc (July 2–4, 2014). Simulation and Analysis of Ventilation Flow Through a Room Caused by a Two-sided Windcatcher Using a LES Method (PDF). World Congress on Engineering. Lecture Notes in Engineering and Computer Science. Vol. 2. London. eISSN 2078-0966. ISBN 978-9881925350. ISSN 2078-0958. Archived (PDF) from the original on April 26, 2018. Retrieved May 13, 2021.*
113. **^** *Zhang, Chen; Kazanci, Ongun Berk; Levinson, Ronnen; Heiselberg, Per; Olesen, Bjarne W.; Chiesa, Giacomo; Sodagar, Behzad; Ai, Zhengtao; Selkowitz, Stephen; Zinzi, Michele; Mahdavi, Ardeshir (November 15, 2021). "Resilient cooling strategies – A critical review and qualitative assessment". Energy and Buildings.* ***251****: 111312. Bibcode:2021EneBu.25111312Z. doi:10.1016/j.enbuild.2021.111312. hdl:2117/363031. ISSN 0378-7788.*
114. **^** *Linden, P. F. (1999). "The Fluid Mechanics of Natural Ventilation". Annual Review of Fluid Mechanics.* ***31****: 201–238. Bibcode:1999AnRFM..31..201L. doi:10.1146/annurev.fluid.31.1.201.*
115. **^** *Santamouris, M.; Asimakoupolos, D. (1996). Passive cooling of buildings (1st ed.). London: James & James (Science Publishers) Ltd. ISBN 978-1-873936-47-4.*
116. **^** *Leo Samuel, D.G.; Shiva Nagendra, S.M.; Maiya, M.P. (August 2013). "Passive alternatives to mechanical air conditioning of building: A review". Building and Environment.* ***66****: 54–64. Bibcode:2013BuEnv..66...54S. doi:10.1016/j.buildenv.2013.04.016.*
117. **^** *M.j, Limb (January 1, 1998). "BIB 08: An Annotated Bibliography: Passive Cooling Technology for Office Buildings in Hot Dry and Temperate Climates".*
118. **^** *Niles, Philip; Kenneth, Haggard (1980). Passive Solar Handbook. California Energy Resources Conservation. ASIN B001UYRTMM.*
119. **^** *"Cooling: The hidden threat for climate change and sustainable goals". phys.org. Retrieved September 18, 2021.*
120. **^** *Ford, Brian (September 2001). "Passive downdraught evaporative cooling: principles and practice". Arq: Architectural Research Quarterly.* ***5*** *(3): 271–280. doi:10.1017/S1359135501001312. ISSN 1474-0516. S2CID 110209529.*

121. ^ ***a b*** *Chen, Meijie; Pang, Dan; Chen, Xingyu; Yan, Hongjie; Yang, Yuan (2022). "Passive daytime radiative cooling: Fundamentals, material designs, and applications". EcoMat.* ***4****. doi:10.1002/eom2.12153. S2CID 240331557. "Passive daytime radiative cooling (PDRC) dissipates terrestrial heat to the extremely cold outer space without using any energy input or producing pollution. It has the potential to simultaneously alleviate the two major problems of energy crisis and global warming."*
122. **^** *Raman, Aaswath P.; Anoma, Marc Abou; Zhu, Linxiao; Rephaeli, Eden; Fan, Shanhui (November 2014). "Passive radiative cooling below ambient air temperature under direct sunlight". Nature.* ***515*** *(7528): 540–544. Bibcode:2014Natur.515..540R. doi:10.1038/nature13883. PMID 25428501.*
123. ^ ***a b*** *Bijarniya, Jay Prakash; Sarkar, Jahar; Maiti, Pralay (November 2020). "Review on passive daytime radiative cooling: Fundamentals, recent researches, challenges and opportunities". Renewable and Sustainable Energy Reviews.* ***133*** *: 110263. Bibcode:2020RSERv.13310263B. doi:10.1016/j.rser.2020.110263. S2CID 224874019.*
124. **^** *Mokhtari, Reza; Ulpiani, Giulia; Ghasempour, Roghayeh (July 2022). "The Cooling Station: Combining hydronic radiant cooling and daytime radiative cooling for urban shelters". Applied Thermal Engineering.* ***211****: 118493. Bibcode:2022AppTE.21118493M. doi:10.1016/j.applthermaleng.2022.118493.*
125. **^** *Yang, Yuan; Zhang, Yifan (July 2020). "Passive daytime radiative cooling: Principle, application, and economic analysis". MRS Energy & Sustainability.* ***7*** *(1). doi:10.1557/mre.2020.18.*
126. **^** *Miranda, Nicole D.; Renaldi, Renaldi; Khosla, Radhika; McCulloch, Malcolm D. (October 2021). "Bibliometric analysis and landscape of actors in passive cooling research". Renewable and Sustainable Energy Reviews.* ***149****: 111406. Bibcode:2021RSERv.14911406M. doi:10.1016/j.rser.2021.111406.*
127. ^ ***a b*** *Needham, Joseph; Wang, Ling (1991). Science and Civilisation in China, Volume 4: Physics and Physical Technology, Part 2, Mechanical Engineering. Cambridge University Press. ISBN 978-0521058032. OCLC 468144152.*
128. **^** *Dalley, Stephanie (2002). Mari and Karana: Two Old Babylonian Cities (2nd ed.). Piscataway, New Jersey: Gorgias Press. p. 91. ISBN 978-1931956024 . OCLC 961899663. Archived from the original on January 29, 2021. Retrieved May 13, 2021.*
129. **^** *Nagengast, Bernard (February 1999). "Comfort from a Block of Ice: A History of Comfort Cooling Using Ice" (PDF). ASHRAE Journal.* ***41*** *(2): 49. ISSN 0001-2491. Archived (PDF) from the original on May 13, 2021. Retrieved May 13, 2021 .*

130. ^ *Bahadori, Mehdi N. (February 1978). "Passive Cooling Systems in Iranian Architecture". Scientific American.* ***238*** *(2): 144–154. Bibcode:1978SciAm.238b.144B. doi:10.1038/SCIENTIFICAMERICAN0278-144.*
131. ^ *Smith, Shane (2000). Greenhouse Gardener's Companion: Growing Food and Flowers in Your Greenhouse Or Sunspace. Illustrated by Marjorie C. Leggitt (illustrated, revised ed.). Golden, Colorado: Fulcrum Publishing. p. 62. ISBN 978-1555914509. OCLC 905564174. Archived from the original on May 13, 2021. Retrieved August 25, 2020.*

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- U.S. patent 808,897 Carrier's original patent
- U.S. patent 1,172,429
- U.S. patent 2,363,294
- *Scientific American*, "Artificial Cold", 28 August 1880, p. 138
- *Scientific American*, "The Presidential Cold Air Machine", 6 August 1881, p. 84

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Heating, ventilation, and air conditioning

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

- 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

Technology

- 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

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

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

See also

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

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Home appliances

- Air conditioner
- Air fryer
- Air ioniser
- Air purifier
- Barbecue grill
- Blender
    - Immersion blender
- Bread machine
- Bug zapper
- Coffee percolator
- Clothes dryer
    - combo
- Clothes iron
- Coffeemaker
- Dehumidifier
- Dishwasher
    - drying cabinet
- Domestic robot
    - comparison
- Deep fryer
- Electric blanket
- Electric drill
- Electric kettle
- Electric knife
- Electric water boiler
- Electric heater
- Electric shaver
- Electric toothbrush
- Epilator
- Espresso machine
- Evaporative cooler
- Food processor
- Fan
    - attic
    - bladeless

See also

- Appliance plug
- Appliance recycling

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Roofs

Roof shapes

- Arched roof
- Barrel roof
- Board roof
- Bochka roof
- Bow roof
- Butterfly roof
- Clerestory
- Conical roof
- Dome
- Flat roof
- Gable roof
- Gablet roof
- Gambrel roof
- Half-hipped roof
- Hip roof
- Onion dome
- Mansard roof
- Pavilion roof
- Rhombic roof
- Ridged roof
- Saddle roof
- Sawtooth roof
- Shed roof
- Tented roof

Cross-gabled roof

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Roof elements	◦ Air conditioning unit ◦ Attic ◦ Catslide ◦ Chimney ◦ Collar beam ◦ Dormer ◦ Eaves ◦ Flashing ◦ Gable ◦ Green roof ◦ Gutter ◦ Hanging beam ◦ Joist ◦ Lightning rod ◦ Loft ◦ Purlin ◦ Rafter ◦ Ridge vent ◦ Roof batten ◦ Roof garden ◦ Roofline ◦ Roof ridge ◦ Roof sheeting ◦ Roof tiles ◦ Roof truss ◦ Roof window ◦ Skylight ◦ Soffit ◦ Solar panels ◦ Spire ◦ Weathervane ◦ Wind brace

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Electronics

Branches	◦ Analogue electronics ◦ Digital electronics ◦ Electronic engineering ◦ Instrumentation ◦ Microelectronics ◦ Optoelectronics ◦ Power electronics ◦ Printed electronics ◦ Semiconductor ◦ Schematic capture ◦ Thermal management
Advanced topics	◦ 2020s in computing ◦ Atomtronics ◦ Bioelectronics ◦ List of emerging electronics ◦ Failure of electronic components ◦ Flexible electronics ◦ Low-power electronics ◦ Molecular electronics ◦ Nanoelectronics ◦ Organic electronics ◦ Photonics ◦ Piezotronics ◦ Quantum electronics ◦ Spintronics

Electronic equipment	◦ Air conditioner ◦ Central heating ◦ Clothes dryer ◦ Computer/Notebook ◦ Camera ◦ Dishwasher ◦ Freezer ◦ Home robot ◦ Home cinema ◦ Home theater PC ◦ Information technology ◦ Cooker ◦ Microwave oven ◦ Mobile phone ◦ Networking hardware ◦ Portable media player ◦ Radio ◦ Refrigerator ◦ Robotic vacuum cleaner ◦ Tablet ◦ Telephone ◦ Television ◦ Water heater ◦ Video game console ◦ Washing machine

- Audio equipment
- Automotive electronics
- Avionics
- Control system
- Data acquisition
- e-book
- e-health
- Electromagnetic warfare
- Electronics industry
- Embedded system
- Home appliance
- Home automation
- Integrated circuit

Applications

- Home appliance
  - Consumer electronics
  - Major appliance
  - Small appliance
- Marine electronics
- Microwave technology
- Military electronics
- Multimedia
- Nuclear electronics
- Open-source hardware
- Radar and Radio navigation
- Radio electronics
- Terahertz technology
- Wired and Wireless Communications

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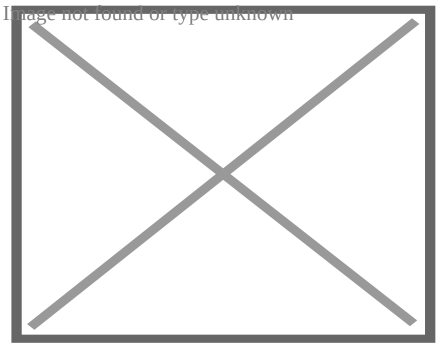
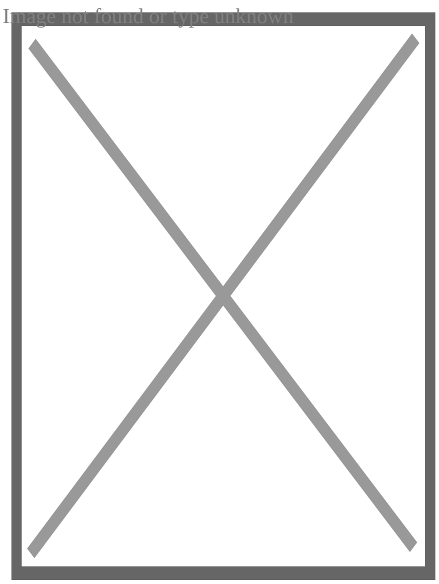
About Heat exchanger



Tubular heat exchanger

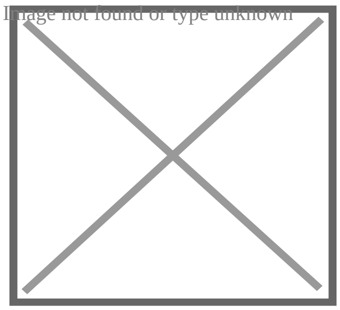


Partial view into inlet plenum of shell and tube heat exchanger of a refrigerant based chiller for providing air-conditioning to a building

A **heat exchanger** is a system used to transfer heat between a source and a working fluid. Heat exchangers are used in both cooling and heating processes.[1] The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.[2] They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.[3]

Flow arrangement

[edit]



Countercurrent (A) and parallel (B) flows

There are three primary classifications of heat exchangers according to their flow arrangement. In *parallel-flow* heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In *counter-flow* heat exchangers the fluids enter the exchanger from opposite ends. The counter current design is the most efficient, in that it can transfer the most heat from the heat (transfer) medium per unit mass due to the fact that the average temperature difference along any unit length is *higher*. See countercurrent exchange. In a *cross-flow* heat exchanger, the fluids travel roughly perpendicular to one another through the exchanger.

Fig. 1: Shell and tube heat

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For efficiency, heat exchangers are designed to maximize the surface area of the wall between the two fluids, while minimizing resistance to fluid flow through the exchanger. The exchanger's performance can also be affected by the addition of fins or corrugations in one or both directions, which increase surface area and may channel fluid flow or induce turbulence.

The driving temperature across the heat transfer surface varies with position, but an appropriate mean temperature can be defined. In most simple systems this is the "log mean temperature difference" (LMTD). Sometimes direct knowledge of the LMTD is not available and the NTU method is used.

Fig. 1: Shell and tube heat exchanger, single pass (1–1 parallel flow)

Fig. 2: Shell and tube heat

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Fig. 2: Shell and tube heat exchanger, 2-pass tube side (1–2 crossflow)

Fig. 3: Shell and tube heat

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Fig. 3: Shell and tube heat exchanger, 2-pass shell side, 2-pass tube side (2-2 countercurrent)

Types

[edit]

Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.

1. Double-pipe heat exchanger

When one fluid flows through the smaller pipe, the other flows through the annular gap between the two pipes. These flows may be parallel or counter-flows in a double pipe heat exchanger.

(a) Parallel flow, where both hot and cold liquids enter the heat exchanger from the same side, flow in the same direction and exit at the same end. This configuration is preferable when the two fluids are intended to reach exactly the same temperature, as it reduces thermal stress and produces a more uniform rate of heat transfer.

(b) Counter-flow, where hot and cold fluids enter opposite sides of the heat exchanger, flow in opposite directions, and exit at opposite ends. This configuration is preferable when the objective is to maximize heat transfer between the fluids, as it creates a larger temperature differential when used under otherwise similar conditions.[*citation needed*]

The figure above illustrates the parallel and counter-flow flow directions of the fluid exchanger.

2. Shell-and-tube heat exchanger

In a shell-and-tube heat exchanger, two fluids at different temperatures flow through the heat exchanger. One of the fluids flows through the tube side and the other fluid flows outside the tubes, but inside the shell (shell side).

Baffles are used to support the tubes, direct the fluid flow to the tubes in an approximately natural manner, and maximize the turbulence of the shell fluid. There are many various kinds of baffles, and the choice of baffle form, spacing, and geometry depends on the allowable flow rate of the drop in shell-side force, the need for tube support, and the flow-induced vibrations. There are several variations of shell-and-tube exchangers available; the differences lie in the arrangement of flow configurations and details of construction.

In application to cool air with shell-and-tube technology (such as intercooler / charge air cooler for combustion engines), fins can be added on the tubes to increase heat transfer area on air side and create a tubes & fins configuration.

3. Plate Heat Exchanger

A plate heat exchanger contains an amount of thin shaped heat transfer plates bundled together. The gasket arrangement of each pair of plates provides two separate channel system. Each pair of plates form a channel where the fluid can flow through. The pairs are attached by welding and bolting methods. The following shows the components in the heat exchanger.

In single channels the configuration of the gaskets enables flow through. Thus, this allows the main and secondary media in counter-current flow. A gasket plate heat exchanger has a heat region from corrugated plates. The gasket function as seal between plates and they are located between frame and pressure plates. Fluid flows in a counter current direction throughout the heat exchanger. An efficient thermal performance is produced. Plates are produced in different depths, sizes and corrugated shapes. There are different types of plates available including plate and frame, plate and shell and spiral plate heat exchangers. The distribution area guarantees the flow of fluid to the whole heat transfer surface. This helps to prevent stagnant area that can cause accumulation of unwanted material on solid surfaces. High flow turbulence between plates results in a greater transfer of heat and a decrease in pressure.

4. Condensers and Boilers Heat exchangers using a two-phase heat transfer system are condensers, boilers and evaporators. Condensers are instruments that take and cool hot gas or vapor to the point of condensation and transform the gas into a liquid form. The point at which liquid transforms to gas is called vaporization and vice versa is called condensation. Surface condenser is the most common type of condenser where it includes a water supply device. Figure 5 below displays a two-pass surface condenser.

The pressure of steam at the turbine outlet is low where the steam density is very low where the flow rate is very high. To prevent a decrease in pressure in the movement of steam from the turbine to condenser, the condenser unit is placed underneath and connected to the turbine. Inside the tubes the cooling water runs in a parallel way, while steam moves in a vertical downward position from the wide opening at the top and travel through the tube. Furthermore, boilers are categorized as initial application of heat exchangers. The word steam generator was regularly used to describe a boiler unit where a hot liquid stream is the source of heat rather than the combustion products. Depending on the dimensions and configurations the boilers are manufactured. Several boilers are only able to produce hot fluid while on the other hand the others are manufactured for steam production.

Shell and tube

[edit]

Main article: Shell and tube heat exchanger

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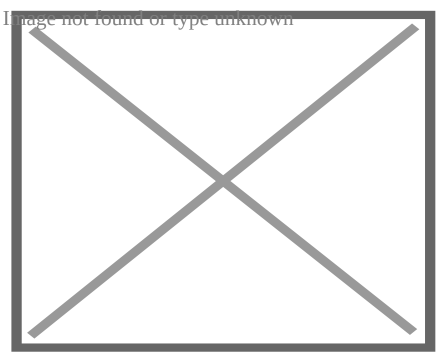
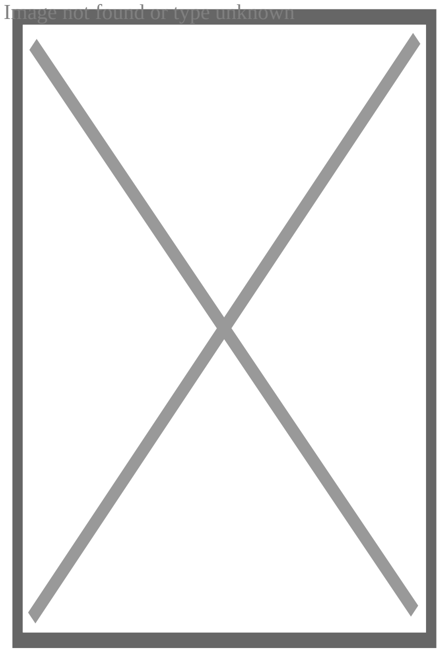


A shell and tube heat exchanger



Shell and tube heat exchanger

Shell and tube heat exchangers consist of a series of tubes which contain fluid that must be either heated or cooled. A second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C).[4] This is because the shell and tube heat exchangers are robust due to their shape.
Several thermal design features must be considered when designing the tubes in the shell and tube heat exchangers: There can be many variations on the shell and tube design. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tubesheets. The tubes may be straight or bent in the shape of a U, called U-tubes.

- Tube diameter: Using a small tube diameter makes the heat exchanger both economical and compact. However, it is more likely for the heat exchanger to foul up faster and the small size makes mechanical cleaning of the fouling difficult. To prevail over the fouling and cleaning problems, larger tube diameters can be used. Thus to determine the tube diameter, the available space, cost and fouling nature of the fluids must be considered.

- Tube thickness: The thickness of the wall of the tubes is usually determined to ensure:
  - There is enough room for corrosion
  - That flow-induced vibration has resistance
  - Axial strength
  - Availability of spare parts
  - Hoop strength (to withstand internal tube pressure)
  - Buckling strength (to withstand overpressure in the shell)
- Tube length: heat exchangers are usually cheaper when they have a smaller shell diameter and a long tube length. Thus, typically there is an aim to make the heat exchanger as long as physically possible whilst not exceeding production capabilities. However, there are many limitations for this, including space available at the installation site and the need to ensure tubes are available in lengths that are twice the required length (so they can be withdrawn and replaced). Also, long, thin tubes are difficult to take out and replace.
- Tube pitch: when designing the tubes, it is practical to ensure that the tube pitch (i.e., the centre-centre distance of adjoining tubes) is not less than 1.25 times the tubes' outside diameter. A larger tube pitch leads to a larger overall shell diameter, which leads to a more expensive heat exchanger.
- Tube corrugation: this type of tubes, mainly used for the inner tubes, increases the turbulence of the fluids and the effect is very important in the heat transfer giving a better performance.
- Tube Layout: refers to how tubes are positioned within the shell. There are four main types of tube layout, which are, triangular (30°), rotated triangular (60°), square (90°) and rotated square (45°). The triangular patterns are employed to give greater heat transfer as they force the fluid to flow in a more turbulent fashion around the piping. Square patterns are employed where high fouling is experienced and cleaning is more regular.

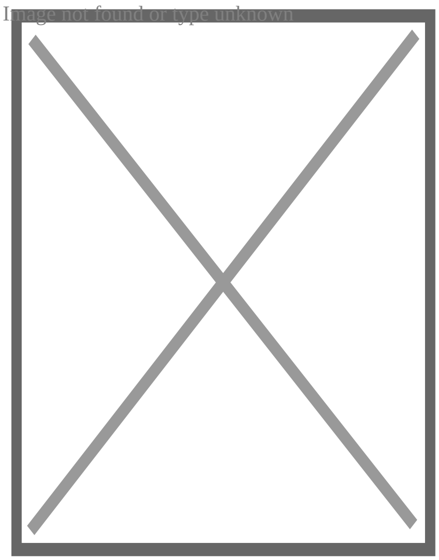
- Baffle Design: baffles are used in shell and tube heat exchangers to direct fluid across the tube bundle. They run perpendicularly to the shell and hold the bundle, preventing the tubes from sagging over a long length. They can also prevent the tubes from vibrating. The most common type of baffle is the segmental baffle. The semicircular segmental baffles are oriented at 180 degrees to the adjacent baffles forcing the fluid to flow upward and downwards between the tube bundle. Baffle spacing is of large thermodynamic concern when designing shell and tube heat exchangers. Baffles must be spaced with consideration for the conversion of pressure drop and heat transfer. For thermo economic optimization it is suggested that the baffles be spaced no closer than 20% of the shell's inner diameter. Having baffles spaced too closely causes a greater pressure drop because of flow redirection. Consequently, having the baffles spaced too far apart means that there may be cooler spots in the corners between baffles. It is also important to ensure the baffles are spaced close enough that the tubes do not sag. The other main type of baffle is the disc and doughnut baffle, which consists of two concentric baffles. An outer, wider baffle looks like a doughnut, whilst the inner baffle is shaped like a disk. This type of baffle forces the fluid to pass around each side of the disk then through the doughnut baffle generating a different type of fluid flow.
- Tubes & fins Design: in application to cool air with shell-and-tube technology (such as intercooler / charge air cooler for combustion engines), the difference in heat transfer between air and cold fluid can be such that there is a need to increase heat transfer area on air side. For this function fins can be added on the tubes to increase heat transfer area on air side and create a tubes & fins configuration.

Fixed tube liquid-cooled heat exchangers especially suitable for marine and harsh applications can be assembled with brass shells, copper tubes, brass baffles, and forged brass integral end hubs.[*citation needed*] *(See: Copper in heat exchangers).*

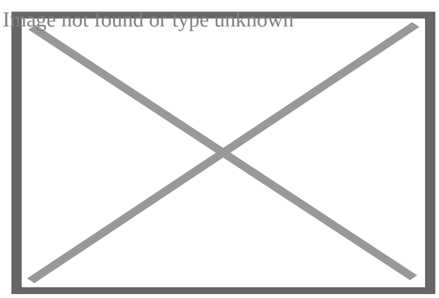
Plate

[edit]

Main article: Plate heat exchanger



Conceptual diagram of a plate and frame heat exchanger



A single plate heat exchanger

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An interchangeable plate heat exchanger directly applied to the system of a swimming pool

Another type of heat exchanger is the plate heat exchanger. These exchangers are composed of many thin, slightly separated plates that have very large surface areas and small fluid flow passages for heat transfer. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical. In HVAC applications, large heat exchangers of this type are called *plate-and-frame*; when used in open loops, these heat exchangers are normally of the gasket type to allow periodic disassembly, cleaning, and inspection. There are many types of permanently bonded plate heat exchangers, such as dip-brazed, vacuum-brazed, and welded plate varieties, and they are often specified for closed-loop applications such as refrigeration. Plate heat exchangers also differ in the types of plates that are used, and in the configurations of those plates. Some plates may be stamped with "chevron", dimpled, or other patterns, where others may have machined fins and/or grooves.

When compared to shell and tube exchangers, the stacked-plate arrangement typically has lower volume and cost. Another difference between the two is that plate exchangers typically serve low to medium pressure fluids, compared to medium and high pressures of shell and tube. A third and important difference is that plate exchangers employ more countercurrent flow rather than cross current flow, which allows lower approach temperature differences, high temperature changes, and increased efficiencies.

Plate and shell

[edit]

A third type of heat exchanger is a plate and shell heat exchanger, which combines plate heat exchanger with shell and tube heat exchanger technologies. The heart of the heat exchanger contains a fully welded circular plate pack made by pressing and cutting round plates and welding them together. Nozzles carry flow in and out of the platepack (the 'Plate side' flowpath). The fully welded platepack is assembled into an outer shell that creates a second flowpath (the 'Shell side'). Plate and shell technology offers high heat transfer, high pressure, high operating temperature, compact size, low fouling and close approach temperature. In particular, it does completely without gaskets, which provides security against leakage at high pressures and temperatures.

Adiabatic wheel

[edit]

A fourth type of heat exchanger uses an intermediate fluid or solid store to hold heat, which is then moved to the other side of the heat exchanger to be released. Two examples of this are adiabatic wheels, which consist of a large wheel with fine threads rotating through the hot and cold fluids, and fluid heat exchangers.

Plate fin

[edit]
Main article: Plate fin heat exchanger

This type of heat exchanger uses "sandwiched" passages containing fins to increase the effectiveness of the unit. The designs include crossflow and counterflow coupled with various fin configurations such as straight fins, offset fins and wavy fins.

Plate and fin heat exchangers are usually made of aluminum alloys, which provide high heat transfer efficiency. The material enables the system to operate at a lower temperature difference and reduce the weight of the equipment. Plate and fin heat exchangers are mostly used for low temperature services such as natural gas, helium and oxygen liquefaction plants, air separation plants and transport industries such as motor and aircraft engines.

Advantages of plate and fin heat exchangers:

- High heat transfer efficiency especially in gas treatment
- Larger heat transfer area
- Approximately 5 times lighter in weight than that of shell and tube heat exchanger. [*citation needed*]
- Able to withstand high pressure

Disadvantages of plate and fin heat exchangers:

- Might cause clogging as the pathways are very narrow
- Difficult to clean the pathways
- Aluminium alloys are susceptible to Mercury Liquid Embrittlement Failure

Finned tube

[edit]

The usage of fins in a tube-based heat exchanger is common when one of the working fluids is a low-pressure gas, and is typical for heat exchangers that operate using ambient air, such as automotive radiators and HVAC air condensers. Fins dramatically increase the surface area with which heat can be exchanged, which improves the efficiency of conducting heat to a fluid with very low thermal conductivity, such as air. The fins are typically made from aluminium or copper since they must conduct heat from the tube along the length of the fins, which are usually very thin.

The main construction types of finned tube exchangers are:

- A stack of evenly-spaced metal plates act as the fins and the tubes are pressed through pre-cut holes in the fins, good thermal contact usually being achieved by deformation of the fins around the tube. This is typical construction for HVAC air coils and large refrigeration condensers.
- Fins are spiral-wound onto individual tubes as a continuous strip, the tubes can then be assembled in banks, bent in a serpentine pattern, or wound into large spirals.
- Zig-zag metal strips are sandwiched between flat rectangular tubes, often being soldered or brazed together for good thermal and mechanical strength. This is common in low-pressure heat exchangers such as water-cooling radiators. Regular flat tubes will expand and deform if exposed to high pressures but flat microchannel tubes allow this construction to be used for high pressures.[5]

Stacked-fin or spiral-wound construction can be used for the tubes inside shell-and-tube heat exchangers when high efficiency thermal transfer to a gas is required.

In electronics cooling, heat sinks, particularly those using heat pipes, can have a stacked-fin construction.

Pillow plate

[edit]

A pillow plate heat exchanger is commonly used in the dairy industry for cooling milk in large direct-expansion stainless steel bulk tanks. Nearly the entire surface area of a tank can be integrated with this heat exchanger, without gaps that would occur between pipes welded to the exterior of the tank. Pillow plates can also be constructed as flat plates that are stacked inside a tank. The relatively flat surface of the plates allows easy cleaning, especially in sterile applications.

The pillow plate can be constructed using either a thin sheet of metal welded to the thicker surface of a tank or vessel, or two thin sheets welded together. The surface of the plate is welded with a regular pattern of dots or a serpentine pattern of weld lines. After welding the enclosed space is pressurised with sufficient force to cause the thin metal to bulge out around the welds, providing a space for heat exchanger liquids to flow, and creating a characteristic appearance of a swelled pillow formed out of metal.

Waste heat recovery units

[edit]

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A waste heat recovery unit (WHRU) is a heat exchanger that recovers heat from a hot gas stream while transferring it to a working medium, typically water or oils. The hot gas stream can be the exhaust gas from a gas turbine or a diesel engine or a waste gas from industry or refinery.

Large systems with high volume and temperature gas streams, typical in industry, can benefit from steam Rankine cycle (SRC) in a waste heat recovery unit, but these cycles are too expensive for small systems. The recovery of heat from low temperature systems requires different working fluids than steam.

An organic Rankine cycle (ORC) waste heat recovery unit can be more efficient at low temperature range using refrigerants that boil at lower temperatures than water. Typical organic refrigerants are ammonia, pentafluoropropane (R-245fa and R-245ca), and toluene.

The refrigerant is boiled by the heat source in the evaporator to produce super-heated vapor. This fluid is expanded in the turbine to convert thermal energy to kinetic energy, that is converted to electricity in the electrical generator. This energy transfer process decreases the temperature of the refrigerant that, in turn, condenses. The cycle is closed and completed using a pump to send the fluid back to the evaporator.

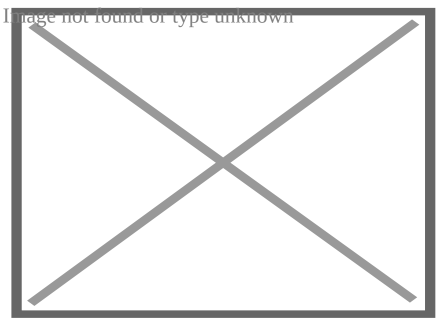
Dynamic scraped surface

[edit]

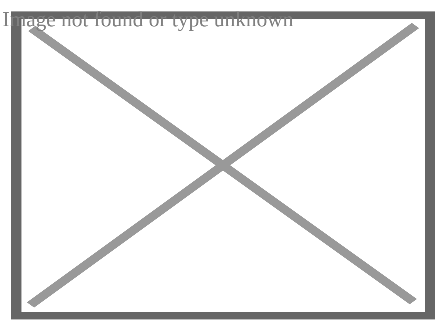
Another type of heat exchanger is called "(dynamic) scraped surface heat exchanger". This is mainly used for heating or cooling with high-viscosity products, crystallization processes, evaporation and high-fouling applications. Long running times are achieved due to the continuous scraping of the surface, thus avoiding fouling and achieving a sustainable heat transfer rate during the process.

Phase-change

[edit]



Typical kettle reboiler used for industrial distillation towers



Typical water-cooled surface condenser

In addition to heating up or cooling down fluids in just a single phase, heat exchangers can be used either to heat a liquid to evaporate (or boil) it or used as condensers to cool a vapor and condense it to a liquid. In chemical plants and refineries, reboilers used to heat incoming feed for distillation towers are often heat exchangers.[6][7]

Distillation set-ups typically use condensers to condense distillate vapors back into liquid.

Power plants that use steam-driven turbines commonly use heat exchangers to boil water into steam. Heat exchangers or similar units for producing steam from water are often called boilers or steam generators.

In the nuclear power plants called pressurized water reactors, special large heat exchangers pass heat from the primary (reactor plant) system to the secondary (steam plant) system, producing steam from water in the process. These are called steam generators. All fossil-fueled and nuclear power plants using steam-driven turbines have surface condensers to convert the exhaust steam from the turbines into condensate (water) for re-use.[8][9]

To conserve energy and cooling capacity in chemical and other plants, regenerative heat exchangers can transfer heat from a stream that must be cooled to another stream that must be heated, such as distillate cooling and reboiler feed pre-heating.

This term can also refer to heat exchangers that contain a material within their structure that has a change of phase. This is usually a solid to liquid phase due to the small volume difference between these states. This change of phase effectively acts as a buffer because it occurs at a constant temperature but still allows for the heat exchanger to accept additional heat. One example where this has been investigated is for use in high power aircraft electronics.

Heat exchangers functioning in multiphase flow regimes may be subject to the Ledinegg instability.

Direct contact

[edit]

Direct contact heat exchangers involve heat transfer between hot and cold streams of two phases in the absence of a separating wall.[10] Thus such heat exchangers can be classified as:

- Gas – liquid
- Immiscible liquid – liquid
- Solid–liquid or solid – gas

Most direct contact heat exchangers fall under the Gas – Liquid category, where heat is transferred between a gas and liquid in the form of drops, films or sprays.[4]

Such types of heat exchangers are used predominantly in air conditioning, humidification, industrial hot water heating, water cooling and condensing plants.[11]

Phases[12]	**Continuous phase**	**Driving force**	**Change of phase**	**Examples**
Gas – Liquid	Gas	Gravity	No	Spray columns, packed columns
			Yes	Cooling towers, falling droplet evaporators
		Forced	No	Spray coolers/quenchers
		Liquid flow	Yes	Spray condensers/evaporation, jet condensers
	Liquid	Gravity	No	Bubble columns, perforated tray columns
			Yes	Bubble column condensers
		Forced	No	Gas spargers
		Gas flow	Yes	Direct contact evaporators, submerged combustion

Microchannel

[edit]

Microchannel heat exchangers are multi-pass parallel flow heat exchangers consisting of three main elements: manifolds (inlet and outlet), multi-port tubes with the hydraulic diameters smaller than 1mm, and fins. All the elements usually brazed together using controllable atmosphere brazing process. Microchannel heat exchangers are characterized by high heat transfer ratio, low refrigerant charges, compact size, and lower airside pressure drops compared to finned tube heat exchangers.[*citation needed*] Microchannel heat exchangers are widely used in automotive industry as the car radiators, and as condenser, evaporator, and cooling/heating coils in HVAC industry.

Main article: Micro heat exchanger

Micro heat exchangers, **Micro-scale heat exchangers**, or **microstructured heat exchangers** are heat exchangers in which (at least one) fluid flows in lateral confinements with typical dimensions below 1 mm. The most typical such confinement are microchannels, which are channels with a hydraulic diameter below 1 mm. Microchannel heat exchangers can be made from metal or ceramics.[13] Microchannel heat exchangers can be used for many applications including:

- high-performance aircraft gas turbine engines[14]
- heat pumps[15]
- Microprocessor and microchip cooling[16]
- air conditioning[17]

HVAC and refrigeration air coils

[edit]

One of the widest uses of heat exchangers is for refrigeration and air conditioning. This class of heat exchangers is commonly called *air coils*, or just *coils* due to their often-serpentine internal tubing, or condensers in the case of refrigeration, and are typically of the finned tube type. Liquid-to-air, or air-to-liquid HVAC coils are typically of modified crossflow arrangement. In vehicles, heat coils are often called heater cores.

On the liquid side of these heat exchangers, the common fluids are water, a water-glycol solution, steam, or a refrigerant. For *heating coils*, hot water and steam are the most common, and this heated fluid is supplied by boilers, for example. For *cooling coils*, chilled water and refrigerant are most common. Chilled water is supplied from a chiller that is potentially located very far away, but refrigerant must come from a nearby condensing unit. When a refrigerant is used, the cooling coil is the evaporator, and the heating coil is the condenser in the vapor-compression refrigeration cycle. HVAC coils that use this direct-expansion of refrigerants are commonly called *DX coils*. Some *DX coils* are "microchannel" type.[5]

On the air side of HVAC coils a significant difference exists between those used for heating, and those for cooling. Due to psychrometrics, air that is cooled often has moisture condensing out of it, except with extremely dry air flows. Heating some air increases that airflow's capacity to hold water. So heating coils need not consider moisture condensation on their air-side, but cooling coils *must* be adequately designed and selected to handle their particular *latent* (moisture) as well as the *sensible* (cooling) loads. The water that is removed is called *condensate*.

For many climates, water or steam HVAC coils can be exposed to freezing conditions. Because water expands upon freezing, these somewhat expensive and difficult to replace thin-walled heat exchangers can easily be damaged or destroyed by just one freeze. As such, freeze protection of coils is a major concern of HVAC designers, installers, and operators.

The introduction of indentations placed within the heat exchange fins controlled condensation, allowing water molecules to remain in the cooled air.[18]

The heat exchangers in direct-combustion furnaces, typical in many residences, are not 'coils'. They are, instead, gas-to-air heat exchangers that are typically made of stamped steel sheet metal. The combustion products pass on one side of these heat exchangers, and air to heat on the other. A *cracked heat exchanger* is therefore a dangerous situation that requires immediate attention because combustion products may enter living space.

Helical-coil

[edit]

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Helical-Coil Heat Exchanger sketch, which consists of a shell, core, and tubes (Scott S. Haraburda design)

Although double-pipe heat exchangers are the simplest to design, the better choice in the following cases would be the helical-coil heat exchanger (HCHE):

- The main advantage of the HCHE, like that for the Spiral heat exchanger (SHE), is its highly efficient use of space, especially when it's limited and not enough straight pipe can be laid.[19]
- Under conditions of low flowrates (or laminar flow), such that the typical shell-and-tube exchangers have low heat-transfer coefficients and becoming uneconomical.[19]
- When there is low pressure in one of the fluids, usually from accumulated pressure drops in other process equipment.[19]

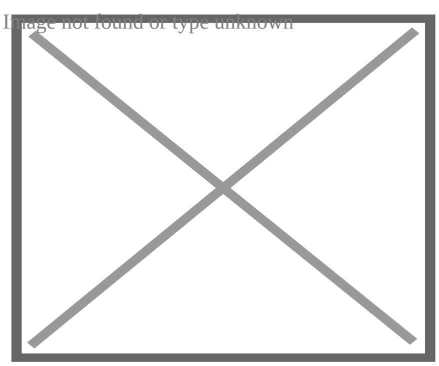
- When one of the fluids has components in multiple phases (solids, liquids, and gases), which tends to create mechanical problems during operations, such as plugging of small-diameter tubes.[20] Cleaning of helical coils for these multiple-phase fluids can prove to be more difficult than its shell and tube counterpart; however the helical coil unit would require cleaning less often.

These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s, using an HCHE device invented by Charles E. Boardman and John H. Germer.[21] There are several simple methods for designing HCHE for all types of manufacturing industries, such as using the Ramachandra K. Patil (et al.) method from India and the Scott S. Haraburda method from the United States.[19][20]

However, these are based upon assumptions of estimating inside heat transfer coefficient, predicting flow around the outside of the coil, and upon constant heat flux.[22]

Spiral

[edit]



Schematic drawing of a spiral heat exchanger

A modification to the perpendicular flow of the typical HCHE involves the replacement of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of different design calculations.[23] These are the Spiral Heat Exchangers (SHE), which may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. A pair of fluid ports are connected tangentially to the outer arms of the spiral, and axial ports are common, but optional.[24]

The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost.) A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an oversized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

Construction

[edit]

The distance between the sheets in the spiral channels is maintained by using spacer studs that were welded prior to rolling. Once the main spiral pack has been rolled, alternate top and bottom edges are welded and each end closed by a gasketed flat or conical cover bolted to the body. This ensures no mixing of the two fluids occurs. Any leakage is from the periphery cover to the atmosphere, or to a passage that contains the same fluid.[25]

Self cleaning

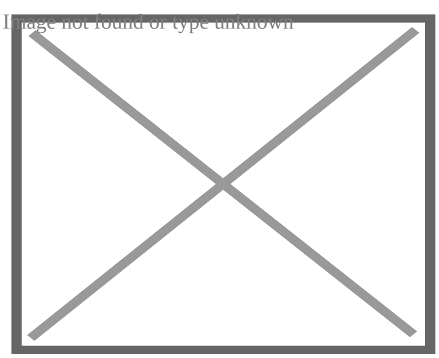
[edit]

Spiral heat exchangers are often used in the heating of fluids that contain solids and thus tend to foul the inside of the heat exchanger. The low pressure drop lets the SHE handle fouling more easily. The SHE uses a "self cleaning" mechanism, whereby fouled surfaces cause a localized increase in fluid velocity, thus increasing the drag (or fluid friction) on the fouled surface, thus helping to dislodge the blockage and keep the heat exchanger clean. "The internal walls that make up the heat transfer surface are often rather thick, which makes the SHE very robust, and able to last a long time in demanding environments."[*citation needed*] They are also easily cleaned, opening out like an oven where any buildup of foulant can be removed by pressure washing.

Self-cleaning water filters are used to keep the system clean and running without the need to shut down or replace cartridges and bags.

Flow arrangements

[edit]



A comparison between the operations and effects of a **cocurrent and a countercurrent flow exchange system** is depicted by the upper and lower diagrams respectively. In both it is assumed (and indicated) that red has a higher value (e.g. of temperature) than blue and that the property being transported in the channels therefore flows from red to blue. Channels are contiguous if effective exchange is to occur (i.e. there can be no gap between the channels).

There are three main types of flows in a spiral heat exchanger:

- **Counter-current Flow**: Fluids flow in opposite directions. These are used for liquid-liquid, condensing and gas cooling applications. Units are usually mounted vertically when condensing vapour and mounted horizontally when handling high concentrations of solids.
- **Spiral Flow/Cross Flow:** One fluid is in spiral flow and the other in a cross flow. Spiral flow passages are welded at each side for this type of spiral heat exchanger. This type of flow is suitable for handling low density gas, which passes through the cross flow, avoiding pressure loss. It can be used for liquid-liquid applications if one liquid has a considerably greater flow rate than the other.
- **Distributed Vapour/Spiral flow:** This design is that of a condenser, and is usually mounted vertically. It is designed to cater for the sub-cooling of both condensate and non-condensables. The coolant moves in a spiral and leaves via the top. Hot gases that enter leave as condensate via the bottom outlet.

Applications

[edit]

The Spiral heat exchanger is good for applications such as pasteurization, digester heating, heat recovery, pre-heating (see: recuperator), and effluent cooling. For sludge treatment, SHEs are generally smaller than other types of heat exchangers.[*citation*
These are used to transfer the heat.

Selection

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Due to the many variables involved, selecting optimal heat exchangers is challenging. Hand calculations are possible, but many iterations are typically needed. As such, heat exchangers are most often selected via computer programs, either by system designers, who are typically engineers, or by equipment vendors.

To select an appropriate heat exchanger, the system designers (or equipment vendors) would firstly consider the design limitations for each heat exchanger type. Though cost is often the primary criterion, several other selection criteria are important:

- High/low pressure limits
- Thermal performance
- Temperature ranges
- Product mix (liquid/liquid, particulates or high-solids liquid)
- Pressure drops across the exchanger
- Fluid flow capacity
- Cleanability, maintenance and repair
- Materials required for construction
- Ability and ease of future expansion
- Material selection, such as copper, aluminium, carbon steel, stainless steel, nickel alloys, ceramic, polymer, and titanium.[26][27]

Small-diameter coil technologies are becoming more popular in modern air conditioning and refrigeration systems because they have better rates of heat transfer than conventional sized condenser and evaporator coils with round copper tubes and aluminum or copper fin that have been the standard in the HVAC industry. Small diameter coils can withstand the higher pressures required by the new generation of environmentally friendlier refrigerants. Two small diameter coil technologies are currently available for air conditioning and refrigeration products: copper microgroove[28] and brazed aluminum microchannel.[*citation needed*]

Choosing the right heat exchanger (HX) requires some knowledge of the different heat exchanger types, as well as the environment where the unit must operate. Typically in the manufacturing industry, several differing types of heat exchangers are used for just one process or system to derive the final product. For example, a kettle HX for pre-heating, a double pipe HX for the 'carrier' fluid and a plate and frame HX for final cooling. With sufficient knowledge of heat exchanger types and operating requirements, an appropriate selection can be made to optimise the process.[29]

Monitoring and maintenance

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Online monitoring of commercial heat exchangers is done by tracking the overall heat transfer coefficient. The overall heat transfer coefficient tends to decline over time due to fouling.

By periodically calculating the overall heat transfer coefficient from exchanger flow rates and temperatures, the owner of the heat exchanger can estimate when cleaning the heat exchanger is economically attractive.

Integrity inspection of plate and tubular heat exchanger can be tested in situ by the conductivity or helium gas methods. These methods confirm the integrity of the plates or tubes to prevent any cross contamination and the condition of the gaskets.

Mechanical integrity monitoring of heat exchanger tubes may be conducted through Nondestructive methods such as eddy current testing.

Fouling

[edit]

Main article: Fouling

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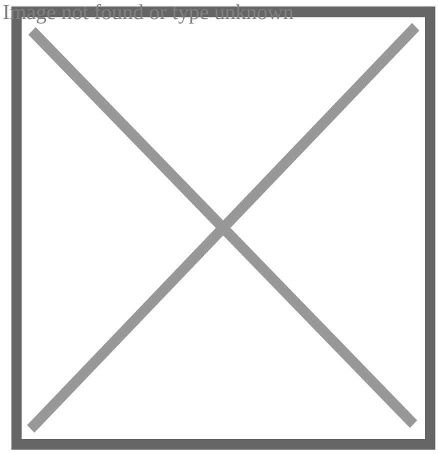


A heat exchanger in a steam power station contaminated with macrofouling

Fouling occurs when impurities deposit on the heat exchange surface. Deposition of these impurities can decrease heat transfer effectiveness significantly over time and are caused by:

- Low wall shear stress
- Low fluid velocities
- High fluid velocities
- Reaction product solid precipitation
- Precipitation of dissolved impurities due to elevated wall temperatures

The rate of heat exchanger fouling is determined by the rate of particle deposition less re-entrainment/suppression. This model was originally proposed in 1959 by Kern and Seaton.

Crude Oil Exchanger Fouling. In commercial crude oil refining, crude oil is heated from 21 °C (70 °F) to 343 °C (649 °F) prior to entering the distillation column. A series of shell and tube heat exchangers typically exchange heat between crude oil and other oil streams to heat the crude to 260 °C (500 °F) prior to heating in a furnace. Fouling occurs on the crude side of these exchangers due to asphaltene insolubility. The nature of asphaltene solubility in crude oil was successfully modeled by Wiehe and Kennedy.[30] The precipitation of insoluble asphaltenes in crude preheat trains has been successfully modeled as a first order reaction by Ebert and Panchal[31] who expanded on the work of Kern and Seaton.

Cooling Water Fouling. Cooling water systems are susceptible to fouling. Cooling water typically has a high total dissolved solids content and suspended colloidal solids. Localized precipitation of dissolved solids occurs at the heat exchange surface due to wall temperatures higher than bulk fluid temperature. Low fluid velocities (less than 3 ft/s) allow suspended solids to settle on the heat exchange surface. Cooling water is typically on the tube side of a shell and tube exchanger because it's easy to clean. To prevent fouling, designers typically ensure that cooling water velocity is greater than 0.9 m/s and bulk fluid temperature is maintained less than 60 °C (140 °F). Other approaches to control fouling control combine the "blind" application of biocides and anti-scale chemicals with periodic lab testing.

Maintenance

[edit]

Plate and frame heat exchangers can be disassembled and cleaned periodically. Tubular heat exchangers can be cleaned by such methods as acid cleaning, sandblasting, high-pressure water jet, bullet cleaning, or drill rods.

In large-scale cooling water systems for heat exchangers, water treatment such as purification, addition of chemicals, and testing, is used to minimize fouling of the heat exchange equipment. Other water treatment is also used in steam systems for power plants, etc. to minimize fouling and corrosion of the heat exchange and other equipment.

A variety of companies have started using water borne oscillations technology to prevent biofouling. Without the use of chemicals, this type of technology has helped in providing a low-pressure drop in heat exchangers.

Design and manufacturing regulations

[edit]

The design and manufacturing of heat exchangers has numerous regulations, which vary according to the region in which they will be used.

Design and manufacturing codes include: ASME Boiler and Pressure Vessel Code (US); PD 5500 (UK); BS 1566 (UK);[32] EN 13445 (EU); CODAP (French); Pressure Equipment Safety Regulations 2016 (PER) (UK); Pressure Equipment Directive (EU); NORSOK (Norwegian); TEMA;[33] API 12; and API 560.[*citation needed*]

In nature

[edit]

Humans

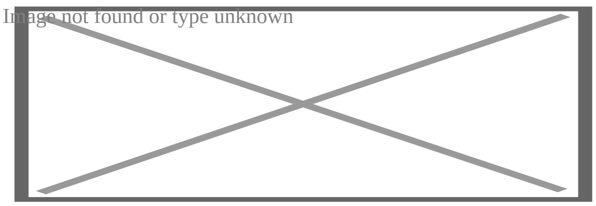
[edit]

The human nasal passages serve as a heat exchanger, with cool air being inhaled and warm air being exhaled. Its effectiveness can be demonstrated by putting the hand in front of the face and exhaling, first through the nose and then through the mouth. Air exhaled through the nose is substantially cooler.[34][35] This effect can be enhanced with clothing, by, for example, wearing a scarf over the face while breathing in cold weather.

In species that have external testes (such as human), the artery to the testis is surrounded by a mesh of veins called the pampiniform plexus. This cools the blood heading to the testes, while reheating the returning blood.

Birds, fish, marine mammals

[edit]



Counter-current exchange conservation circuit

Further information: Counter-current exchange in biological systems

"Countercurrent" heat exchangers occur naturally in the circulatory systems of fish, whales and other marine mammals. Arteries to the skin carrying warm blood are intertwined with veins from the skin carrying cold blood, causing the warm arterial blood to exchange heat with the cold venous blood. This reduces the overall heat loss in cold water. Heat exchangers are also present in the tongues of baleen whales as large volumes of water flow through their mouths.[36][37] Wading birds use a similar system to limit heat losses from their body through their legs into the water.

Carotid rete

[edit]

Carotid rete is a counter-current heat exchanging organ in some ungulates. The blood ascending the carotid arteries on its way to the brain, flows via a network of vessels where heat is discharged to the veins of cooler blood descending from the nasal passages. The carotid rete allows Thomson's gazelle to maintain its brain almost 3 °C (5.4 °F) cooler than the rest of the body, and therefore aids in tolerating bursts in metabolic heat production such as associated with outrunning cheetahs (during which the body temperature exceeds the maximum temperature at which the brain could function).[38] Humans with other primates lack a carotid rete.[39]

In industry

[edit]

Heat exchangers are widely used in industry both for cooling and heating large scale industrial processes. The type and size of heat exchanger used can be tailored to suit a process depending on the type of fluid, its phase, temperature, density, viscosity, pressures, chemical composition and various other thermodynamic properties.

In many industrial processes there is waste of energy or a heat stream that is being exhausted, heat exchangers can be used to recover this heat and put it to use by heating a different stream in the process. This practice saves a lot of money in industry, as the heat supplied to other streams from the heat exchangers would otherwise come from an external source that is more expensive and more harmful to the environment.

Heat exchangers are used in many industries, including:

- Waste water treatment
- Refrigeration
- Wine and beer making
- Petroleum refining
- Nuclear power

In waste water treatment, heat exchangers play a vital role in maintaining optimal temperatures within anaerobic digesters to promote the growth of microbes that remove pollutants. Common types of heat exchangers used in this application are the double pipe heat exchanger as well as the plate and frame heat exchanger.

In aircraft

[edit]

In commercial aircraft heat exchangers are used to take heat from the engine's oil system to heat cold fuel.[40] This improves fuel efficiency, as well as reduces the possibility of water entrapped in the fuel freezing in components.[41]

Current market and forecast

[edit]

Estimated at US$17.5 billion in 2021, the global demand of heat exchangers is expected to experience robust growth of about 5% annually over the next years. The market value is expected to reach US$27 billion by 2030. With an expanding desire for environmentally friendly options and increased development of offices, retail sectors, and public buildings, market expansion is due to grow.[42]

A model of a simple heat exchanger

[edit]

A simple heat exchange [43][44] might be thought of as two straight pipes with fluid flow, which are thermally connected. Let the pipes be of equal length *L*, carrying fluids with heat capacity $\displaystyle C_i$ (energy per unit mass per unit change in temperature) and let the mass flow rate of the fluids through the pipes, both in the same direction, be $\displaystyle J_i$ (mass per unit time), where the subscript *i* applies to pipe 1 or pipe 2.

Temperature profiles for the pipes are $\displaystyle T_1(x)$ and $\displaystyle T_2(x)$ where x is the distance along the pipe. Assume a steady state, so that the temperature profiles are not functions of time. Assume also that the only transfer of heat from a small volume of fluid in one pipe is to the fluid element in the other pipe at the same position, i.e., there is no transfer of heat along a pipe due to temperature differences in that pipe. By Newton's law of cooling the rate of change in energy of a small volume of fluid is proportional to the difference in temperatures between it and the corresponding element in the other pipe:

$$\displaystyle \frac{du_1}{dt}=\gamma (T_2-T_1)$$

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$$\displaystyle \frac{du_2}{dt}=\gamma (T_1-T_2)$$

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(this is for parallel flow in the same direction and opposite temperature gradients, but for counter-flow heat exchange countercurrent exchange the sign is opposite in the second equation in front of $\gamma (T_1-T_2)$), where $u_i(x)$ is the thermal energy per unit length and γ is the thermal connection constant per unit length between the two pipes. This change in internal energy results in a change in the temperature of the fluid element. The time rate of change for the fluid element being carried along by the flow is:

$$\displaystyle \frac{du_1}{dt}=J_1\frac{dT_1}{dx}$$

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$$\displaystyle \frac{du_2}{dt}=J_2\frac{dT_2}{dx}$$

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where $J_i=C_i j_i$ is the "thermal mass flow rate". The differential equations governing the heat exchanger may now be written as:

$$\displaystyle J_1\frac{\partial T_1}{\partial x}=\gamma (T_2-T_1)$$

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$$\displaystyle J_2\frac{\partial T_2}{\partial x}=\gamma (T_1-T_2).$$

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Since the system is in a steady state, there are no partial derivatives of temperature with respect to time, and since there is no heat transfer along the pipe, there are no second derivatives in *x* as is found in the heat equation. These two coupled first-order differential equations may be solved to yield:

$$T_1=A-\frac{B}{k}k_1\,e^{-kx}$$

$$T_2=A+\frac{B}{k}k_2\,e^{-kx}$$

where $k_1=\gamma/J_1$, $k_2=\gamma/J_2$

$$k=k_1+k_2$$

(this is for parallel-flow, but for counter-flow the sign in front of k_2 is negative, so that if $k_2=k_1$ for the same "thermal mass flow rate" in both opposite directions, the gradient of temperature is constant and the temperatures linear in position *x* with a constant difference (T_2-T_1) along the exchanger, explaining why the counter current design countercurrent exchange is the most efficient)

and *A* and *B* are two as yet undetermined constants of integration. Let T_{10} and T_{20} be the temperatures at x=0 and let T_{1L} and T_{2L} be the temperatures at the end of the pipe at x=L. Define the average temperatures in each pipe as:

$$\overline{T}_1=\frac{1}{L}\int_0^L T_1(x)dx$$

$$\overline{T}_2=\frac{1}{L}\int_0^L T_2(x)dx.$$

Using the solutions above, these temperatures are:

$T_{10}=A-\frac{B}{k}k_1$	$T_{20}=A+\frac{B}{k}k_2$
$T_{1L}=A-\frac{B}{k}k_1e^{-kL}$	$T_{2L}=A+\frac{B}{k}k_2e^{-kL}$
$\overline{T}_1=A-\frac{Bk_1}{k^2L}(1-e^{-kL})$	$\overline{T}_2=A+\frac{Bk_2}{k^2L}$ …

Choosing any two of the temperatures above eliminates the constants of integration, letting us find the other four temperatures. We find the total energy transferred by integrating the expressions for the time rate of change of internal energy per unit length:

\displaystyle \frac dU_1dt=\int _0^L\frac du_1dt\,dx=J_1(T_1L-T_10)=\gamma L(\ov

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\displaystyle \frac dU_2dt=\int _0^L\frac du_2dt\,dx=J_2(T_2L-T_20)=\gamma L(\

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By the conservation of energy, the sum of the two energies is zero. The quantity \displaystyle \overline T_2-\overline T_1

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is known as the *Log mean temperature difference*, and is a measure of the effectiveness of the heat exchanger in transferring heat energy.

See also

[edit]

- Architectural engineering
- Chemical engineering
- Cooling tower
- Copper in heat exchangers
- Heat pipe
- Heat pump
- Heat recovery ventilation
- Jacketed vessel
- Log mean temperature difference (LMTD)
- Marine heat exchangers
- Mechanical engineering
- Micro heat exchanger
- Moving bed heat exchanger
- Packed bed and in particular Packed columns
- Pumpable ice technology
- Reboiler

- Recuperator, or cross plate heat exchanger
- Regenerator
- Run around coil
- Steam generator (nuclear power)
- Surface condenser
- Toroidal expansion joint
- Thermosiphon
- Thermal wheel, or rotary heat exchanger (including enthalpy wheel and desiccant wheel)
- Tube tool
- Waste heat

References

[edit]

1. **^** *Al-Sammarraie, Ahmed T.; Vafai, Kambiz (2017). "Heat transfer augmentation through convergence angles in a pipe". Numerical Heat Transfer, Part A: Applications. **72** (3): 197–214. Bibcode:2017NHTA...72..197A. doi:10.1080/10407782.2017.1372670. S2CID 125509773.*
2. **^** *Sadik Kakaç; Hongtan Liu (2002). Heat Exchangers: Selection, Rating and Thermal Design (2nd ed.). CRC Press. ISBN 978-0-8493-0902-1.*
3. **^** *Farzaneh, Mahsa; Forouzandeh, Azadeh; Al-Sammarraie, Ahmed T.; Salimpour, Mohammad Reza (2019). "Constructal Design of Circular Multilayer Microchannel Heat Sinks". Journal of Thermal Science and Engineering Applications. **11**. doi:10.1115/1.4041196. S2CID 126162513.*
4. ^ ***a b*** Saunders, E. A. (1988). Heat Exchanges: Selection, Design and Construction. New York: Longman Scientific and Technical.
5. ^ ***a b*** *"MICROCHANNEL TECHNOLOGY" (PDF). Archived from the original (PDF) on June 4, 2013.*
6. **^** *Kister, Henry Z. (1992). Distillation Design (1st ed.). McGraw-Hill. ISBN 978-0-07-034909-4.*
7. **^** *Perry, Robert H.; Green, Don W. (1984). Perry's Chemical Engineers' Handbook (6th ed.). McGraw-Hill. ISBN 978-0-07-049479-4.*
8. **^** Air Pollution Control Orientation Course from website of the Air Pollution Training Institute

9. ^ Energy savings in steam systems Archived 2007-09-27 at the Wayback Machine *Figure 3a, Layout of surface condenser* (scroll to page 11 of 34 PDF pages)
10. ^ Coulson, J. & Richardson, J. (1983), Chemical Engineering – Design (SI Units), Volume 6, Pergamon Press, Oxford.
11. ^ Hewitt G, Shires G, Bott T (1994), Process Heat Transfer, CRC Press Inc, Florida.
12. ^ Table: Various Types of Gas – Liquid Direct Contact Heat Exchangers (Hewitt G, Shires G & Bott T, 1994)
13. ^ *Kee Robert J.; et al. (2011). "The design, fabrication, and evaluation of a ceramic counter-flow microchannel heat exchanger". Applied Thermal Engineering.* ***31*** *(11): 2004–2012. doi:10.1016/j.applthermaleng.2011.03.009.*
14. ^ *Northcutt B.; Mudawar I. (2012). "Enhanced design of cross-flow microchannel heat exchanger module for high-performance aircraft gas turbine engines". Journal of Heat Transfer.* ***134*** *(6): 061801. doi:10.1115/1.4006037.*
15. ^ *Moallem E.; Padhmanabhan S.; Cremaschi L.; Fisher D. E. (2012). "Experimental investigation of the surface temperature and water retention effects on the frosting performance of a compact microchannel heat exchanger for heat pump systems". International Journal of Refrigeration.* ***35*** *(1): 171–186. doi:10.1016/j.ijrefrig.2011.08.010.*
16. ^ Sarvar-Ardeh, S., Rafee, R., Rashidi, S. (2021). Hybrid nanofluids with temperature-dependent properties for use in double-layered microchannel heat sink; hydrothermal investigation. Journal of the Taiwan Institute of Chemical Engineers. cite journal https://doi.org/10.1016/j.jtice.2021.05.007
17. ^ Xu, B., Shi, J., Wang, Y., Chen, J., Li, F., & Li, D. (2014). Experimental Study of Fouling Performance of Air Conditioning System with Microchannel Heat Exchanger.
18. ^ Patent 2,046,968 John C Raisley[*dead link*] issued July 7, 1936; filed Jan. 8, 1934 [1]
19. ^ ***a b c d*** *Patil, Ramachandra K.; Shende, B.W.; Ghosh, Prasanfa K. (13 December 1982). "Designing a helical-coil heat exchanger". Chemical Engineering.* ***92*** *(24): 85–88. Retrieved 14 July 2015.*
20. ^ ***a b*** *Haraburda, Scott S. (July 1995). "Three-Phase Flow? Consider Helical-Coil Heat Exchanger". Chemical Engineering.* ***102*** *(7): 149–151. Retrieved 14 July 2015.*

21. ^ US 3805890, Boardman, Charles E. & Germer, John H., "Helical Coil Heat Exchanger", issued 1974
22. ^ *Rennie, Timothy J. (2004). Numerical And Experimental Studies Of A Doublepipe Helical Heat Exchanger (PDF) (Ph.D.). Montreal: McGill University. pp. 3–4. Retrieved 14 July 2015.*
23. ^ *Rennie, Timothy J.; Raghavan, Vijaya G.S. (September 2005). "Experimental studies of a double-pipe helical heat exchanger". Experimental Thermal and Fluid Science.* ***29*** *(8): 919–924. doi:10.1016/j.expthermflusci.2005.02.001.*
24. ^ *"Cooling Text". Archived from the original on 2009-02-09. Retrieved 2019-09-09.*
25. ^ E.A.D.Saunders (1988). *Heat Exchangers:Selection Design And Construction* Longman Scientific and Technical ISBN 0-582-49491-5
26. ^ *Hartman, A. D.; Gerdemann, S. J.; Hansen, J. S. (1998-09-01). "Producing lower-cost titanium for automotive applications". JOM.* ***50*** *(9): 16–19. Bibcode:1998JOM....50i..16H. doi:10.1007/s11837-998-0408-1. ISSN 1543-1851. S2CID 92992840.*
27. ^ *Nyamekye, Patricia; Rahimpour Golroudbary, Saeed; Piili, Heidi; Luukka, Pasi; Kraslawski, Andrzej (2023-05-01). "Impact of additive manufacturing on titanium supply chain: Case of titanium alloys in automotive and aerospace industries". Advances in Industrial and Manufacturing Engineering.* ***6****: 100112. doi: 10.1016/j.aime.2023.100112. ISSN 2666-9129. S2CID 255534598. Archived from the original on Feb 4, 2024.*
28. ^ *"Small Tube Copper Is Economical and Eco-Friendly | The MicroGroove Advantage". microgroove.net. Archived from the original on Dec 8, 2023.*cite web: CS1 maint: unfit URL (link)
29. ^
    - White, F.M. 'Heat and Mass Transfer' © 1988 Addison-Wesley Publishing Co. pp. 602–604
    - *Rafferty, Kevin D. "Heat Exchangers". Gene Culver Geo-Heat Center. Geothermal Networks. Archived from the original on 2008-03-29.* Last accessed 17/3/08.
    - *"Process Heating". process-heating.com. BNP Media. Archived from the original on Mar 16, 2008.* Last accessed 17/3/08.
30. ^ *Wiehe, Irwin A.; Kennedy, Raymond J. (1 January 2000). "The Oil Compatibility Model and Crude Oil Incompatibility". Energy & Fuels.* ***14*** *(1): 56–59.*

doi:10.1021/ef990133+.

31. ^ Panchal C;B; and Ebert W., Analysis of Exxon Crude–Oil–Slip–Stream Coking Data, Proc of Fouling Mitigation of Industrial Heat–Exchanger Equipment, San Luis Obispo, California, USA, p 451, June 1995
32. ^ *Domestic heating compliance guide : compliance with approved documents L1A: New dwellings and L1B: Existing dwellings : the Building Regulations 2000 as amended 2006. London: TSO. 2006. ISBN 978-0-11-703645-1. OCLC 500282471.*
33. ^ *Epstein, Norman (2014), "Design and construction codes", HEDH Multimedia, Begellhouse, doi:10.1615/hedhme.a.000413, ISBN 978-1-56700-423-6, retrieved 2022-04-12*
34. ^ Heat Loss from the Respiratory Tract in Cold, Defense Technical Information Center, April 1955
35. ^ *Randall, David J.; Warren W. Burggren; Kathleen French; Roger Eckert (2002). Eckert animal physiology: mechanisms and adaptations. Macmillan. p. 587. ISBN 978-0-7167-3863-3.*
36. ^ *"Natural History Museum: Research & Collections: History". Archived from the original on 2009-06-14. Retrieved 2019-09-09.*
37. ^ *Heyning and Mead; Mead, JG (November 1997). "Thermoregulation in the Mouths of Feeding Gray Whales". Science.* ***278*** *(5340): 1138–1140. Bibcode:1997Sci...278.1138H. doi:10.1126/science.278.5340.1138. PMID 9353198.*
38. ^ *"Carotid rete cools brain : Thomson's Gazelle".*
39. ^ *Bruner, Emiliano; Mantini, Simone; Musso, Fabio; De La Cuétara, José Manuel; Ripani, Maurizio; Sherkat, Shahram (2010-11-30). "The evolution of the meningeal vascular system in the human genus: From brain shape to thermoregulation". American Journal of Human Biology.* ***23*** *(1): 35–43. doi:10.1002/ajhb.21123. ISSN 1042-0533. PMID 21120884.*
40. ^ *"United States Patent 4498525, Fuel/oil heat exchange system for an engine". United States Patent and Trademark Office. Retrieved 3 February 2009.*
41. ^ *Croft, John. "Boeing links Heathrow, Atlanta Trent 895 engine rollbacks". FlightGlobal.com. Retrieved 3 February 2009.*
42. ^ *Research, Straits (2022-07-06). "Heat Exchanger Market Size is projected to reach USD 27 Billion by 2030, growing at a CAGR of 5%: Straits Research". GlobeNewswire News Room (Press release). Retrieved 2022-07-15.*
43. ^ Kay J M & Nedderman R M (1985) *Fluid Mechanics and Transfer Processes*, Cambridge University Press

44. ^ *"MIT web course on Heat Exchangers". [MIT].*
  - Coulson, J. and Richardson, J (1999). Chemical Engineering– Fluid Flow. Heat Transfer and Mass Transfer– Volume 1; Reed Educational & Professional Publishing LTD
  - Dogan Eryener (2005), 'Thermoeconomic optimization of baffle spacing for shell and tube heat exchangers', Energy Conservation and Management, Volume 47, Issue 11–12, Pages 1478–1489.
  - G.F.Hewitt, G.L.Shires, T.R.Bott (1994) Process Heat Transfer, CRC Press, Inc, United States Of America.

External links

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Wikimedia Commons has media related to ***Heat exchangers***.

- Shell and Tube Heat Exchanger Design Software for Educational Applications (PDF)
- EU Pressure Equipment Guideline
- A Thermal Management Concept For More Electric Aircraft Power System Application (PDF)

Authority control databases: National

- Germany
- United States
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- BnF data
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Heating, ventilation, and air conditioning

Fundamental concepts

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

- 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

Technology

- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling

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

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

About Durham Supply Inc

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Things To Do in Tulsa County

Photo

Blue Whale of Catoosa

4.5 (3899)

Photo

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Guthrie Green

4.7 (3055)

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The Blue Dome

4.5 (60)

Photo

Philbrook Museum of Art

4.8 (3790)

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The Outsiders House Museum

4.7 (885)

Photo

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Tulsa Zoo

4.5 (10481)

Driving Directions in Tulsa County

Driving Directions From OYO Hotel Tulsa International Airport to Durham Supply Inc

Driving Directions From Tulsa to Durham Supply Inc

Driving Directions From Church on the Move Tulsa to Durham Supply Inc

Driving Directions From East Central High School to Durham Supply Inc

Driving Directions From Nights Stay Hotel to Durham Supply Inc

Driving Directions From Lincoln Christian School to Durham Supply Inc

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Driving Directions From The Tulsa Arts District to Durham Supply Inc

Driving Directions From Gathering Place to Durham Supply Inc

Driving Directions From The Outsiders House Museum to Durham Supply Inc

Driving Directions From The Tulsa Arts District to Durham Supply Inc

Driving Directions From Philbrook Museum of Art to Durham Supply Inc

Driving Directions From Tulsa Zoo to Durham Supply Inc

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Reviews for Durham Supply Inc

Durham Supply Inc

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Gerald Clifford Brewster

(5)

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

Durham Supply Inc

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Ethel Schiller

(5)

This place is really neat, if they don't have it they can order it from another of their stores and have it there overnight in most cases. Even hard to find items for a trailer! I definitely recommend this place to everyone! O and the prices is awesome too!

Durham Supply Inc

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Ty Spears

(5)

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

Durham Supply Inc

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B Mann

(5)

I was in need of some items for a double wide that I am remodeling and this place is the only place in town that had what I needed (I didn't even try the other rude place)while I was there I learned the other place that was in Tulsa that also sold mobile home supplies went out of business (no wonder the last time I was in there they were VERY RUDE and high priced) I like the way Dunham does business they answered all my questions and got me the supplies I needed, very friendly, I will be back to purchase the rest of my items when the time comes.

Minimizing Drafts Through Sealed Mobile Home Duct Systems**View GBP**

Frequently Asked Questions

How can sealing ductwork in a mobile home reduce drafts and improve HVAC efficiency?

Sealing ductwork prevents air leaks that cause drafts, ensuring that conditioned air is delivered efficiently throughout the home. This minimizes energy loss, reduces utility bills, and improves overall comfort by maintaining consistent temperatures.

What materials are recommended for effectively sealing ducts in a mobile home HVAC system?

Mastic sealant or metal foil tape is recommended for sealing ducts. These materials provide durable seals that withstand temperature fluctuations and prevent air leakage better than traditional duct tape.

How often should the ductwork in a mobile home be inspected for leaks to maintain optimal efficiency?

Ductwork should be inspected annually to identify and repair any leaks or damage. Regular inspections help maintain HVAC efficiency, prevent drafts, and prolong the lifespan of the system.

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State : OK

Zip : 73149

Address : Unknown Address

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