



- **Reviewing Key Safety Measures for Mobile Home HVAC Work**
Reviewing Key Safety Measures for Mobile Home HVAC Work Understanding PPE Guidelines for Mobile Home Furnace Repair Following OSHA Standards During Mobile Home AC Installations Noting Electrical Hazard Precautions in Mobile Home HVAC Projects Planning Lockout Procedures for Mobile Home Heating Maintenance Checking for Proper Ventilation in Mobile Home HVAC Crawl Spaces Confirming Compliance with HUD Requirements for Mobile Home Ducts Conducting On Site Safety Assessments Before Mobile Home AC Repairs Checking Gas Line Integrity in Mobile Home Heating Systems Identifying Combustion Clearance Issues in Mobile Home Furnaces Monitoring Air Quality Factors During Mobile Home HVAC Upkeep Coordinating Exit Strategies for Emergencies in Mobile Home HVAC Work
- **Identifying Warning Signs of Outdated Components**
Identifying Warning Signs of Outdated Components Converting Older Units to High Efficiency Models Examining Duct Layout for Better Distribution Adjusting Equipment Size to Fit Modern Needs Evaluating Newer Options to Replace Electric Heaters Implementing Airflow Balancing Techniques Overcoming Physical Constraints in Legacy Structures Transitioning to Improved Refrigerants for Compliance Strengthening Insulation to Enhance Performance Matching Compatibility of Controls and Existing Wiring Coordinating Expert Consultations for Complex Projects Planning Timelines for Effective System Upgrades
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Combustion clearance in furnaces is a critical aspect of ensuring safety and efficiency, particularly in mobile home environments where space constraints and construction materials can pose unique challenges. Understanding combustion clearance involves examining the space necessary around furnace components to allow for proper air flow, heat dissipation, and safe operation.

In mobile homes, furnaces are often installed in compact areas with limited ventilation options. This makes them more susceptible to issues arising from inadequate combustion clearance. Drainage systems prevent moisture buildup around mobile home HVAC units. **Mobile Home Air Conditioning Installation Services** energy. If not properly addressed, these issues can lead to dangerous situations such as carbon monoxide buildup or even fires.

One common problem associated with insufficient combustion clearance is restricted airflow. Furnaces require a certain amount of air to function correctly; without it, the fuel may not burn completely. This incomplete combustion can produce harmful gases like carbon monoxide, which can accumulate inside the living space if not adequately vented. Moreover, poor airflow can cause the furnace to overheat, placing additional stress on components and leading to premature failure or hazardous conditions.

Another issue is the accumulation of flammable materials near the furnace due to limited space in mobile homes. Items like clothes, furniture, and other household goods might be stored too close to the furnace unit inadvertently blocking essential vents or coming into direct contact with hot surfaces. Over time, this proximity increases the risk of fire hazards.

To mitigate these risks, it's vital for homeowners and technicians alike to ensure that adequate clearance guidelines are followed during installation and maintenance checks. This involves reviewing manufacturer specifications for specific distance requirements between the furnace and surrounding structures or objects. Additionally, regular inspections should be conducted to ensure that no debris or clutter has encroached upon these clearances over time.

Education also plays an important role in addressing combustion clearance issues. Mobile home residents should be made aware of potential hazards associated with their heating

systems and given practical advice on how to maintain safe operating conditions.

In conclusion, identifying and addressing combustion clearance issues in mobile home furnaces is crucial for maintaining both safety and performance standards. By ensuring sufficient space around heating units for air circulation and heat dissipation-and by keeping combustible materials at a safe distance-homeowners can significantly reduce risks while enhancing comfort within their living spaces. Regular inspections coupled with awareness campaigns will further help prevent accidents related to improper furnace installations or neglectful maintenance practices in these unique residential environments.

Common Hazards Associated with Mobile Home HVAC Systems —

- Importance of Safety in Mobile Home HVAC Work
- Common Hazards Associated with Mobile Home HVAC Systems
- Essential Safety Gear and Equipment for Technicians
- Proper Procedures for Handling Refrigerants and Chemicals
- Electrical Safety Protocols for Mobile Home HVAC Work
- Best Practices for Ensuring Structural Integrity During Installation and Maintenance

When it comes to maintaining the efficiency and safety of mobile home furnaces, understanding combustion clearance issues is crucial. These issues often arise when there is insufficient space around the furnace for proper airflow and heat dissipation, leading to a host of problems that can compromise both performance and safety. Identifying these problems early on can prevent costly repairs and ensure the continued comfort and safety of the home's occupants.

One of the most common indicators of combustion clearance issues is unusual noise emanating from the furnace. When a furnace struggles with restricted airflow due to inadequate clearance, it often works harder than necessary, leading to rattling or banging sounds. These noises are not just annoying; they signal that the system is under stress, which

could lead to premature wear or even failure if left unaddressed.

Another telltale sign is fluctuating temperatures within the home. A furnace that cannot ventilate properly may produce inconsistent heating, resulting in cold spots or uneven warmth throughout the living space. This inconsistency is not only uncomfortable but also inefficient, as it forces homeowners to adjust thermostats frequently in an attempt to maintain a steady temperature-ultimately driving up energy costs.

Visible soot or discoloration around vents and registers can also indicate combustion clearance problems. When there isn't enough room for exhaust gases to escape, they can accumulate and leave deposits on surfaces near the furnace outlets. This soot buildup not only signals poor ventilation but also poses a health risk, as it may contain harmful particles that degrade indoor air quality.

Moreover, increased frequency of pilot light extinguishing could signify an issue with combustion clearance. A stable pilot light relies on adequate airflow; if blocked by insufficient space around the unit, it may be prone to going out unexpectedly. This recurring problem requires immediate attention since it affects both operational efficiency and safety.

Lastly, one should pay attention to any unusual smells coming from the furnace area. A musty odor could suggest mildew growth due to condensation build-up around improperly cleared areas, while a metallic smell might indicate overheating components struggling without sufficient ventilation.

In conclusion, recognizing these common indicators of combustion clearance issues in mobile home furnaces-unusual noises, fluctuating temperatures, visible soot deposits, frequent pilot light failures, and strange odors-is essential for maintaining both safe operation and optimal performance. Addressing these signs promptly through inspection and appropriate adjustments ensures long-term reliability and prevents potential hazards associated with neglected maintenance tasks in these compact yet crucial heating systems.

Posted by on

Essential Safety Gear and Equipment for Technicians

The concept of combustion clearance is critical in understanding the overall performance and safety of mobile home furnaces. The term "restricted combustion clearance" refers to a situation where the space allocated for air and fuel mixture to combust efficiently is reduced or obstructed. This seemingly minor issue can have significant implications on the functionality, efficiency, and safety of heating systems in mobile homes.

In mobile home furnaces, optimal combustion clearance ensures that there is enough space for a complete mix of air and fuel to ignite properly. This process is fundamental to achieving efficient energy release, which translates into effective heating. However, when this clearance is restricted due to design flaws, debris accumulation, or improper maintenance, it can lead to incomplete combustion. Incomplete combustion not only reduces the furnace's efficiency but also poses severe risks by producing carbon monoxide—a dangerous gas that can be lethal at high concentrations.

The impact on system performance can be profound. Firstly, restricted combustion clearance often leads to inefficient fuel use. The furnace must consume more fuel to achieve desired heat levels because the flame's size and intensity are compromised by inadequate space. This results in higher operational costs for homeowners who rely on these systems during colder months.

Moreover, restricted clearance may cause increased wear and tear on furnace components due to overheating or inefficient burning cycles. Components such as burners and heat exchangers might degrade faster than anticipated, leading to frequent breakdowns and costly repairs. Over time, this degradation diminishes the reliability of the heating system—an undesirable outcome for any homeowner seeking comfort during winter months.

Safety concerns also multiply with restricted combustion clearance. As previously mentioned, incomplete combustion can lead to carbon monoxide production—a grave health hazard that

requires immediate attention through proper ventilation or professional inspection services. Furthermore, obstruction within the furnace may lead to flame rollout or backdrafting scenarios where flames escape their intended path-posing fire hazards if not rectified promptly.

Identifying these issues early through regular inspections and maintenance is crucial for mitigating their impact on system performance. Homeowners should prioritize routine checks conducted by certified professionals who can recognize signs of restricted clearance such as abnormal noises during operation or visible soot deposits around vents.

In conclusion, addressing restricted combustion clearance in mobile home furnaces is vital for maintaining optimal system performance while ensuring safety standards are met adequately. By recognizing its impacts-from fuel inefficiency and component degradation to potential health risks-homeowners can make informed decisions about regular maintenance practices necessary for safeguarding both their investment and well-being throughout seasonal changes demanding reliable heating solutions.





Proper Procedures for Handling Refrigerants and Chemicals

Identifying combustion clearance issues in mobile home furnaces is a critical aspect of ensuring safety and efficiency in these compact living environments. Mobile homes often have limited space, which can complicate the installation and maintenance of heating systems. Clearance problems can lead to inefficient combustion, increased emissions, or even dangerous conditions such as carbon monoxide leakage or fire hazards. Therefore, employing effective inspection techniques is essential for identifying and addressing these issues promptly.

One common inspection technique involves visual examination. Inspectors should start by visually assessing the furnace area to ensure that there is adequate space around the unit for proper air circulation. This includes checking for any obstructions that may impede airflow or cause heat buildup. The manufacturer's specifications typically provide guidance on the minimum clearances required around the furnace, so it's crucial to compare these recommendations with the actual installation.

Another important technique is using diagnostic tools to assess combustion efficiency directly. A combustion analyzer can be an invaluable tool in this regard, as it measures flue gas concentrations and temperatures to evaluate how well the furnace is burning fuel. By analyzing parameters such as oxygen levels, carbon monoxide emissions, and stack temperature, inspectors can gain insights into whether clearance issues might be affecting combustion quality.

Regular maintenance checks also play a vital role in identifying potential clearance problems before they escalate. Routine tasks such as cleaning or replacing filters, inspecting vents and ducts for blockages, and checking seals on doors and windows can help maintain optimal airflow around the furnace. During these checks, it's important to look for signs of wear or damage that could indicate clearance-related issues affecting performance.

Thermal imaging cameras offer another advanced inspection method by detecting heat patterns around the furnace area. These devices can identify hot spots that might suggest restricted airflow due to inadequate clearances or faulty components within the system. By visualizing these thermal anomalies, inspectors can pinpoint areas where adjustments are necessary to enhance both safety and performance.

Finally, collaboration with experienced professionals cannot be underestimated when dealing with complex clearance problems in mobile home furnaces. HVAC technicians have specialized knowledge about different furnace models and their specific requirements regarding clearances and ventilation needs. Seeking their expertise during inspections

ensures that any potential issues are identified accurately and addressed in line with industry standards.

In conclusion, identifying combustion clearance issues in mobile home furnaces involves a combination of visual assessments, diagnostic testing, regular maintenance practices, thermal imaging technology, and professional consultation. By utilizing these inspection techniques effectively, homeowners can ensure their heating systems operate safely and efficiently while minimizing risks associated with improper clearances-ultimately contributing to a more comfortable living environment within their mobile homes.

Electrical Safety Protocols for Mobile Home HVAC Work

When it comes to mobile home furnaces, ensuring safety is of paramount importance. The confined and often compact nature of mobile homes means that any malfunction or oversight in the heating system can quickly escalate into a hazardous situation. One critical aspect that warrants close attention is combustion clearance. Identifying and addressing issues related to this can prevent potential dangers such as carbon monoxide poisoning or even fires.

Combustion clearance refers to the safe distance required between the furnace and any combustible materials. This space is crucial for allowing adequate air circulation, which aids in efficient fuel burning while preventing heat build-up that could ignite nearby materials. In mobile homes, where space is at a premium, maintaining these clearances can pose a challenge but is essential for safety.

To effectively identify combustion clearance issues, it's important to conduct regular inspections of the furnace installation. Homeowners should be vigilant about checking for any signs of restricted airflow or heat damage around the unit. This includes looking for discoloration on walls or ceilings near the furnace, which could indicate excessive heat exposure.

In addition to visual inspections, ensuring proper maintenance of the furnace itself plays a substantial role in detecting problems early. Regular servicing by qualified technicians can uncover hidden issues such as blocked vents or damaged components that might compromise safe operation. These professionals are trained to measure and verify the necessary clearances according to manufacturer specifications and local building codes.

Precautionary measures should extend beyond simple inspections and professional servicing. Mobile home owners can take proactive steps by keeping flammable objects away from the furnace area altogether. Items such as curtains, furniture, and cleaning supplies should not be stored near the heating unit.

Furthermore, installing carbon monoxide detectors throughout the mobile home provides an additional layer of security. As furnaces burn fuel, they produce carbon monoxide-a colorless and odorless gas that can be deadly if inhaled over time. Detectors are designed to alert occupants if dangerous levels are present in the air, offering time to evacuate and address any underlying issues with the heating system.

Finally, education plays an invaluable role in enhancing safety regarding combustion clearance concerns in mobile home furnaces. Homeowners should familiarize themselves with their specific furnace model's guidelines on safe distances and maintenance requirements. Understanding how their system operates empowers them to recognize when something seems amiss-allowing for timely intervention before minor problems turn into major hazards.

In conclusion, identifying combustion clearance issues involves a combination of regular inspections, professional maintenance, proactive organization around furnaces, installation of safety devices like carbon monoxide detectors, and ongoing education on best practices for usage and care of heating systems within mobile homes. By prioritizing these steps diligently ensures both comfort during colder months but more importantly guarantees peace of mind knowing your living environment remains protected against unforeseen risks associated with improper furnace operation-a commitment every homeowner should make unequivocally towards safeguarding their household's well-being year-round!

Best Practices for Ensuring Structural Integrity During Installation and Maintenance

In the realm of mobile home living, maintaining a comfortable and safe environment is paramount. One crucial aspect that often demands attention is the furnace system, which plays a vital role in providing warmth during colder months. A key factor in ensuring the efficiency and safety of these furnaces is optimizing combustion clearance, a term that might not be familiar to all but is essential for both performance and longevity of heating systems.

Combustion clearance refers to the space within the furnace where air and fuel mix before being ignited. This area must be carefully regulated to ensure that combustion occurs efficiently and safely. When combustion clearance issues arise, they can lead to incomplete burning of fuel, causing excessive emissions, reduced heat output, and even potential hazards such as carbon monoxide buildup.

Identifying combustion clearance issues in mobile home furnaces requires vigilance and an understanding of common symptoms. Homeowners should look out for signs like unusual noises during operation, inconsistent heating output, or an unexpected rise in energy bills. Regular visual inspections can also reveal soot accumulation or discoloration around the furnace area-indicators that combustion may not be occurring as intended.

Once identified, addressing these issues involves implementing effective solutions and maintenance practices. One fundamental approach is ensuring adequate ventilation around the furnace unit. Proper airflow is critical to maintaining appropriate combustion clearance and preventing harmful gas buildup. Homeowners should regularly check vents for blockages or obstructions that could impede this crucial airflow.

Routine maintenance practices are equally important in optimizing furnace performance. Replacing air filters on a regular basis helps ensure clean air supply to the combustion chamber, enhancing both efficiency and safety. Additionally, scheduling professional inspections at least once a year allows experts to assess burner alignment and make necessary adjustments to maintain proper clearance levels.

In some cases, technological upgrades can offer more advanced solutions for optimizing combustion clearance. Modern furnace models often come equipped with sensors that monitor air-fuel ratios in real-time, making automatic adjustments as needed for optimal performance. While this may require an initial investment, it can significantly enhance both energy efficiency and safety over time.

Ultimately, by understanding the importance of combustion clearance and adopting proactive solutions along with diligent maintenance practices, mobile home owners can ensure their furnaces operate at peak performance while minimizing risks associated with improper combustion. Through vigilance and regular care, residents can enjoy warm winters with peace of mind knowing their heating systems are both efficient and safe.

About Prefabrication

Not to be confused with Preproduction.

"Prefab" redirects here. For other uses, see Prefab (disambiguation).



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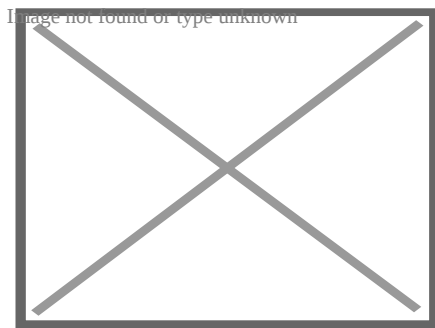
Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. Some researchers refer it to “various materials joined together to form a component of the final installation procedure”.

The most commonly cited definition is by Goodier and Gibb in 2007, which described the process of manufacturing and preassembly of a certain number of building components, modules, and elements before their shipment and installation on construction sites.^[1]

The term *prefabrication* also applies to the manufacturing of things other than structures at a fixed site. It is frequently used when fabrication of a section of a machine or any movable structure is shifted from the main manufacturing site to another location, and the section is supplied assembled and ready to fit. It is not generally used to refer to electrical or electronic components of a machine, or mechanical parts such as pumps, gearboxes and compressors which are usually supplied as separate items, but to sections of the body of the machine which in the past were fabricated with the whole machine. Prefabricated parts of the body of the machine may be called 'sub-assemblies' to distinguish them from the other components.

Process and theory

[edit]



Levittown, Puerto Rico

An example from house-building illustrates the process of prefabrication. The conventional method of building a house is to transport bricks, timber, cement, sand, steel and construction aggregate, etc. to the site, and to construct the house on site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof are prefabricated (assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together.

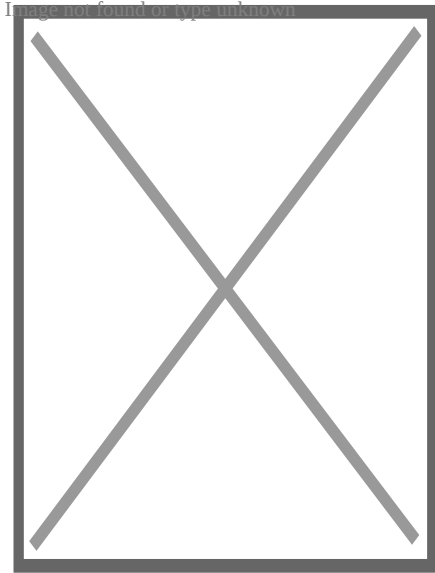
Prefabrication is used in the manufacture of ships, aircraft and all kinds of vehicles and machines where sections previously assembled at the final point of manufacture are assembled elsewhere instead, before being delivered for final assembly.

The theory behind the method is that time and cost is saved if similar construction tasks can be grouped, and assembly line techniques can be employed in prefabrication at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be reduced. The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed. Prefabrication avoids the need to transport so many skilled workers to the construction site, and other restricting conditions such as a lack of power, lack of water, exposure to harsh weather or a hazardous environment

are avoided. Against these advantages must be weighed the cost of transporting prefabricated sections and lifting them into position as they will usually be larger, more fragile and more difficult to handle than the materials and components of which they are made.

History

[edit]



"Loren" Iron House, at Old Gippsstown in Moe, Australia

Prefabrication has been used since ancient times. For example, it is claimed that the world's oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site.^{*[citation needed]*}

Sinhalese kings of ancient Sri Lanka have used prefabricated buildings technology to erect giant structures, which dates back as far as 2000 years, where some sections were prepared separately and then fitted together, specially in the Kingdom of Anuradhapura and Polonnaruwa.

After the great Lisbon earthquake of 1755, the Portuguese capital, especially the Baixa district, was rebuilt by using prefabrication on an unprecedented scale. Under the guidance of Sebastião José de Carvalho e Melo, popularly known as the Marquis de Pombal, the most powerful royal minister of D. Jose I, a new Pombaline style of architecture and urban planning arose, which introduced early anti-seismic design features and innovative prefabricated construction methods, according to which large multistory buildings were entirely manufactured outside the city, transported in pieces and then assembled on site. The process, which lasted into the nineteenth century,

lodged the city's residents in safe new structures unheard-of before the quake.

Also in Portugal, the town of Vila Real de Santo António in the Algarve, founded on 30 December 1773, was quickly erected through the use of prefabricated materials en masse. The first of the prefabricated stones was laid in March 1774. By 13 May 1776, the centre of the town had been finished and was officially opened.

In 19th century Australia a large number of prefabricated houses were imported from the United Kingdom.

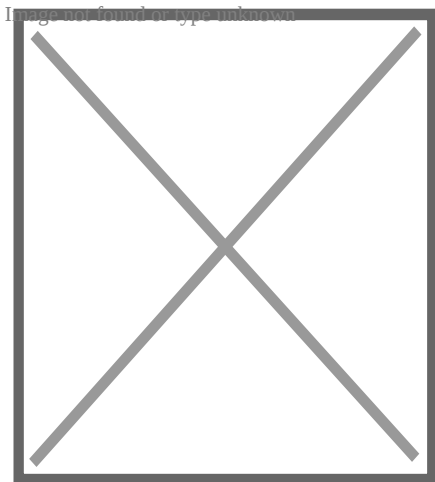
The method was widely used in the construction of prefabricated housing in the 20th century, such as in the United Kingdom as temporary housing for thousands of urban families "bombed out" during World War II. Assembling sections in factories saved time on-site and the lightness of the panels reduced the cost of foundations and assembly on site. Coloured concrete grey and with flat roofs, prefab houses were uninsulated and cold and life in a prefab acquired a certain stigma, but some London prefabs were occupied for much longer than the projected 10 years.^[2]

The Crystal Palace, erected in London in 1851, was a highly visible example of iron and glass prefabricated construction; it was followed on a smaller scale by Oxford Rewley Road railway station.

During World War II, prefabricated Cargo ships, designed to quickly replace ships sunk by Nazi U-boats became increasingly common. The most ubiquitous of these ships was the American Liberty ship, which reached production of over 2,000 units, averaging 3 per day.

Current uses

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A house being built with prefabricated concrete panels.

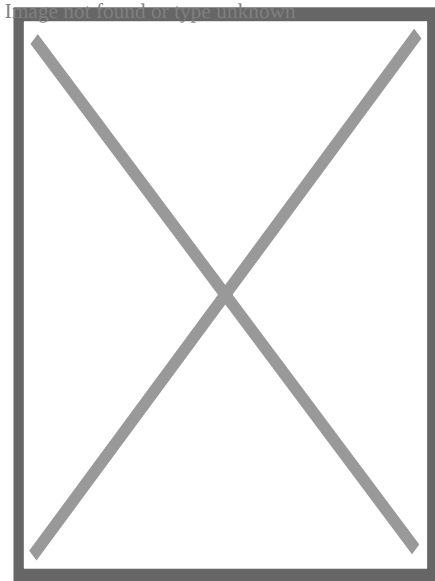
The most widely used form of prefabrication in building and civil engineering is the use of prefabricated concrete and prefabricated steel sections in structures where a particular part or form is repeated many times. It can be difficult to construct the formwork required to mould concrete components on site, and delivering wet concrete to the site before it starts to set requires precise time management. Pouring concrete sections in a factory brings the advantages of being able to re-use moulds and the concrete can be mixed on the spot without having to be transported to and pumped wet on a congested construction site. Prefabricating steel sections reduces on-site cutting and welding costs as well as the associated hazards.

Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units. Prefabrication is an essential part of the industrialization of construction.^[3] The quality of prefabricated housing units had increased to the point that they may not be distinguishable from traditionally built units to those that live in them. The technique is also used in office blocks, warehouses and factory buildings. Prefabricated steel and glass sections are widely used for the exterior of large buildings.

Detached houses, cottages, log cabin, saunas, etc. are also sold with prefabricated elements. Prefabrication of modular wall elements allows building of complex thermal insulation, window frame components, etc. on an assembly line, which tends to improve quality over on-site construction of each individual wall or frame. Wood construction in particular benefits from the improved quality. However, tradition often favors building by hand in many countries, and the image of prefab as a "cheap" method only slows its adoption. However, current practice already allows the modifying the floor plan according to the customer's requirements and selecting the surfacing material, e.g. a personalized brick facade can be masoned even if the load-supporting elements are timber.

Today, prefabrication is used in various industries and construction sectors such as healthcare, retail, hospitality, education, and public administration, due to its many advantages and benefits over traditional on-site construction, such as reduced installation time and cost savings.^[4] Being used in single-story buildings as well as in multi-story projects and constructions. Providing the possibility of applying it to a specific part of the project or to the whole of it.

The efficiency and speed in the execution times of these works offer that, for example, in the case of the educational sector, it is possible to execute the projects without the cessation of the operations of the educational facilities during the development of the same.



Transportation of prefabricated Airbus wing assembly

Prefabrication saves engineering time on the construction site in civil engineering projects. This can be vital to the success of projects such as bridges and avalanche galleries, where weather conditions may only allow brief periods of construction. Prefabricated bridge elements and systems offer bridge designers and contractors significant advantages in terms of construction time, safety, environmental impact, constructibility, and cost. Prefabrication can also help minimize the impact on traffic from bridge building. Additionally, small, commonly used structures such as concrete pylons are in most cases prefabricated.

Radio towers for mobile phone and other services often consist of multiple prefabricated sections. Modern lattice towers and guyed masts are also commonly assembled of prefabricated elements.

Prefabrication has become widely used in the assembly of aircraft and spacecraft, with components such as wings and fuselage sections often being manufactured in different countries or states from the final assembly site. However, this is sometimes for political rather than commercial reasons, such as for Airbus.

Advantages

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- Moving partial assemblies from a factory often costs less than moving pre-production resources to each site
- Deploying resources on-site can add costs; prefabricating assemblies can save costs by reducing on-site work
- Factory tools - jigs, cranes, conveyors, etc. - can make production faster and more precise

- Factory tools - shake tables, hydraulic testers, etc. - can offer added quality assurance
- Consistent indoor environments of factories eliminate most impacts of weather on production
- Cranes and reusable factory supports can allow shapes and sequences without expensive on-site falsework
- Higher-precision factory tools can aid more controlled movement of building heat and air, for lower energy consumption and healthier buildings
- Factory production can facilitate more optimal materials usage, recycling, noise capture, dust capture, etc.
- Machine-mediated parts movement, and freedom from wind and rain can improve construction safety
- Homogeneous manufacturing allows high standardization and quality control, ensuring quality requirements subject to performance and resistance tests, which also facilitate high scalability of construction projects. [5]
- The specific production processes in industrial assembly lines allow high sustainability, which enables savings of up to 20% of the total final cost, as well as considerable savings in indirect costs. [6]

Disadvantages

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- Transportation costs may be higher for voluminous prefabricated sections (especially sections so big that they constitute oversize loads requiring special signage, escort vehicles, and temporary road closures) than for their constituent materials, which can often be packed more densely and are more likely to fit onto standard-sized vehicles.
- Large prefabricated sections may require heavy-duty cranes and precision measurement and handling to place in position.

Off-site fabrication

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Off-site fabrication is a process that incorporates prefabrication and pre-assembly. The process involves the design and manufacture of units or modules, usually remote from the work site, and the installation at the site to form the permanent works at the site. In its fullest sense, off-site fabrication requires a project strategy that will change the orientation of the project process from construction to manufacture to installation. Examples of off-site fabrication are wall panels for homes, wooden truss bridge spans, airport control stations.

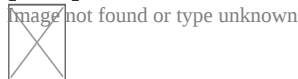
There are four main categories of off-site fabrication, which is often also referred to as off-site construction. These can be described as component (or sub-assembly)

systems, panelised systems, volumetric systems, and modular systems. Below these categories different branches, or technologies are being developed. There are a vast number of different systems on the market which fall into these categories and with recent advances in digital design such as building information modeling (BIM), the task of integrating these different systems into a construction project is becoming increasingly a "digital" management proposition.

The prefabricated construction market is booming. It is growing at an accelerated pace both in more established markets such as North America and Europe and in emerging economies such as the Asia-Pacific region (mainly China and India). Considerable growth is expected in the coming years, with the prefabricated modular construction market expected to grow at a CAGR (compound annual growth rate) of 8% between 2022 and 2030. It is expected to reach USD 271 billion by 2030. ^[7]

See also

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Wikimedia Commons has media related to ***Prefabrication***.

- Prefabricated home
- Prefabricated buildings
- Concrete perpend
- Panelák
- Tower block
- St Crispin's School — an example of a prefabricated school building
- Nonsuch House, first prefabricated building
- Agile construction
- Intermediate good

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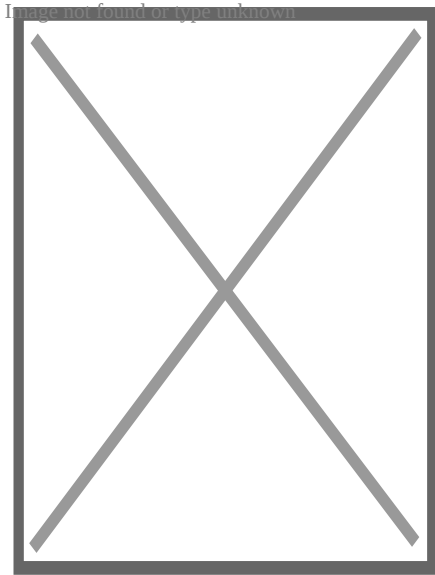
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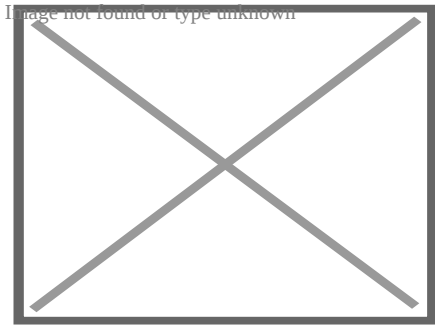
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External heat exchanger of an air-source heat pump for both heating and cooling



Mitsubishi heat pump interior air handler wall unit

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Part of a series on

Sustainable energy

A car drives past 4 wind turbines in a field, with more on the horizon

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Energy conservation

- Arcology
- Building insulation
- Cogeneration
- Compact fluorescent lamp
- Eco hotel
- Eco-cities
- Ecohouse
- Ecolabel
- Efficient energy use
- Energy audit
- Energy efficiency implementation
- Energy recovery
- Energy recycling
- Energy saving lamp
- Energy Star
- Energy storage
- Environmental planning
- Environmental technology
- Fossil fuel phase-out
- Glass in green buildings
- Green building and wood
- Green building
- Heat pump
- List of low-energy building techniques
- Low-energy house
- Microgeneration
- Passive house
- Passive solar building design
- Sustainable architecture
- Sustainable city
- Sustainable habitat
- Sustainable refurbishment
- Thermal energy storage
- Tropical green building
- Waste-to-energy
- Zero heating building
- Zero-energy building

Renewable energy

- Biofuel
 - Sustainable
- Biogas
- Biomass
- Carbon-neutral fuel
- Geothermal energy
- Geothermal power
- Geothermal heating
- Hydropower
 - Hydroelectricity
 - Micro hydro
 - Pico hydro
 - Run-of-the-river
 - Small hydro
- Marine current power
- Marine energy
- Tidal power
 - Tidal barrage
 - Tidal farm
 - Tidal stream generator
- Ocean thermal energy conversion
- Renewable energy transition
- Renewable heat
- Solar
- Wave
- Wind
 - Community
 - Farm
 - Floating wind turbine
 - Forecasting
 - Industry
 - Lens
 - Outline
 - Rights
 - Turbine
 - Windbelt
 - Windpump

Sustainable transport

- Green vehicle
 - Electric vehicle
 - Bicycle
 - Solar vehicle
 - Wind-powered vehicle
- Hybrid vehicle
 - Human-electric
 - Twike
 - Plug-in
- Human-powered transport
 - Helicopter
 - Hydrofoil
 - Land vehicle
 - Bicycle
 - Cycle rickshaw
 - Kick scooter
 - Quadracycle
 - Tricycle
 - Velomobile
 - Roller skating
 - Skateboarding
 - Walking
 - Watercraft
- Personal transporter
- Rail transport
 - Tram
- Rapid transit
 - Personal rapid transit
-  Category
-  Renewable energy portal

A **heat pump** is a device that consumes energy (usually electricity) to transfer heat from a cold heat sink to a hot heat sink. Specifically, the heat pump transfers thermal energy using a refrigeration cycle, cooling the cool space and warming the warm space.^[1] In cold weather, a heat pump can move heat from the cool outdoors to warm a house (e.g. winter); the pump may also be designed to move heat from the house to the warmer outdoors in warm weather (e.g. summer). As they transfer heat rather than generating heat, they are more energy-efficient than other ways of heating or cooling a home.^[2]

A gaseous refrigerant is compressed so its pressure and temperature rise. When operating as a heater in cold weather, the warmed gas flows to a heat exchanger in the indoor space where some of its thermal energy is transferred to that indoor space, causing the gas to condense to its liquid state. The liquified refrigerant flows to a heat exchanger in the outdoor space where the pressure falls, the liquid evaporates and the temperature of the gas falls. It is now colder than the temperature of the outdoor space being used as a heat source. It can again take up energy from the heat source, be compressed and repeat the cycle.

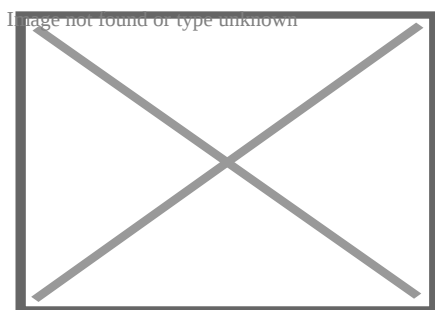
Air source heat pumps are the most common models, while other types include ground source heat pumps, water source heat pumps and exhaust air heat pumps.^[3] Large-scale heat pumps are also used in district heating systems.^[4]

The efficiency of a heat pump is expressed as a coefficient of performance (COP), or seasonal coefficient of performance (SCOP). The higher the number, the more efficient a heat pump is. For example, an air-to-water heat pump that produces 6kW at a SCOP of 4.62 will give over 4kW of energy into a heating system for every kilowatt of energy that the heat pump uses itself to operate. When used for space heating, heat pumps are typically more energy-efficient than electric resistance and other heaters.

Because of their high efficiency and the increasing share of fossil-free sources in electrical grids, heat pumps are playing a role in climate change mitigation.^[5]^[6] Consuming 1 kWh of electricity, they can transfer 1^[7] to 4.5 kWh of thermal energy into a building. The carbon footprint of heat pumps depends on how electricity is generated, but they usually reduce emissions.^[8] Heat pumps could satisfy over 80% of global space and water heating needs with a lower carbon footprint than gas-fired condensing boilers: however, in 2021 they only met 10%.^[4]

Principle of operation

[edit]



A: indoor compartment, B: outdoor compartment, I: insulation, 1: condenser, 2: expansion valve, 3: evaporator, 4: compressor

Main articles: Heat pump and refrigeration cycle and Vapor-compression refrigeration

Heat flows spontaneously from a region of higher temperature to a region of lower temperature. Heat does not flow spontaneously from lower temperature to higher, but it can be made to flow in this direction if work is performed. The work required to transfer a given amount of heat is usually much less than the amount of heat; this is the motivation for using heat pumps in applications such as the heating of water and the interior of buildings.^[9]

The amount of work required to drive an amount of heat Q from a lower-temperature reservoir such as ambient air to a higher-temperature reservoir such as the interior of a

building is:  where

- W is the work performed on the working fluid by the heat pump's compressor.
- Q is the heat transferred from the lower-temperature reservoir to the higher-temperature reservoir.
- COP is the instantaneous coefficient of performance for the heat pump at the temperatures prevailing in the reservoirs at one instant.

The coefficient of performance of a heat pump is greater than one so the work required is less than the heat transferred, making a heat pump a more efficient form of heating than electrical resistance heating. As the temperature of the higher-temperature reservoir increases in response to the heat flowing into it, the coefficient of performance decreases, causing an increasing amount of work to be required for each unit of heat being transferred.^[9]

The coefficient of performance, and the work required by a heat pump can be calculated easily by considering an ideal heat pump operating on the reversed Carnot cycle:

- If the low-temperature reservoir is at a temperature of 270 K (−3 °C) and the interior of the building is at 280 K (7 °C) the relevant coefficient of performance is 27. This means only 1 joule of work is required to transfer 27 joules of heat from a reservoir at 270 K to another at 280 K. The one joule of work ultimately ends up as thermal energy in the interior of the building so for each 27 joules of heat that are removed from the low-temperature reservoir, 28 joules of heat are added to the building interior, making the heat pump even more attractive from an efficiency perspective.^[note 1]
- As the temperature of the interior of the building rises progressively to 300 K (27 °C) the coefficient of performance falls progressively to 9. This means each joule of work is responsible for transferring 9 joules of heat out of the low-temperature reservoir and into the building. Again, the 1 joule of work ultimately ends up as thermal energy in the interior of the building so 10 joules of heat are added to the building interior.^[note 2]

This is the theoretical amount of heat pumped but in practice it will be less for various reasons, for example if the outside unit has been installed where there is not enough airflow. More data sharing with owners and academics—perhaps from heat meters—could improve efficiency in the long run.^[11]

History

[edit]

Milestones:

1748

William Cullen demonstrates artificial refrigeration.^[12]

1834

Jacob Perkins patents a design for a practical refrigerator using dimethyl ether.^[13]

1852

Lord Kelvin describes the theory underlying heat pumps.^[14]

1855–1857

Peter von Rittinger develops and builds the first heat pump.^[15]

1877

In the period before 1875, heat pumps were for the time being pursued for vapour compression evaporation (open heat pump process) in salt works with their obvious advantages for saving wood and coal. In 1857, Peter von Rittinger was the first to try to implement the idea of vapor compression in a small pilot plant. Presumably inspired by Rittinger's experiments in Ebensee, Antoine-Paul Piccard from the University of Lausanne and the engineer J. H. Weibel from the Weibel–Briquet company in Geneva built the world's first really functioning vapor compression system with a two-stage piston compressor. In 1877 this first heat pump in Switzerland was installed in the Bex salt works.^{[14][16]}

1928

Aurel Stodola constructs a closed-loop heat pump (water source from Lake Geneva) which provides heating for the Geneva city hall to this day.^[17]

1937–1945

During the First World War, fuel prices were very high in Switzerland but it had plenty of hydropower.^[14]

:*Äf* *Æ* *Ä*†*â*€™*Äf* *â*€ *Ä*¢*â*,*-â*,,¢*Äf* *Æ* *Ä*¢*â*,*-Ä* *Äf* *Ä*¢*Ä*¢*â*€Š*Ä*-*Ä*¢*â*€ž*Ä*¢*Äf* *Æ* *Ä*†*â*€™*Äf* *Ä*¢*Ä*¢*â*€

In the period before and especially during the Second World War, when neutral Switzerland was completely surrounded by fascist-ruled countries, the coal shortage became alarming again. Thanks to their leading position in energy technology, the Swiss companies Sulzer, Escher Wyss and Brown Boveri built and put in operation around 35 heat pumps between 1937 and 1945. The main heat sources were lake water, river water, groundwater, and waste heat. Particularly noteworthy are the six historic heat pumps from the city of Zurich with heat outputs from 100 kW to 6 MW. An international milestone is the heat pump built by Escher

Wyss in 1937/38 to replace the wood stoves in the City Hall of Zurich. To avoid noise and vibrations, a recently developed rotary piston compressor was used. This historic heat pump heated the town hall for 63 years until 2001. Only then was it replaced by a new, more efficient heat pump.^[14]

1945

John Sumner, City Electrical Engineer for Norwich, installs an experimental water-source heat pump fed central heating system, using a nearby river to heat new Council administrative buildings. It had a seasonal efficiency ratio of 3.42, average thermal delivery of 147 kW, and peak output of 234 kW.^[18]

1948

Robert C. Webber is credited as developing and building the first ground-source heat pump.^[19]

1951

First large scale installation—the Royal Festival Hall in London is opened with a town gas-powered reversible water-source heat pump, fed by the Thames, for both winter heating and summer cooling needs.^[18]

2019

The Kigali Amendment to phase out harmful refrigerants takes effect.

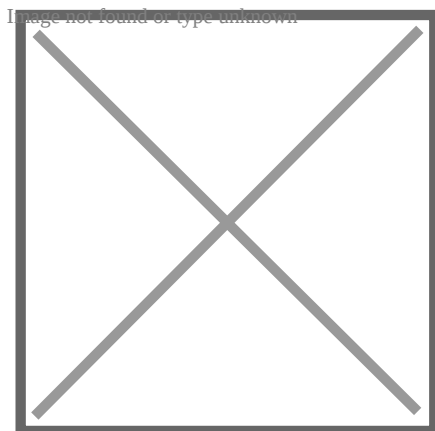
Types

[edit]

Air-source

[edit]

This section is an excerpt from Air source heat pump.^[edit]



Heat pump on balcony of apartment

An air source heat pump (ASHP) is a heat pump that can absorb heat from air outside a building and release it inside; it uses the same vapor-compression refrigeration process

and much the same equipment as an air conditioner, but in the opposite direction. ASHPs are the most common type of heat pump and, usually being smaller, tend to be used to heat individual houses or flats rather than blocks, districts or industrial processes.^{[20][21]}

Air-to-air heat pumps provide hot or cold air directly to rooms, but do not usually provide hot water. *Air-to-water* heat pumps use radiators or underfloor heating to heat a whole house and are often also used to provide domestic hot water.

An ASHP can typically gain 4 kWh thermal energy from 1 kWh electric energy. They are optimized for flow temperatures between 30 and 40 °C (86 and 104 °F), suitable for buildings with heat emitters sized for low flow temperatures. With losses in efficiency, an ASHP can even provide full central heating with a flow temperature up to 80 °C (176 °F).^[22]

As of 2023 about 10% of building heating worldwide is from ASHPs. They are the main way to phase out gas boilers (also known as "furnaces") from houses, to avoid their greenhouse gas emissions.^[23]

Air-source heat pumps are used to move heat between two heat exchangers, one outside the building which is fitted with fins through which air is forced using a fan and the other which either directly heats the air inside the building or heats water which is then circulated around the building through radiators or underfloor heating which releases the heat to the building. These devices can also operate in a cooling mode where they extract heat via the internal heat exchanger and eject it into the ambient air using the external heat exchanger. Some can be used to heat water for washing which is stored in a domestic hot water tank.^[24]

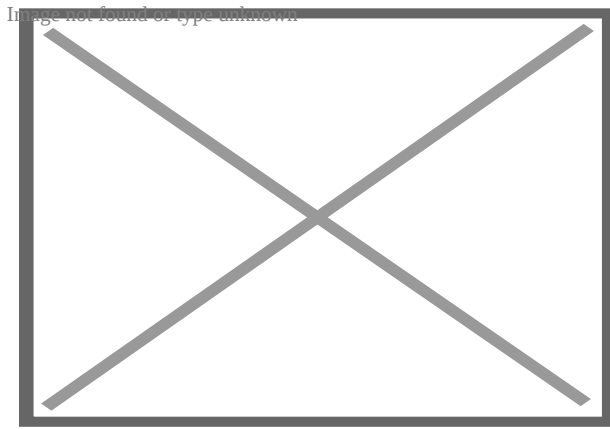
Air-source heat pumps are relatively easy and inexpensive to install, so are the most widely used type. In mild weather, coefficient of performance (COP) may be between 2 and 5, while at temperatures below around 7 °C (45 °F) an air-source heat pump may still achieve a COP of 1 to 4.^[25]

While older air-source heat pumps performed relatively poorly at low temperatures and were better suited for warm climates, newer models with variable-speed compressors remain highly efficient in freezing conditions allowing for wide adoption and cost savings in places like Minnesota and Maine in the United States.^[26]

Ground source

[edit]

This section is an excerpt from Ground source heat pump.[edit]



A heat pump in combination with heat and cold storage

A ground source heat pump (also geothermal heat pump) is a heating/cooling system for buildings that use a type of heat pump to transfer heat to or from the ground, taking advantage of the relative constancy of temperatures of the earth through the seasons. Ground-source heat pumps (GSHPs) – or geothermal heat pumps (GHP), as they are commonly termed in North America – are among the most energy-efficient technologies for providing HVAC and water heating, using far less energy than can be achieved by burning a fuel in a boiler/furnace or by use of resistive electric heaters.

Efficiency is given as a coefficient of performance (CoP) which is typically in the range 3 – 6, meaning that the devices provide 3 – 6 units of heat for each unit of electricity used. Setup costs are higher than for other heating systems, due to the requirement to install ground loops over large areas or to drill bore holes, and for this reason, ground source is often suitable when new blocks of flats are built.^[27] Otherwise air-source heat pumps are often used instead.

Heat recovery ventilation

[edit]

Main article: Heat recovery ventilation

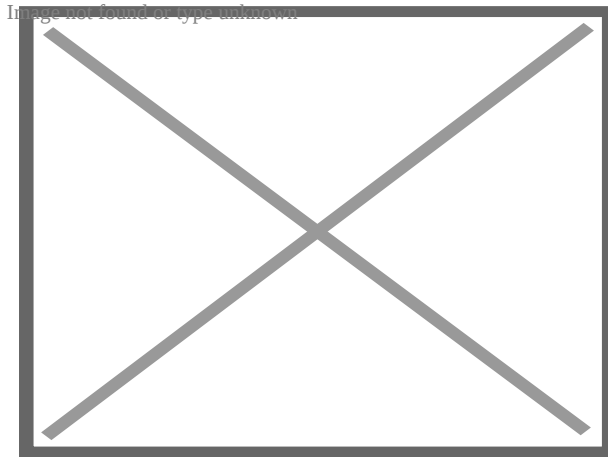
Exhaust air heat pumps extract heat from the exhaust air of a building and require mechanical ventilation. Two classes exist:

- Exhaust air-air heat pumps transfer heat to intake air.
- Exhaust air-water heat pumps transfer heat to a heating circuit that includes a tank of domestic hot water.

Solar-assisted

[edit]

This section is an excerpt from Solar-assisted heat pump.[edit]



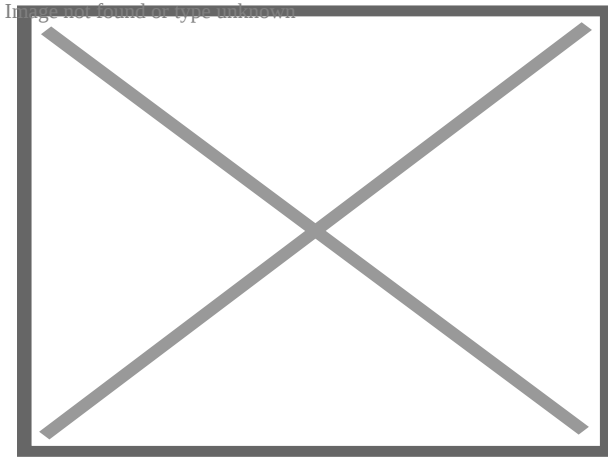
Hybrid photovoltaic-thermal solar panels of a SAHP in an experimental installation at Department of Energy at Polytechnic of Milan

A solar-assisted heat pump (SAHP) is a machine that combines a heat pump and thermal solar panels and/or PV solar panels in a single integrated system.^[28] Typically these two technologies are used separately (or only placing them in parallel) to produce hot water.^[29] In this system the solar thermal panel performs the function of the low temperature heat source and the heat produced is used to feed the heat pump's evaporator.^[30] The goal of this system is to get high coefficient of performance (COP) and then produce energy in a more efficient and less expensive way.

It is possible to use any type of solar thermal panel (sheet and tubes, roll-bond, heat pipe, thermal plates) or hybrid (mono/polycrystalline, thin film) in combination with the heat pump. The use of a hybrid panel is preferable because it allows covering a part of the electricity demand of the heat pump and reduce the power consumption and consequently the variable costs of the system.

Water-source

[edit]



Water-source heat exchanger being installed

A water-source heat pump works in a similar manner to a ground-source heat pump, except that it takes heat from a body of water rather than the ground. The body of water does, however, need to be large enough to be able to withstand the cooling effect of the unit without freezing or creating an adverse effect for wildlife.^[31] The largest water-source heat pump was installed in the Danish town of Esbjerg in 2023.^{[32][33]}

Others

[edit]

A thermoacoustic heat pump operates as a thermoacoustic heat engine without refrigerant but instead uses a standing wave in a sealed chamber driven by a loudspeaker to achieve a temperature difference across the chamber.^[34]

Electrocaloric heat pumps are solid state.^[35]

Applications

[edit]

The International Energy Agency estimated that, as of 2021, heat pumps installed in buildings have a combined capacity of more than 1000 GW.^[4] They are used for heating, ventilation, and air conditioning (HVAC) and may also provide domestic hot water and tumble clothes drying.^[36] The purchase costs are supported in various countries by consumer rebates.^[37]

Space heating and sometimes also cooling

[edit]

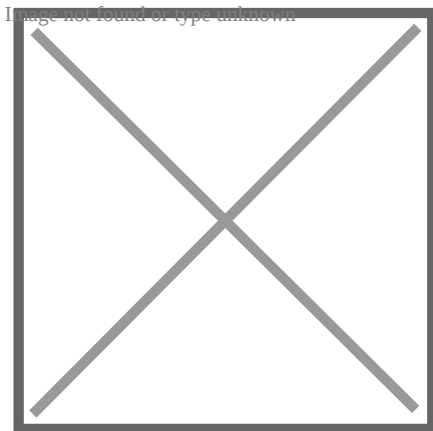
In HVAC applications, a heat pump is typically a vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of *heat flow* (thermal energy movement) may be reversed. The reversing valve switches the direction of refrigerant through the cycle and therefore the heat pump may deliver either heating or cooling to a building.

Because the two heat exchangers, the condenser and evaporator, must swap functions, they are optimized to perform adequately in both modes. Therefore, the Seasonal Energy Efficiency Rating (SEER in the US) or European seasonal energy efficiency ratio of a reversible heat pump is typically slightly less than those of two separately optimized machines. For equipment to receive the US Energy Star rating, it must have a rating of at least 14 SEER. Pumps with ratings of 18 SEER or above are considered highly efficient. The highest efficiency heat pumps manufactured are up to 24 SEER.^[38]

Heating seasonal performance factor (in the US) or Seasonal Performance Factor (in Europe) are ratings of heating performance. The SPF is Total heat output per annum / Total electricity consumed per annum in other words the average heating COP over the year.^[39]

Window mounted heat pump

[edit]



Saddle-style window mounted heat pump 3D sketch

Window mounted heat pumps run on standard 120v AC outlets and provide heating, cooling, and humidity control. They are more efficient with lower noise levels, condensation management, and a smaller footprint than window mounted air conditioners that just do cooling.^[40]

Water heating

[edit]

In water heating applications, heat pumps may be used to heat or preheat water for swimming pools, homes or industry. Usually heat is extracted from outdoor air and transferred to an indoor water tank.^{[41][42]}

District heating

[edit]

Large (megawatt-scale) heat pumps are used for district heating.^[43] However as of 2022 about 90% of district heat is from fossil fuels.^[44] In Europe, heat pumps account for a mere 1% of heat supply in district heating networks but several countries have targets to decarbonise their networks between 2030 and 2040.^[4] Possible sources of heat for such applications are sewage water, ambient water (e.g. sea, lake and river water), industrial waste heat, geothermal energy, flue gas, waste heat from district cooling and heat from solar seasonal thermal energy storage.^[45] Large-scale heat pumps for district heating combined with thermal energy storage offer high flexibility for the integration of variable renewable energy. Therefore, they are regarded as a key technology for limiting climate change by phasing out fossil fuels.^{[45][46]} They are also a crucial element of systems which can both heat and cool districts.^[47]

Industrial heating

[edit]

There is great potential to reduce the energy consumption and related greenhouse gas emissions in industry by application of industrial heat pumps, for example for process heat.^{[48][49]} Short payback periods of less than 2 years are possible, while achieving a

high reduction of CO₂ emissions (in some cases more than 50%).^{[50][51]} Industrial heat pumps can heat up to 200 °C, and can meet the heating demands of many light industries.^{[52][53]} In Europe alone, 15 GW of heat pumps could be installed in 3,000 facilities in the paper, food and chemicals industries.^[4]

Performance

[edit]

Main article: Coefficient of performance

The performance of a heat pump is determined by the ability of the pump to extract heat from a low temperature environment (the *source*) and deliver it to a higher temperature environment (the *sink*).^[54] Performance varies, depending on installation details, temperature differences, site elevation, location on site, pipe runs, flow rates, and maintenance.

In general, heat pumps work most efficiently (that is, the heat output produced for a given energy input) when the difference between the heat source and the heat sink is small. When using a heat pump for space or water heating, therefore, the heat pump will be most efficient in mild conditions, and decline in efficiency on very cold days. Performance metrics supplied to consumers attempt to take this variation into account.

Common performance metrics are the SEER (in cooling mode) and seasonal coefficient of performance (SCOP) (commonly used just for heating), although SCOP can be used for both modes of operation.^[54] Larger values of either metric indicate better performance.^[54] When comparing the performance of heat pumps, the term *performance* is preferred to *efficiency*, with coefficient of performance (COP) being used to describe the ratio of useful heat movement per work input.^[54] An electrical resistance heater has a COP of 1.0, which is considerably lower than a well-designed heat pump which will typically have a COP of 3 to 5 with an external temperature of 10 °C and an internal temperature of 20 °C. Because the ground is a constant temperature source, a ground-source heat pump is not subjected to large temperature fluctuations, and therefore is the most energy-efficient type of heat pump.^[54]

The "seasonal coefficient of performance" (SCOP) is a measure of the aggregate energy efficiency measure over a period of one year which is dependent on regional climate.^[54] One framework for this calculation is given by the Commission Regulation (EU) No. 813/2013.^[55]

A heat pump's operating performance in cooling mode is characterized in the US by either its energy efficiency ratio (EER) or seasonal energy efficiency ratio (SEER), both of which have units of BTU/(h·W) (note that 1 BTU/(h·W) = 0.293 W/W) and larger values indicate better performance.

COP variation with output temperature

Pump type and source	Typical use	35 °C (e.g. heated screed floor)	
High-efficiency air-source heat pump (ASHP), air at 20 °C[56]		2.2	
Two-stage ASHP, air at 20 °C[57]	Low source temperature	2.4	
High-efficiency ASHP, air at 0 °C[56]	Low output temperature	3.8	
Prototype transcritical CO ₂ (R744) heat pump with tripartite gas cooler, source at 0 °C[58]	High output temperature	3.3	$\frac{1}{\eta_{HP}} = \frac{1}{\eta_{HP,ref}} \left(\frac{T_{HP,ref}}{T_{HP}} \right)^{\frac{1}{\eta_{HP,ref}}}$
Ground-source heat pump (GSHP), water at 0 °C[56]		5.0	
GSHP, ground at 10 °C[56]	Low output temperature	7.2	

Theoretical Carnot cycle limit, source 20 °C	5.6
Theoretical Carnot cycle limit, source 0 °C	8.8
Theoretical Lorentzen cycle limit (CO 2 pump), return fluid 25 °C, source 0 °C ^[58]	10.1
Theoretical Carnot cycle limit, source 10 °C	12.3

Carbon footprint

[edit]

The carbon footprint of heat pumps depends on their individual efficiency and how electricity is produced. An increasing share of low-carbon energy sources such as wind and solar will lower the impact on the climate.

heating system	emissions of energy source	efficiency	resulting emissions for thermal energy
heat pump with onshore wind power	11 gCO ₂ /kWh ^[59]	400% (COP=4)	3 gCO ₂ /kWh
heat pump with global electricity mix	436 gCO ₂ /kWh ^[60] (2022)	400% (COP=4)	109 gCO ₂ /kWh

natural-gas thermal (high efficiency)	201 gCO ₂ /kWh ^[61]	90% ^[citation needed]	223 gCO ₂ /kWh
heat pump			
electricity by lignite (old power plant) and low performance	1221 gCO ₂ /kWh ^[61]	300% (COP=3)	407 gCO ₂ /kWh

In most settings, heat pumps will reduce CO₂ emissions compared to heating systems powered by fossil fuels.^[62] In regions accounting for 70% of world energy consumption, the emissions savings of heat pumps compared with a high-efficiency gas boiler are on average above 45% and reach 80% in countries with cleaner electricity mixes.^[4] These values can be improved by 10 percentage points, respectively, with alternative refrigerants. In the United States, 70% of houses could reduce emissions by installing a heat pump.^[63]^[4] The rising share of renewable electricity generation in many countries is set to increase the emissions savings from heat pumps over time.^[4]

Heating systems powered by green hydrogen are also low-carbon and may become competitors, but are much less efficient due to the energy loss associated with hydrogen conversion, transport and use. In addition, not enough green hydrogen is expected to be available before the 2030s or 2040s.^[64]^[65]

Operation

[edit]

See also: Vapor-compression refrigeration



This section **needs additional citations for verification**. Please help improve this article by adding citations to reliable sources in this section. Unsourced material may be challenged and removed. *(May 2021) (Learn how and when to remove this message)*

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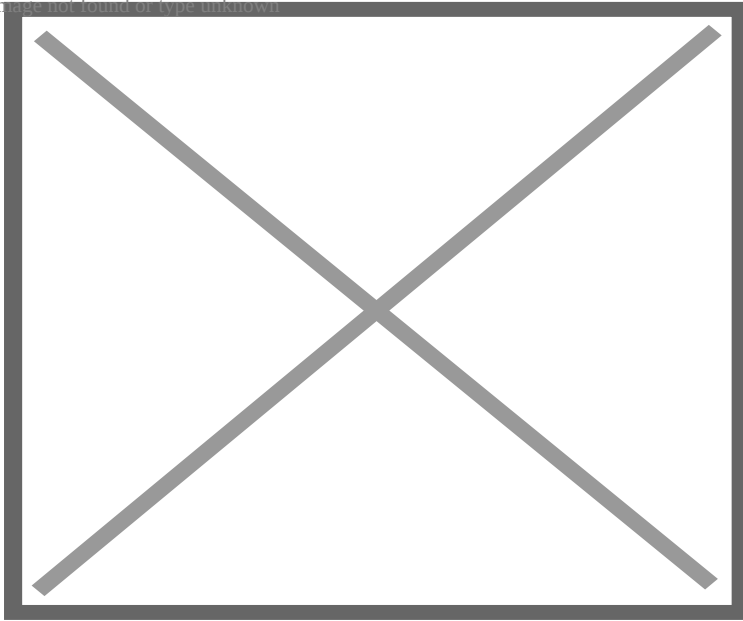
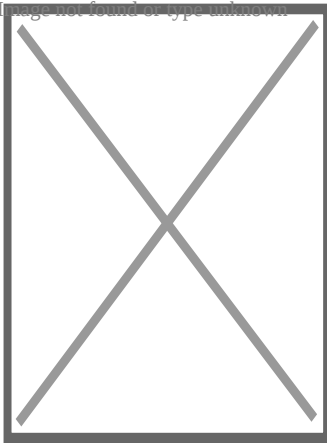


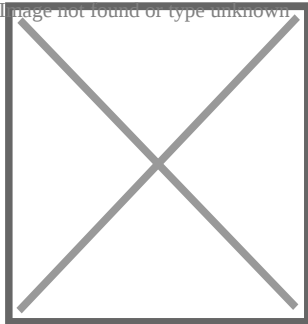
Figure 2: Temperature–entropy diagram of the vapor-compression cycle

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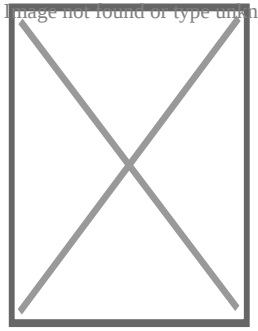


An internal view of the outdoor unit of an Ecodan air source heat pump

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Large heat pump
setup for a
commercial building



Wiring and connections to a central air unit inside

Vapor-compression uses a circulating refrigerant as the medium which absorbs heat from one space, compresses it thereby increasing its temperature before releasing it in another space. The system normally has eight main components: a compressor, a reservoir, a reversing valve which selects between heating and cooling mode, two thermal expansion valves (one used when in heating mode and the other when used in cooling mode) and two heat exchangers, one associated with the external heat source/sink and the other with the interior. In heating mode the external heat exchanger is the evaporator and the internal one being the condenser; in cooling mode the roles are reversed.

Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor^[66] and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air flowing across the coil or tubes. In heating mode this heat is used to heat the building using the internal heat exchanger, and in cooling mode this heat is rejected via the external heat exchanger.

The condensed, liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and-vapor refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in

the condenser and transferred elsewhere by the water or air used in the condenser.

To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.

Over time, the evaporator may collect ice or water from ambient humidity. The ice is melted through defrosting cycle. An internal heat exchanger is either used to heat/cool the interior air directly or to heat water that is then circulated through radiators or underfloor heating circuit to either heat or cool the buildings.

Improvement of coefficient of performance by subcooling

[edit]

Main article: Subcooling

Heat input can be improved if the refrigerant enters the evaporator with a lower vapor content. This can be achieved by cooling the liquid refrigerant after condensation. The gaseous refrigerant condenses on the heat exchange surface of the condenser. To achieve a heat flow from the gaseous flow center to the wall of the condenser, the temperature of the liquid refrigerant must be lower than the condensation temperature.

Additional subcooling can be achieved by heat exchange between relatively warm liquid refrigerant leaving the condenser and the cooler refrigerant vapor emerging from the evaporator. The enthalpy difference required for the subcooling leads to the superheating of the vapor drawn into the compressor. When the increase in cooling achieved by subcooling is greater than the compressor drive input required to overcome the additional pressure losses, such a heat exchange improves the coefficient of performance.^[67]

One disadvantage of the subcooling of liquids is that the difference between the condensing temperature and the heat-sink temperature must be larger. This leads to a moderately high pressure difference between condensing and evaporating pressure, whereby the compressor energy increases.

Refrigerant choice

[edit]

Main article: Refrigerant

Pure refrigerants can be divided into organic substances (hydrocarbons (HCs), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), hydrofluoroolefins (HFOs), and HCFOs), and inorganic substances (ammonia (NH₃), carbon dioxide (CO₂), and water (H₂O))^[68].^[69] Their boiling points are usually below 25 °C.^[70]

In the past 200 years, the standards and requirements for new refrigerants have changed. Nowadays low global warming potential (GWP) is required, in addition to all the previous requirements for safety, practicality, material compatibility, appropriate atmospheric life,^[clarification needed] and compatibility with high-efficiency products. By 2022, devices using refrigerants with a very low GWP still have a small market share but are expected to play an increasing role due to enforced regulations,^[71] as most countries have now ratified the Kigali Amendment to ban HFCs.^[72] Isobutane (R600A) and propane (R290) are far less harmful to the environment than conventional hydrofluorocarbons (HFC) and are already being used in air-source heat pumps.^[73] Propane may be the most suitable for high temperature heat pumps.^[74] Ammonia (R717) and carbon dioxide (R-744) also have a low GWP. As of 2023 smaller CO₂ heat pumps are not widely available and research and development of them continues.^[75] A 2024 report said that refrigerants with GWP are vulnerable to further international restrictions.^[76]

Until the 1990s, heat pumps, along with fridges and other related products used chlorofluorocarbons (CFCs) as refrigerants, which caused major damage to the ozone layer when released into the atmosphere. Use of these chemicals was banned or severely restricted by the Montreal Protocol of August 1987.^[77]

Replacements, including R-134a and R-410A, are hydrofluorocarbons (HFC) with similar thermodynamic properties with insignificant ozone depletion potential (ODP) but had problematic GWP.^[78] HFCs are powerful greenhouse gases which contribute to climate change.^[79]^[80] Dimethyl ether (DME) also gained in popularity as a refrigerant in combination with R404a.^[81] More recent refrigerants include difluoromethane (R32) with a lower GWP, but still over 600.

refrigerant	20-year GWP	100-year GWP
R-290 propane ^[82]	0.072	0.02
R-600a isobutane		3 ^[83]
R-32 ^[82]	491	136
R-410a ^[84]	4705	2285

R-134a ^[84]	4060	1470
R-404a ^[84]	7258	4808

Devices with R-290 refrigerant (propane) are expected to play a key role in the future.^{[74][85]} The 100-year GWP of propane, at 0.02, is extremely low and is approximately 7000 times less than R-32. However, the flammability of propane requires additional safety measures: the maximum safe charges have been set significantly lower than for lower flammability refrigerants (only allowing approximately 13.5 times less refrigerant in the system than R-32).^{[86][87][88]} This means that R-290 is not suitable for all situations or locations. Nonetheless, by 2022, an increasing number of devices with R-290 were offered for domestic use, especially in Europe.^[citation needed]

At the same time,^[when?] HFC refrigerants still dominate the market. Recent government mandates have seen the phase-out of R-22 refrigerant. Replacements such as R-32 and R-410A are being promoted as environmentally friendly but still have a high GWP.^[89] A heat pump typically uses 3 kg of refrigerant. With R-32 this amount still has a 20-year impact equivalent to 7 tons of CO₂, which corresponds to two years of natural gas heating in an average household. Refrigerants with a high ODP have already been phased out.^[citation needed]

Government incentives

[edit]

Financial incentives aim to protect consumers from high fossil gas costs and to reduce greenhouse gas emissions,^[90] and are currently available in more than 30 countries around the world, covering more than 70% of global heating demand in 2021.^[4]

Australia

[edit]

Food processors, brewers, petfood producers and other industrial energy users are exploring whether it is feasible to use renewable energy to produce industrial-grade heat. Process heating accounts for the largest share of onsite energy use in Australian manufacturing, with lower-temperature operations like food production particularly well-suited to transition to renewables.

To help producers understand how they could benefit from making the switch, the Australian Renewable Energy Agency (ARENA) provided funding to the Australian Alliance for Energy Productivity (A2EP) to undertake pre-feasibility studies at a range of

sites around Australia, with the most promising locations advancing to full feasibility studies.^[91]

In an effort to incentivize energy efficiency and reduce environmental impact, the Australian states of Victoria, New South Wales, and Queensland have implemented rebate programs targeting the upgrade of existing hot water systems. These programs specifically encourage the transition from traditional gas or electric systems to heat pump based systems.^{[92][93][94][95][96]}

Canada

[edit]

In 2022, the Canada Greener Homes Grant^[97] provides up to \$5000 for upgrades (including certain heat pumps), and \$600 for energy efficiency evaluations.

China

[edit]

Purchase subsidies in rural areas in the 2010s reduced burning coal for heating, which had been causing ill health.^[98]

In the 2024 report by the International Energy Agency (IEA) titled "The Future of Heat Pumps in China," it is highlighted that China, as the world's largest market for heat pumps in buildings, plays a critical role in the global industry. The country accounts for over one-quarter of global sales, with a 12% increase in 2023 alone, despite a global sales dip of 3% the same year.^[99]

Heat pumps are now used in approximately 8% of all heating equipment sales for buildings in China as of 2022, and they are increasingly becoming the norm in central and southern regions for both heating and cooling. Despite their higher upfront costs and relatively low awareness, heat pumps are favored for their energy efficiency, consuming three to five times less energy than electric heaters or fossil fuel-based solutions. Currently, decentralized heat pumps installed in Chinese buildings represent a quarter of the global installed capacity, with a total capacity exceeding 250 GW, which covers around 4% of the heating needs in buildings.^[99]

Under the Announced Pledges Scenario (APS), which aligns with China's carbon neutrality goals, the capacity is expected to reach 1,400 GW by 2050, meeting 25% of heating needs. This scenario would require an installation of about 100 GW of heat pumps annually until 2050. Furthermore, the heat pump sector in China employs over 300,000 people, with employment numbers expected to double by 2050, underscoring the importance of vocational training for industry growth. This robust development in the heat pump market is set to play a significant role in reducing direct emissions in buildings by 30% and cutting PM2.5 emissions from residential heating by nearly 80% by 2030.^[99]^[100]

European Union

[edit]

To speed up the deployment rate of heat pumps, the European Commission launched the Heat Pump Accelerator Platform in November 2024.^[101] It will encourage industry experts, policymakers, and stakeholders to collaborate, share best practices and ideas, and jointly discuss measures that promote sustainable heating solutions.^[102]

United Kingdom

[edit]

As of 2022: heat pumps have no Value Added Tax (VAT) although in Northern Ireland they are taxed at the reduced rate of 5% instead of the usual level of VAT of 20% for most other products.^[103] As of 2022 the installation cost of a heat pump is more than a gas boiler, but with the "Boiler Upgrade Scheme"^[104] government grant and assuming electricity/gas costs remain similar their lifetime costs would be similar on average.^[105] However lifetime cost relative to a gas boiler varies considerably depending on several factors, such as the quality of the heat pump installation and the tariff used.^[106] In 2024 England was criticised for still allowing new homes to be built with gas boilers, unlike some other counties where this is banned.^[107]

United States

[edit]

Further information: Environmental policy of the Joe Biden administration and Climate change in the United States

The High-efficiency Electric Home Rebate Program was created in 2022 to award grants to State energy offices and Indian Tribes in order to establish state-wide high-efficiency electric-home rebates. Effective immediately, American households are eligible for a tax credit to cover the costs of buying and installing a heat pump, up to \$2,000. Starting in 2023, low- and moderate-level income households will be eligible for a heat-pump rebate of up to \$8,000.^[108]

In 2022, more heat pumps were sold in the United States than natural gas furnaces.^[109]

In November 2023 Biden's administration allocated 169 million dollars from the Inflation Reduction Act to speed up production of heat pumps. It used the Defense Production Act to do so, because according to the administration, energy that is better for the climate is also better for national security.^[110]

Notes

[edit]

1. ^ As explained in Coefficient of performance TheoreticalMaxCOP = $(\text{desiredIndoorTempC} + 273) \div (\text{desiredIndoorTempC} - \text{outsideTempC}) = (7+273) \div (7 - (-3)) = 280 \div 10 = 28$ ^[10]
2. ^ As explained in Coefficient of performance TheoreticalMaxCOP = $(\text{desiredIndoorTempC} + 273) \div (\text{desiredIndoorTempC} - \text{outsideTempC}) = (27+273) \div (27 - (-3)) = 300 \div 30 = 10$ ^[10]

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External links

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Heating, ventilation, and air conditioning

**Fundamental
concepts**

- Air changes per hour
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- Building envelope
- Convection
- Dilution
- Domestic energy consumption
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- Fluid dynamics
- Gas compressor
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- Particulates
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- Thermal destratification
- Thermal mass
- Thermodynamics
- Vapour pressure of water

Technology

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- Absorption refrigerator
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- Air conditioning
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- Displacement ventilation
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- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling
- Passive daytime radiative cooling
- Passive house
- Passive ventilation
- Radiant heating and cooling
- Radiant cooling
- Radiant heating
- Radon mitigation
- Refrigeration
- Renewable heat
- Room air distribution
- Solar air heat
- Solar combisystem
- Solar cooling

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

**Measurement
and control**

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

**Professions,
trades,
and services**

- Duct cleaning
- Duct leakage testing
- Environmental engineering
- Hydronic balancing
- Kitchen exhaust cleaning
- Mechanical engineering
- Mechanical, electrical, and plumbing
- Mold growth, assessment, and remediation
- Refrigerant reclamation
- Testing, adjusting, balancing

Industry organizations

- AHRI
- AMCA
- ASHRAE
- ASTM International
- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC

Health and safety

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

See also

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

Authority control databases: National

- Germany
- United States
- France

- Japan
- Czech Republic
- Israel

About Durham Supply Inc

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Things To Do in Tulsa County

Photo

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Blue Whale of Catoosa

4.5 (3899)

Photo

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Tulsa Botanic Garden

4.7 (1397)

Photo

Bob Dylan Center

4.9 (245)

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Gathering Place

4.8 (12116)

Photo

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Tulsa Zoo

4.5 (10482)

Photo

The Cave House

4.6 (249)

Driving Directions in Tulsa County

Driving Directions From Waffle House to Durham Supply Inc

Driving Directions From Nights Stay Hotel to Durham Supply Inc

Driving Directions From East Central High School to Durham Supply Inc

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

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Driving Directions From Tulsa Air and Space Museum & Planetarium to Durham Supply Inc

Driving Directions From Route 66 Historical Village to Durham Supply Inc

Driving Directions From The Blue Dome to Durham Supply Inc

Driving Directions From Streetwalker Tours to Durham Supply Inc

Driving Directions From Tulsa Botanic Garden 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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Dennis Champion

(5)

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

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.

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.

Identifying Combustion Clearance Issues in Mobile Home Furnaces[View GBP](#)

Frequently Asked Questions

What are common signs of combustion clearance issues in mobile home furnaces?

Common signs include unusual noises, poor heating performance, soot accumulation around the furnace area, yellow or flickering burner flames instead of blue, and the presence of a strong smell of gas or combustion byproducts.

How can improper combustion clearances affect furnace efficiency and safety?

Improper clearances can lead to restricted airflow, causing inefficient combustion that reduces heating effectiveness. This can also result in dangerous conditions like carbon monoxide buildup or increased risk of fire due to overheating.

What steps should be taken to assess and correct combustion clearance problems in a mobile home furnace?

Begin with a visual inspection for blockages or obstructions around the furnace. Ensure that all venting systems are properly installed and unobstructed. Consult installation manuals for proper clearance specifications and hire a professional technician if necessary to adjust the setup.

How often should mobile home furnaces be inspected for combustion clearance issues?

It's recommended that mobile home furnaces be inspected annually by a qualified HVAC technician. Regular maintenance helps identify potential clearance issues early and ensures safe operation.

Are there specific regulations or guidelines regarding furnace combustion clearances in mobile homes?

Yes, building codes and manufacturer guidelines specify required clearances to ensure safe operation. These regulations may vary by location but generally provide minimum distance requirements between the furnace unit and other structures or materials within the mobile home.

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Google Business Profile

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

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