

HVAC cost



- **Estimating Labor Expenses for Repair Services**
Estimating Labor Expenses for Repair Services **Comparing Replacement Part Prices for Various Systems** **Reviewing Maintenance Plan Rates in Detail** **Exploring Payment Arrangements for Major Overhauls** **Analyzing Long Term Savings with Efficient Upgrades** **Investigating Seasonal Discounts from Service Providers** **Understanding Monthly Budgeting for HVAC Projects** **Balancing Initial Spending with Potential Savings** **Evaluating Total Costs for System Retrofits** **Preparing for Unexpected Repair Fees** **Weighing Return on Investment for Modern Equipment** **Identifying Hidden Expenses in Older Units**
- **Understanding Local Building Code Requirements**
Understanding Local Building Code Requirements **Reviewing State Regulations for HVAC Installation** **Exploring County Permit Applications for Mobile Homes** **Navigating EPA 608 Certification Steps** **Recognizing UL Rated Components for Safety** **Determining Required Inspections for New Units** **Preparing Official Documents for System Upgrades** **Knowing When to Seek Professional Licensing Support** **Identifying Legal Mandates for Refrigerant Disposal** **Sorting Out Utility Guidelines for Meter Upgrades** **Meeting Deadlines for Permit Renewals** **Locating Reliable Compliance Resources for Homeowners**
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Mobile home HVAC (Heating, Ventilation, and Air Conditioning) systems are integral to maintaining a comfortable and safe living environment. These systems are specially designed to cater to the unique needs of mobile homes, which often face challenges such as limited space and varying insulation levels. Understanding these systems' components is crucial for ensuring their efficiency and safety, particularly in recognizing UL-rated components.

The design of mobile home HVAC systems typically involves compact units that can efficiently heat or cool smaller spaces. Seasonal tune-ups help ensure optimal HVAC performance in mobile homes **mobile home hvac systems** screen reader. Despite their size, these systems must be robust enough to handle extreme weather conditions while maintaining energy efficiency. Key elements include furnaces, air conditioners, heat pumps, ductwork, and thermostats. Each component plays a vital role in regulating the indoor climate and contributing to overall comfort.

Recognizing UL-rated components within these systems is paramount for safety assurance. Underwriters Laboratories (UL) is an independent organization dedicated to testing products for safety standards compliance. When a component is UL-rated, it means it has been rigorously tested and meets specific criteria for electrical safety, performance under stress conditions, and overall reliability.

For mobile home HVAC systems, using UL-rated components ensures that each part of the system adheres to stringent safety protocols. This is particularly important given the confined spaces in mobile homes where any malfunction could quickly escalate into a hazardous situation. For instance, a UL-rated furnace will have features designed to prevent overheating or electrical failures that could lead to fires.

Moreover, UL ratings help homeowners make informed decisions about maintenance and upgrades. When selecting replacement parts or considering system enhancements, looking for the UL mark can provide peace of mind that these components are less likely to fail unexpectedly or pose risks due to manufacturing flaws.

In conclusion, understanding the overview of mobile home HVAC systems involves appreciating their compact yet efficient nature tailored for constrained spaces. Recognizing the significance of UL-rated components within these systems underscores a commitment to safety and reliability—key factors that ensure homeowners can enjoy their living environments without unnecessary risk or concern over potential malfunctions. As technology continues to advance in this field, adhering to recognized safety standards remains an essential practice

Factors Influencing Labor Costs in Mobile Home HVAC Repairs —

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

In the realm of HVAC systems, safety and reliability are paramount. This is where the term "UL Rated Components" becomes crucial. UL, or Underwriters Laboratories, is an independent global safety certification company that sets rigorous standards for a wide range of products, including those used in heating, ventilation, and air conditioning (HVAC) systems. Recognizing UL rated components in HVAC systems ensures that these components meet established safety and performance standards.

The significance of using UL rated components within HVAC systems cannot be overstated. These components undergo extensive testing to ensure they can withstand the demands placed upon them in various environments. For instance, motors, wires, circuit boards, and other electrical parts are scrutinized under conditions that simulate real-world scenarios. This process helps to identify any potential points of failure or hazards such as fire risks or electrical shocks.

By incorporating UL rated components into HVAC systems, manufacturers provide an additional layer of assurance to consumers and building operators. It signifies that each component has met stringent guidelines for safety and quality—a vital consideration given that

HVAC systems often run continuously over long periods and are subject to fluctuating environmental conditions.

Furthermore, recognizing UL ratings aids in compliance with local codes and regulations which frequently stipulate the use of certified components. This not only assists in avoiding legal complications but also aligns with best practices for installation and maintenance procedures.

Additionally, from a consumer perspective, the presence of UL rated components can influence purchasing decisions by providing peace of mind regarding product durability and user safety. In an age where energy efficiency and sustainability are increasingly prioritized, utilizing certified components supports these goals by ensuring optimal system performance without compromising on safety standards.

In conclusion, understanding and recognizing UL rated components within HVAC systems plays a critical role in promoting operational reliability while safeguarding users against potential hazards. The adoption of these certified elements reflects a commitment to excellence from manufacturers and offers tangible benefits both legally and functionally. As technology continues to evolve within the industry, maintaining adherence to such high standards will remain essential for fostering trust with consumers worldwide.

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Steps to Accurately Estimate Labor Expenses for HVAC Repair Services

When it comes to ensuring the safety and reliability of HVAC equipment, the UL (Underwriters Laboratories) certification stands as a cornerstone in the industry. UL certification provides assurance that products meet rigorous safety standards, and recognizing UL-rated components is crucial for maintaining these benchmarks. In this essay, we will explore the criteria for UL certification in HVAC equipment and discuss the importance of identifying UL-rated components for safety.

UL certification is not merely a badge; it represents a thorough evaluation process where HVAC equipment undergoes extensive testing against established safety standards. The criteria for achieving this certification are multifaceted. Firstly, the design and construction of the equipment are scrutinized to ensure they adhere to specific guidelines regarding materials, component placement, and overall build quality. This includes evaluating materials for flammability, durability, and electrical conductivity to prevent potential hazards such as fires or electrical failures.

Furthermore, performance testing plays an essential role in UL certification. HVAC systems must operate safely under various conditions, including extreme temperatures and humidity levels. They are tested for airflow efficiency, cooling or heating capacity, and overall energy consumption to guarantee they perform reliably without posing any risks to users or property.

In addition to these technical assessments, manufacturers must also provide comprehensive documentation detailing how their products comply with safety regulations. This includes user manuals specifying installation procedures, maintenance schedules, and operating instructions that align with safe usage practices.

Recognizing UL-rated components within HVAC systems is equally vital for ensuring ongoing safety compliance. Each component-be it wires, motors, fans or thermostats-must individually meet UL standards before contributing to the system's overall performance. Identifying these components involves checking for the distinctive UL mark on each part-a symbol indicating that it has passed necessary safety tests independently.

The significance of using only UL-rated components cannot be overstated. Non-certified parts might compromise system integrity by introducing vulnerabilities such as increased risk of overheating or short-circuiting. Moreover, utilizing uncertified components can void warranties and violate building codes or insurance requirements.

For consumers and professionals alike-whether you're purchasing new equipment or performing routine maintenance-the ability to recognize UL marks ensures confidence in product safety and compliance with regulatory expectations. It acts as a safeguard against substandard parts that could endanger both property and lives.

In conclusion, understanding the criteria for UL certification in HVAC equipment is imperative for anyone involved in selecting or servicing these systems. It guarantees adherence to high safety standards while providing peace of mind through reliable performance assurances. Recognizing UL-rated components helps maintain this integrity by ensuring every part contributes positively towards safe operation-a fundamental aspect that underpins trust within today's complex technological landscape.





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

In today's modern world, mobile homes offer a convenient and affordable living solution for many individuals and families. However, ensuring the safety of these homes is paramount, given their unique structural and electrical systems. One essential aspect of this safety is the use of UL rated components. Recognizing UL rated components in mobile homes not only enhances safety but also provides numerous other benefits that contribute to the overall well-being of their occupants.

UL, or Underwriters Laboratories, is an independent global safety certification company that sets rigorous standards for product safety. When a component is UL rated, it means that it has been tested and certified to meet specific standards for performance and safety. This certification process involves comprehensive evaluations, including testing for fire hazards, electrical shock risks, and potential mechanical failures.

The primary benefit of using UL rated components in mobile homes is the assurance of enhanced safety. Mobile homes often contain complex electrical systems that can pose significant risks if not properly managed. UL rated components help mitigate these risks by ensuring that all parts meet stringent safety criteria. For example, electrical wirings and outlets with a UL rating are less likely to overheat or cause fires because they have been designed to handle specific loads safely.

Furthermore, using UL rated components can lead to improved reliability and durability in mobile home systems. Components that have been rigorously tested are more likely to function correctly over time without failing unexpectedly. This reliability reduces maintenance needs and lowers the likelihood of costly repairs due to component failure or malfunction.

Another advantage of recognizing and using UL rated components is energy efficiency. Many UL certified products are designed with energy conservation in mind, helping homeowners reduce their overall energy consumption. This efficiency not only helps protect the environment by reducing carbon footprints but also translates into cost savings on utility bills—a significant consideration for many mobile home residents who may be budget-conscious.

Moreover, having UL rated components installed can increase property value and marketability if homeowners decide to sell their mobile home in the future. Potential buyers often view such certifications as indicators of quality construction and reliable performance which can be a deciding factor during transactions.

Finally, utilizing UL rated components fosters peace of mind among residents who want assurance that they are living in a safe environment built with high-quality materials. Knowing that every switchplate cover or circuit breaker has undergone meticulous testing provides confidence against potential hazards lurking from inferior products.

In conclusion, recognizing the importance of using UL rated components in mobile homes cannot be overstated when considering occupant safety along with additional benefits such as enhanced durability , improved efficiency , increased property values ,and greater peace-of-mind . By prioritizing these certified parts throughout construction or renovations ,mobile homeowners invest wisely towards securing themselves against unforeseen dangers while contributing positively towards sustainable living practices .

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

When it comes to ensuring the safety and reliability of HVAC systems, recognizing UL-rated components is of paramount importance. UL, or Underwriters Laboratories, is a globally recognized safety certification organization that rigorously tests and certifies products for compliance with specific safety standards. For homeowners, technicians, and engineers alike, understanding how to identify these UL ratings on HVAC components can be instrumental in maintaining system integrity and preventing potential hazards.

First and foremost, it is essential to understand what a UL rating signifies. A UL rating indicates that a product has been tested and meets stringent safety criteria outlined by the organization. This rating provides assurance that the component will perform safely under normal usage conditions. In the realm of HVAC systems, which often involve electrical connections, refrigerants, and other potentially hazardous elements, this assurance is invaluable.

Identifying UL-rated components begins with locating the UL mark itself. Typically, this mark appears directly on the product or its packaging as a label or stamp. The presence of this mark is a clear indicator that the component has undergone evaluation by Underwriters Laboratories. It's crucial to ensure that this mark is authentic; counterfeit marks can occasionally surface in markets where regulatory oversight is less stringent.

In addition to the basic UL logo-which usually consists of the letters "UL" encircled-further information may accompany it. This could include a unique file number or category code specific to the type of product being certified. These numbers are useful for those wishing to verify the authenticity of the certification through online databases maintained by Underwriters Laboratories.

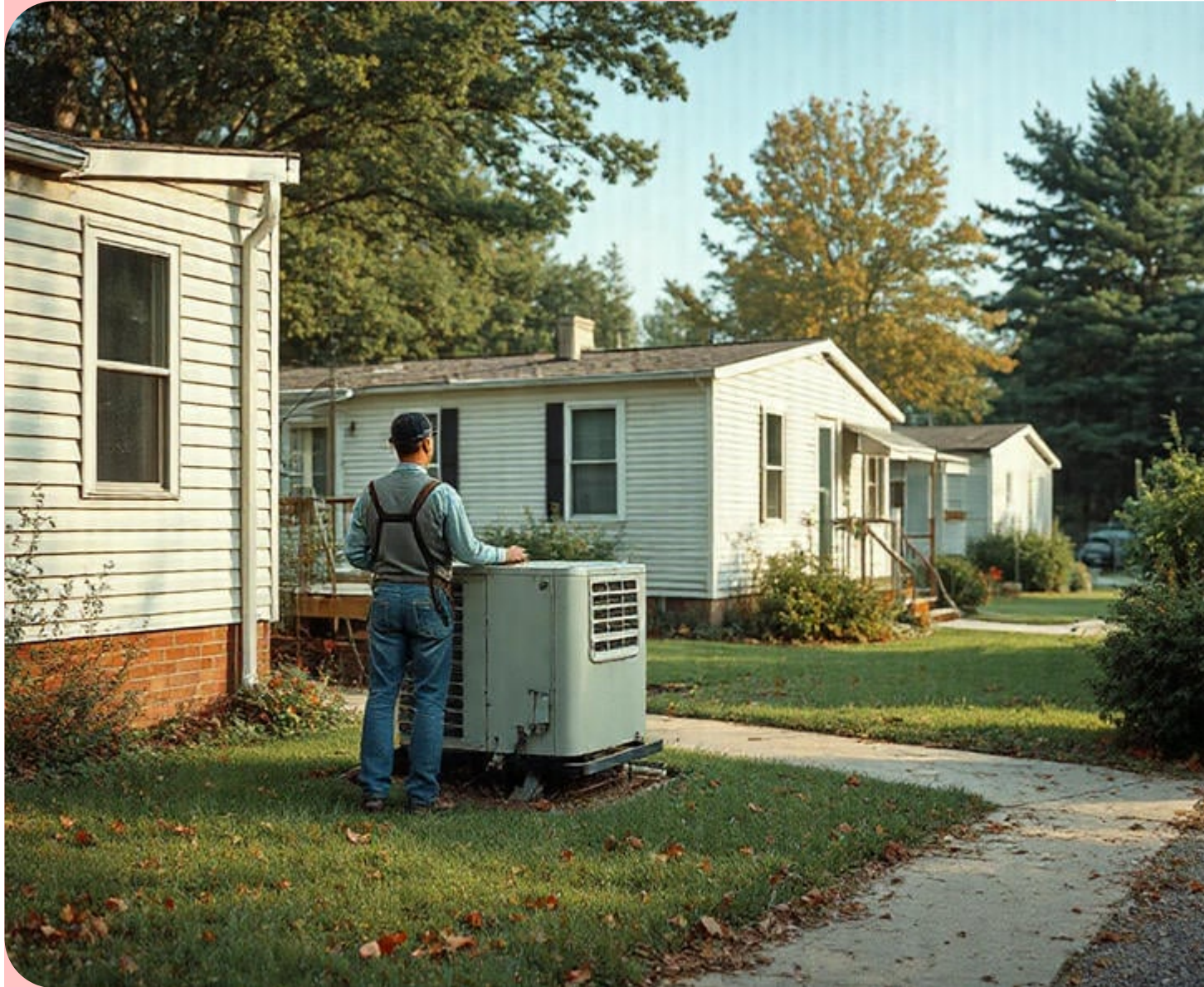
Moreover, understanding different types of UL ratings can provide deeper insights into what aspects have been evaluated. For instance, some components might be rated for fire resistance while others for shock protection or environmental durability. Knowing these distinctions helps users make informed decisions based on their specific needs-for example, selecting components designed to withstand harsh environmental conditions if they are intended for outdoor units.

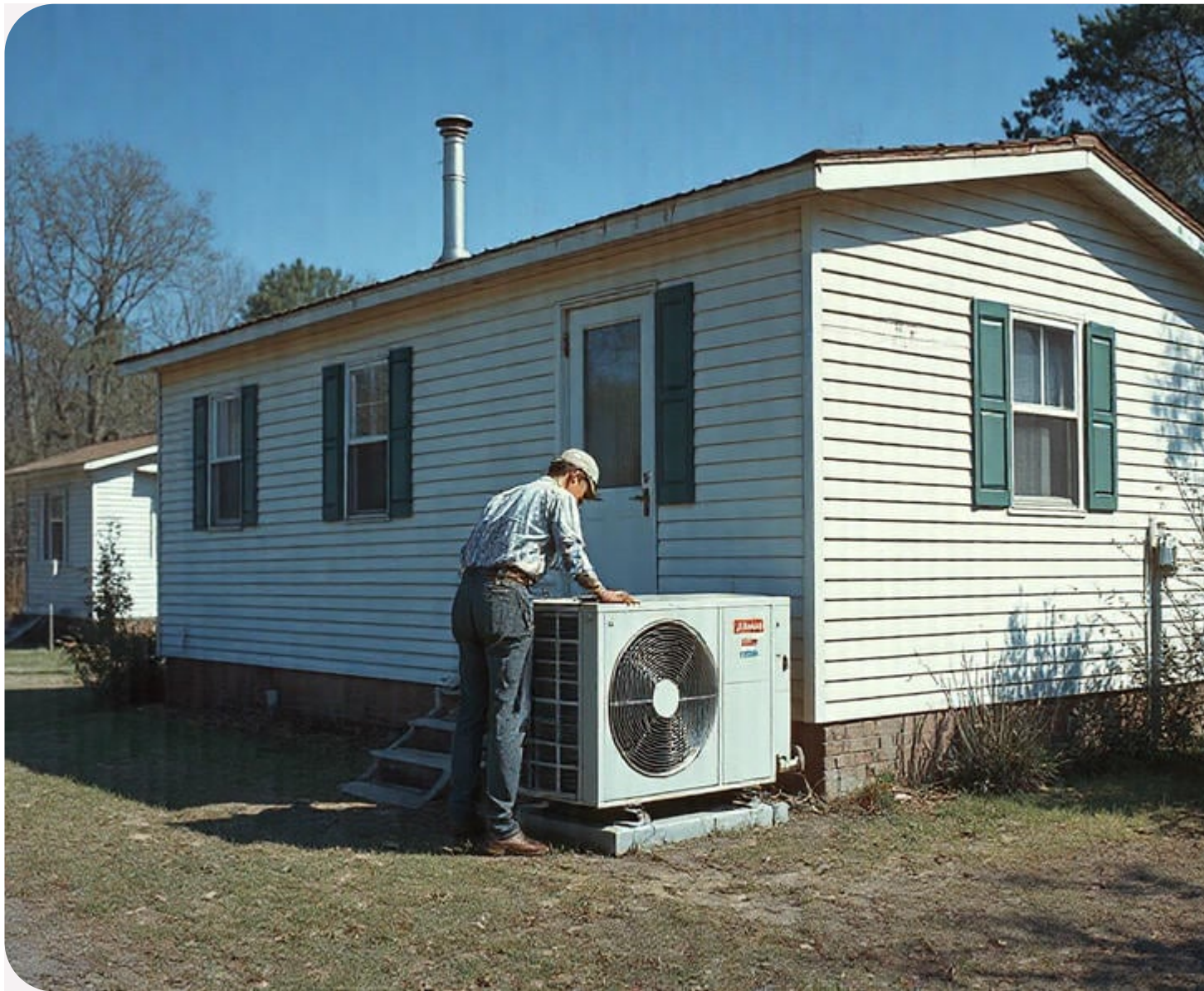
Another crucial aspect of identifying UL-rated components involves familiarity with technical documentation provided by manufacturers. Often overlooked, these manuals or datasheets contain detailed descriptions of certifications alongside installation guidelines and operational limits defined by testing outcomes.

For professionals in particular-such as HVAC installers or maintenance personnel-it's prudent not only to recognize but also document all certified parts used within an installation project thoroughly. This practice ensures traceability should any issues arise later down the line requiring inspection or replacement under warranty terms tied closely with adherence towards using approved materials exclusively specified originally via contractual obligations established beforehand between parties involved during procurement phases initially undertaken prior commencement activities actually commencing onsite thereafter subsequently thusly forthwith henceforth ergo accordingly thereof thereby hereinafter forthwith...

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Tips for Managing and Reducing Labor Expenses Without Compromising Quality

In the realm of electrical safety, UL (Underwriters Laboratories) ratings serve as a crucial benchmark for ensuring that components meet established safety standards. However, the use of non-UL rated components in various applications often leads to a host of common issues that can compromise both safety and functionality. Recognizing these issues is essential for understanding why UL ratings are not merely bureaucratic hurdles but vital elements of safeguarding lives and property.

One of the primary concerns with non-UL rated components is their lack of rigorous testing. UL rated components undergo extensive evaluations that simulate real-world conditions, ensuring they can handle expected stressors such as heat, moisture, and electrical surges. Non-UL components might not be subjected to such comprehensive testing, raising questions about their reliability under normal or adverse conditions. This absence of standardized testing increases the risk of component failure, which can lead to dangerous situations like electrical fires or equipment malfunctions.

Another significant issue lies in the inconsistency in quality control among non-UL rated products. While some manufacturers may adhere to high standards even without pursuing UL certification, others might cut corners to reduce costs. This lack of uniformity means that two seemingly identical non-UL rated components could perform very differently, introducing unpredictability into any system that relies on them. Such variability is particularly concerning in critical applications where consistent performance is paramount.

The potential for compatibility issues also looms large when integrating non-UL rated components into systems designed around UL standards. These components might not conform to specific size or performance specifications required by other parts in the system, leading to mismatches that can cause inefficiencies or failures. For instance, an improperly sized component might generate excessive heat or fail prematurely due to stress it wasn't designed to withstand.

Moreover, using non-UL rated components can have legal and insurance implications. Many building codes and insurance policies specify UL-rated products as a requirement for compliance and coverage. Utilizing non-compliant parts could potentially void insurance claims or result in legal liabilities should an incident occur linked back to those unverified components.

Finally, there is the broader impact on consumer trust and brand reputation. In a marketplace where safety is increasingly prioritized by end-users aware of technological risks, companies relying on non-UL rated parts risk damaging their credibility if these components lead to product recalls or publicized failures.

In conclusion, while opting for non-UL rated components might offer short-term cost savings or convenience, it introduces significant risks that far outweigh these benefits. Understanding these common issues highlights the importance of recognizing and adhering to UL ratings when selecting electrical components for any application where safety cannot be compromised. The peace of mind offered by knowing a component has met stringent safety standards is invaluable—an assurance worth prioritizing above all else in our increasingly interconnected world.

About Sick building syndrome



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Sick building syndrome

Specialty Environmental medicine, immunology  [Edit this on Wikidata](#)

Sick building syndrome (SBS) is a condition in which people develop symptoms of illness or become infected with chronic disease from the building in which they work or reside.^[1] In scientific literature, SBS is also known as **building-related illness (BRI)**, **building-related symptoms (BRS)**, or **idiopathic environmental intolerance (IEI)**.

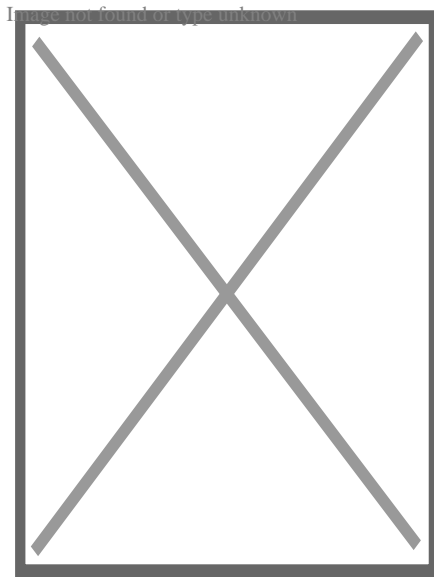
The main identifying observation is an increased incidence of complaints of such symptoms as headache, eye, nose, and throat irritation, fatigue, dizziness, and nausea. The 1989 Oxford English Dictionary defines SBS in that way.^[2] The World Health Organization created a 484-page tome on indoor air quality 1984, when SBS was attributed only to non-organic causes, and suggested that the book might form a basis for legislation or litigation.^[3]

The outbreaks may or may not be a direct result of inadequate or inappropriate cleaning.^[2] SBS has also been used to describe staff concerns in post-war buildings with faulty building aerodynamics, construction materials, construction process, and maintenance.^[2] Some symptoms tend to increase in severity with the time people spend in the building, often improving or even disappearing when people are away from the building.^[2]^[4] The term SBS is also used interchangeably with "**building-related symptoms**", which orients the name of the condition around patients' symptoms rather than a "sick" building.^[5]

Attempts have been made to connect sick building syndrome to various causes, such as contaminants produced by outgassing of some building materials, volatile organic compounds (VOC), improper exhaust ventilation of ozone (produced by the operation of some office machines), light industrial chemicals used within, and insufficient fresh-air intake or air filtration (see "Minimum efficiency reporting value").^[2] Sick building syndrome has also been attributed to heating, ventilation, and air conditioning (HVAC) systems, an attribution about which there are inconsistent findings.^[6]

Signs and symptoms

[edit]



An air quality monitor

Human exposure to aerosols has a variety of adverse health effects.^[7] Building occupants complain of symptoms such as sensory irritation of the eyes, nose, or throat; neurotoxic or general health problems; skin irritation; nonspecific hypersensitivity reactions; infectious diseases;^[8] and odor and taste sensations.^[9] Poor lighting has caused general malaise.^[10]

Extrinsic allergic alveolitis has been associated with the presence of fungi and bacteria in the moist air of residential houses and commercial offices.^[11] A study in 2017 correlated several inflammatory diseases of the respiratory tract with objective evidence of damp-caused damage in homes.^[12]

The WHO has classified the reported symptoms into broad categories, including mucous-membrane irritation (eye, nose, and throat irritation), neurotoxic effects (headaches, fatigue, and irritability), asthma and asthma-like symptoms (chest tightness and wheezing), skin dryness and irritation, and gastrointestinal complaints.^[13]

Several sick occupants may report individual symptoms that do not seem connected. The key to discovery is the increased incidence of illnesses in general with onset or exacerbation in a short period, usually weeks. In most cases, SBS symptoms are relieved soon after the occupants leave the particular room or zone.^[14] However, there can be lingering effects of various neurotoxins, which may not clear up when the occupant leaves the building. In some cases, including those of sensitive people, there are long-term health effects.^[15]

Cause

[edit]

ASHRAE has recognized that polluted urban air, designated within the United States Environmental Protection Agency (EPA)'s air quality ratings as unacceptable, requires the installation of treatment such as filtration for which the HVAC practitioners generally apply carbon-impregnated filters and their likes. Different toxins will aggravate the human body in different ways. Some people are more allergic to mold, while others are highly sensitive to dust. Inadequate ventilation will exaggerate small problems (such as deteriorating fiberglass insulation or cooking fumes) into a much more serious indoor air quality problem.^[10]

Common products such as paint, insulation, rigid foam, particle board, plywood, duct liners, exhaust fumes and other chemical contaminants from indoor or outdoor sources, and biological contaminants can be trapped inside by the HVAC AC system. As this air is recycled using fan coils the overall oxygenation ratio drops and becomes harmful. When combined with other stress factors such as traffic noise and poor lighting, inhabitants of buildings located in a polluted urban area can quickly become ill as their immune system is overwhelmed.^[10]

Certain VOCs, considered toxic chemical contaminants to humans, are used as adhesives in many common building construction products. These aromatic carbon rings / VOCs can cause acute and chronic health effects in the occupants of a building, including cancer, paralysis, lung failure, and others. Bacterial spores, fungal spores, mold spores, pollen, and viruses are types of biological contaminants and can all cause

allergic reactions or illness described as SBS. In addition, pollution from outdoors, such as motor vehicle exhaust, can enter buildings, worsen indoor air quality, and increase the indoor concentration of carbon monoxide and carbon dioxide.^[16] Adult SBS symptoms were associated with a history of allergic rhinitis, eczema and asthma.^[17]

A 2015 study concerning the association of SBS and indoor air pollutants in office buildings in Iran found that, as carbon dioxide increased in a building, nausea, headaches, nasal irritation, dyspnea, and throat dryness also rose.^[10] Some work conditions have been correlated with specific symptoms: brighter light, for example was significantly related to skin dryness, eye pain, and malaise.^[10] Higher temperature is correlated with sneezing, skin redness, itchy eyes, and headache; lower relative humidity has been associated with sneezing, skin redness, and eye pain.^[10]

In 1973, in response to the oil crisis and conservation concerns, ASHRAE Standards 62-73 and 62-81 reduced required ventilation from 10 cubic feet per minute (4.7 L/s) per person to 5 cubic feet per minute (2.4 L/s) per person, but this was found to be a contributing factor to sick building syndrome.^[18] As of the 2016 revision, ASHRAE ventilation standards call for 5 to 10 cubic feet per minute of ventilation per occupant (depending on the occupancy type) in addition to ventilation based on the zone floor area delivered to the breathing zone.^[19]

Workplace

[edit]

Excessive work stress or dissatisfaction, poor interpersonal relationships and poor communication are often seen to be associated with SBS, recent^[when?] studies show that a combination of environmental sensitivity and stress can greatly contribute to sick building syndrome.^[15]^[citation needed]

Greater effects were found with features of the psycho-social work environment including high job demands and low support. The report concluded that the physical environment of office buildings appears to be less important than features of the psycho-social work environment in explaining differences in the prevalence of symptoms. However, there is still a relationship between sick building syndrome and symptoms of workers regardless of workplace stress.^[20]

Specific work-related stressors are related with specific SBS symptoms. Workload and work conflict are significantly associated with general symptoms (headache, abnormal tiredness, sensation of cold or nausea). While crowded workspaces and low work satisfaction are associated with upper respiratory symptoms.^[21] Work productivity has been associated with ventilation rates, a contributing factor to SBS, and there's a

significant increase in production as ventilation rates increase, by 1.7% for every two-fold increase of ventilation rate.^[22] Printer effluent, released into the office air as ultra-fine particles (UFPs) as toner is burned during the printing process, may lead to certain SBS symptoms.^[23]^[24] Printer effluent may contain a variety of toxins to which a subset of office workers are sensitive, triggering SBS symptoms.^[25]

Specific careers are also associated with specific SBS symptoms. Transport, communication, healthcare, and social workers have highest prevalence of general symptoms. Skin symptoms such as eczema, itching, and rashes on hands and face are associated with technical work. Forestry, agriculture, and sales workers have the lowest rates of sick building syndrome symptoms.^[26]

From the assessment done by Fisk and Mudarri, 21% of asthma cases in the United States were caused by wet environments with mold that exist in all indoor environments, such as schools, office buildings, houses and apartments. Fisk and Berkeley Laboratory colleagues also found that the exposure to the mold increases the chances of respiratory issues by 30 to 50 percent.^[27] Additionally, studies showing that health effects with dampness and mold in indoor environments found that increased risk of adverse health effects occurs with dampness or visible mold environments.^[28]

Milton et al. determined the cost of sick leave specific for one business was an estimated \$480 per employee, and about five days of sick leave per year could be attributed to low ventilation rates. When comparing low ventilation rate areas of the building to higher ventilation rate areas, the relative risk of short-term sick leave was 1.53 times greater in the low ventilation areas.^[29]

Home

[edit]

Sick building syndrome can be caused by one's home. Laminate flooring may release more SBS-causing chemicals than do stone, tile, and concrete floors.^[17] Recent redecorating and new furnishings within the last year are associated with increased symptoms; so are dampness and related factors, having pets, and cockroaches.^[17] Mosquitoes are related to more symptoms, but it is unclear whether the immediate cause of the symptoms is the mosquitoes or the repellents used against them.^[17]

Mold

[edit]

Main article: Mold health issues

Sick building syndrome may be associated with indoor mold or mycotoxin contamination. However, the attribution of sick building syndrome to mold is controversial and supported by little evidence.^{[30][31][32]}

Indoor temperature

[edit]

Main article: Room temperature § Health effects

Indoor temperature under 18 °C (64 °F) has been shown to be associated with increased respiratory and cardiovascular diseases, increased blood levels, and increased hospitalization.^[33]

Diagnosis

[edit]

While sick building syndrome (SBS) encompasses a multitude of non-specific symptoms, building-related illness (BRI) comprises specific, diagnosable symptoms caused by certain agents (chemicals, bacteria, fungi, etc.). These can typically be identified, measured, and quantified.^[34] There are usually four causal agents in BRI: immunologic, infectious, toxic, and irritant.^[34] For instance, Legionnaire's disease, usually caused by *Legionella pneumophila*, involves a specific organism which could be ascertained through clinical findings as the source of contamination within a building.^[34]

Prevention

[edit]

- Reduction of time spent in the building
- If living in the building, moving to a new place
- Fixing any deteriorated paint or concrete deterioration
- Regular inspections to indicate for presence of mold or other toxins
- Adequate maintenance of all building mechanical systems
- Toxin-absorbing plants, such as sansevieria^{[35][36][37][38][39][40][41]}^[excessive citations]
- Roof shingle non-pressure cleaning for removal of algae, mold, and *Gloeocapsa magma*
- Using ozone to eliminate the many sources, such as VOCs, molds, mildews, bacteria, viruses, and even odors. However, numerous studies identify high-ozone shock treatment as ineffective despite commercial popularity and popular belief.
- Replacement of water-stained ceiling tiles and carpeting

- Only using paints, adhesives, solvents, and pesticides in well-ventilated areas or only using these pollutant sources during periods of non-occupancy
- Increasing the number of air exchanges; the American Society of Heating, Refrigeration and Air-Conditioning Engineers recommend a minimum of 8.4 air exchanges per 24-hour period
- Increased ventilation rates that are above the minimum guidelines^[22]
- Proper and frequent maintenance of HVAC systems
- UV-C light in the HVAC plenum
- Installation of HVAC air cleaning systems or devices to remove VOCs and bioeffluents (people odors)
- Central vacuums that completely remove all particles from the house including the ultrafine particles (UFPs) which are less than 0.1 μm
- Regular vacuuming with a HEPA filter vacuum cleaner to collect and retain 99.97% of particles down to and including 0.3 micrometers
- Placing bedding in sunshine, which is related to a study done in a high-humidity area where damp bedding was common and associated with SBS^[17]
- Lighting in the workplace should be designed to give individuals control, and be natural when possible^[42]
- Relocating office printers outside the air conditioning boundary, perhaps to another building
- Replacing current office printers with lower emission rate printers^[43]
- Identification and removal of products containing harmful ingredients

Management

[edit]

SBS, as a non-specific blanket term, does not have any specific cause or cure. Any known cure would be associated with the specific eventual disease that was caused by exposure to known contaminants. In all cases, alleviation consists of removing the affected person from the building associated. BRI, on the other hand, utilizes treatment appropriate for the contaminant identified within the building (e.g., antibiotics for Legionnaire's disease).^[citation needed]

Improving the indoor air quality (IAQ) of a particular building can attenuate, or even eliminate, the continued exposure to toxins. However, a Cochrane review of 12 mold and dampness remediation studies in private homes, workplaces and schools by two independent authors were deemed to be very low to moderate quality of evidence in reducing adult asthma symptoms and results were inconsistent among children.^[44] For the individual, the recovery may be a process involved with targeting the acute symptoms of a specific illness, as in the case of mold toxins.^[45] Treating various building-related illnesses is vital to the overall understanding of SBS. Careful analysis by certified building professionals and physicians can help to identify the exact cause of the BRI, and help to illustrate a causal path to infection. With this knowledge one can,

theoretically, remediate a building of contaminants and rebuild the structure with new materials. Office BRI may more likely than not be explained by three events: "Wide range in the threshold of response in any population (susceptibility), a spectrum of response to any given agent, or variability in exposure within large office buildings." [46]

Isolating any one of the three aspects of office BRI can be a great challenge, which is why those who find themselves with BRI should take three steps, history, examinations, and interventions. History describes the action of continually monitoring and recording the health of workers experiencing BRI, as well as obtaining records of previous building alterations or related activity. Examinations go hand in hand with monitoring employee health. This step is done by physically examining the entire workspace and evaluating possible threats to health status among employees. Interventions follow accordingly based on the results of the Examination and History report. [46]

Epidemiology

[edit]

Some studies have found that women have higher reports of SBS symptoms than men. [17][10] It is not entirely clear, however, if this is due to biological, social, or occupational factors.

A 2001 study published in the Journal Indoor Air, gathered 1464 office-working participants to increase the scientific understanding of gender differences under the Sick Building Syndrome phenomenon. [47] Using questionnaires, ergonomic investigations, building evaluations, as well as physical, biological, and chemical variables, the investigators obtained results that compare with past studies of SBS and gender. The study team found that across most test variables, prevalence rates were different in most areas, but there was also a deep stratification of working conditions between genders as well. For example, men's workplaces tend to be significantly larger and have all-around better job characteristics. Secondly, there was a noticeable difference in reporting rates, specifically that women have higher rates of reporting roughly 20% higher than men. This information was similar to that found in previous studies, thus indicating a potential difference in willingness to report. [47]

There might be a gender difference in reporting rates of sick building syndrome, because women tend to report more symptoms than men do. Along with this, some studies have found that women have a more responsive immune system and are more prone to mucosal dryness and facial erythema. Also, women are alleged by some to be more exposed to indoor environmental factors because they have a greater tendency to have clerical jobs, wherein they are exposed to unique office equipment and materials (example: blueprint machines, toner-based printers), whereas men often have jobs based outside of offices. [48]

History

[edit]



This section **possibly contains original research**. Please improve it by verifying the claims made and adding inline citations. Statements consisting only of original research should be removed. *(August 2017) (Learn how and when to remove this message)*

In the late 1970s, it was noted that nonspecific symptoms were reported by tenants in newly constructed homes, offices, and nurseries. In media it was called "office illness". The term "sick building syndrome" was coined by the WHO in 1986, when they also estimated that 10–30% of newly built office buildings in the West had indoor air problems. Early Danish and British studies reported symptoms.

Poor indoor environments attracted attention. The Swedish allergy study (SOU 1989:76) designated "sick building" as a cause of the allergy epidemic as was feared. In the 1990s, therefore, extensive research into "sick building" was carried out. Various physical and chemical factors in the buildings were examined on a broad front.

The problem was highlighted increasingly in media and was described as a "ticking time bomb". Many studies were performed in individual buildings.

In the 1990s "sick buildings" were contrasted against "healthy buildings". The chemical contents of building materials were highlighted. Many building material manufacturers were actively working to gain control of the chemical content and to replace criticized additives. The ventilation industry advocated above all more well-functioning ventilation. Others perceived ecological construction, natural materials, and simple techniques as a solution.

At the end of the 1990s came an increased distrust of the concept of "sick building". A dissertation at the Karolinska Institute in Stockholm 1999 questioned the methodology of previous research, and a Danish study from 2005 showed these flaws experimentally. It was suggested that sick building syndrome was not really a coherent syndrome and was not a disease to be individually diagnosed, but a collection of as many as a dozen semi-related diseases. In 2006 the Swedish National Board of Health and Welfare recommended in the medical journal *Läkartidningen* that "sick building syndrome" should not be used as a clinical diagnosis. Thereafter, it has become increasingly less common to use terms such as *sick buildings* and *sick building syndrome* in research. However, the concept remains alive in popular culture and is used to designate the set of symptoms related to poor home or work environment engineering. *Sick building* is therefore an expression used especially in the context of workplace health.

Sick building syndrome made a rapid journey from media to courtroom where professional engineers and architects became named defendants and were represented

by their respective professional practice insurers. Proceedings invariably relied on expert witnesses, medical and technical experts along with building managers, contractors and manufacturers of finishes and furnishings, testifying as to cause and effect. Most of these actions resulted in sealed settlement agreements, none of these being dramatic. The insurers needed a defense based upon Standards of Professional Practice to meet a court decision that declared that in a modern, essentially sealed building, the HVAC systems must produce breathing air for suitable human consumption. ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers, currently with over 50,000 international members) undertook the task of codifying its indoor air quality (IAQ) standard.

ASHRAE empirical research determined that "acceptability" was a function of outdoor (fresh air) ventilation rate and used carbon dioxide as an accurate measurement of occupant presence and activity. Building odors and contaminants would be suitably controlled by this dilution methodology. ASHRAE codified a level of 1,000 ppm of carbon dioxide and specified the use of widely available sense-and-control equipment to assure compliance. The 1989 issue of ASHRAE 62.1-1989 published the whys and wherefores and overrode the 1981 requirements that were aimed at a ventilation level of 5,000 ppm of carbon dioxide (the OSHA workplace limit), federally set to minimize HVAC system energy consumption. This apparently ended the SBS epidemic.

Over time, building materials changed with respect to emissions potential. Smoking vanished and dramatic improvements in ambient air quality, coupled with code compliant ventilation and maintenance, per ASHRAE standards have all contributed to the acceptability of the indoor air environment.^{[49][50]}

See also

[edit]

- Aerotoxic syndrome
- Air purifier
- Asthmagen
- Cleanroom
- Electromagnetic hypersensitivity
- Havana syndrome
- Healthy building
- Indoor air quality
- Lead paint
- Multiple chemical sensitivity
- NASA Clean Air Study
- Nosocomial infection
- Particulates
- Power tools
- Renovation

- Somatization disorder
- Fan death

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External links

[edit]

- Best Practices for Indoor Air Quality when Remodeling Your Home, US EPA
- Renovation and Repair, Part of Indoor Air Quality Design Tools for Schools, US EPA
- Addressing Indoor Environmental Concerns During Remodeling, US EPA
- Dust FAQs, UK HSE Archived 2023-03-20 at the Wayback Machine
- CCOHS: Welding - Fumes And Gases | Health Effect of Welding Fumes

Classification	○ MeSH: D018877	D
External resources	○ Patient UK: Sick building syndrome	

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Heating, ventilation, and air conditioning

**Fundamental
concepts**

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

Technology

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

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

**Measurement
and control**

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

**Professions,
trades,
and services**

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

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Employment

Classifications

- Academic tenure
- Casual
- Contingent work
- Full-time job
- Gig worker
- Job sharing
- Part-time job
- Self-employment
- Side job
- Skilled worker
 - Journeyman
 - Technician
 - Tradesperson
- Independent contractor
- Labour hire
- Temporary work
- Laborer
- Wage labour

Hiring

- Application
- Background check
- Business networking
- Cover letter
- Curriculum vitae
- Drug testing
- Employment contract
- Employment counsellor
- Executive search
 - list
- Induction programme
- Job fair
- Job fraud
- Job hunting
- Job interview
- Letter of recommendation
- Onboarding
- Overqualification
- Person–environment fit
- Personality–job fit theory
- Personality hire
- Probation
- Realistic job preview
- Recruitment
- Résumé
- Simultaneous recruiting of new graduates
- Underemployment
- Work-at-home scheme
- Cooperative
- Employee
- Employer
- Internship

Roles

- Job
- Labour hire
- Permanent employment
- Supervisor
- Volunteering

Working class

- Blue-collar
- Green-collar
- Grey-collar
- Pink-collar
- Precariat
- White-collar
- Red-collar
- New-collar
- No-collar
- Orange-collar
- Scarlet-collar
- Black-collar
- Gold-collar

Career and training

- Apprenticeship
- Artisan
 - Master craftsman
- Avocation
- Career assessment
- Career counseling
- Career development
- Coaching
- Creative class
- Education
 - Continuing education
 - E-learning
 - Employability
 - Further education
 - Graduate school
 - Induction training
 - Knowledge worker
 - Licensure
 - Lifelong learning
 - Overspecialization
 - Practice-based professional learning
 - Professional association
 - Professional certification
 - Professional development
 - Professional school
 - Reflective practice
 - Retraining
 - Vocational education
 - Vocational school
 - Vocational university
- Mentorship
- Occupational Outlook Handbook
- Practice firm
- Profession
 - Operator
 - Professional
- Tradesman
- Vocation

Attendance

- Break
- Break room
- Career break
- Furlough
- Gap year
- Leave of absence
- Long service leave
- No call, no show
- Sabbatical
- Sick leave
- Time clock
- 35-hour workweek
- Four-day week
- Eight-hour day
- 996 working hour system
- Flextime

Schedules

- On-call
- Overtime
- Remote work
- Six-hour day
- Shift work
- Working time
- Workweek and weekend
- Income bracket
- Income tax
- Living wage
- Maximum wage
- National average salary
 - World
 - Europe
- Minimum wage
 - Canada
 - Hong Kong
 - Europe
 - United States

Wages and salaries

- Progressive wage
 - Singapore
- Overtime rate
- Paid time off
- Performance-related pay
- Salary cap
- Wage compression
- Working poor

Benefits

- Annual leave
- Casual Friday
- Child care
- Disability insurance
- Health insurance
- Life insurance
- Marriage leave
- Parental leave
- Pension
- Sick leave
 - United States
- Take-home vehicle
- Crunch
- Epilepsy and employment
- Human factors and ergonomics
- Karoshi
- List of countries by rate of fatal workplace accidents
- Occupational burnout
- Occupational disease
- Occupational exposure limit
- Occupational health psychology
- Occupational injury
- Occupational noise
- Occupational stress
- Personal protective equipment
- Repetitive strain injury
- Right to sit
 - United States
- Sick building syndrome
- Work accident
 - Occupational fatality
- Workers' compensation
- Workers' right to access the toilet
- Workplace health promotion
- Workplace phobia
- Workplace wellness
- Affirmative action
- Equal pay for equal work
- Gender pay gap
- Glass ceiling

Safety and health

Equal opportunity

Infractions

- Corporate collapses and scandals
 - Accounting scandals
 - Control fraud
 - Corporate behaviour
 - Corporate crime
- Discrimination
- Exploitation of labour
- Dress code
- Employee handbook
- Employee monitoring
- Evaluation
- Labour law
- Sexual harassment
- Sleeping while on duty
- Wage theft
- Whistleblower
- Workplace bullying
- Workplace harassment
- Workplace incivility
- Boreout
- Careerism
- Civil conscription
- Conscription
- Critique of work
- Dead-end job
- Job satisfaction
- McJob
- Organizational commitment
- Refusal of work
- Slavery

Willingness

- Bonded labour
- Human trafficking
- Labour camp
- Penal labour
- Peonage
- Truck wages
- Unfree labour
- Wage slavery
- Work ethic
- Work–life interface
 - Downshifting
 - Slow living
- Workaholic

Termination

- At-will employment
- Dismissal
 - Banishment room
 - Constructive dismissal
 - Wrongful dismissal
- Employee offboarding
- Exit interview
- Layoff
- Notice period
- Pink slip
- Resignation
 - Letter of resignation
- Restructuring
- Retirement
 - Mandatory retirement
 - Retirement age
 - Retirement planning
- Severance package
 - Golden handshake
 - Golden parachute
- Turnover

Unemployment

- Barriers to entry
- Discouraged worker
- Economic depression
 - Great Depression
 - Long Depression
- Frictional unemployment
- Full employment
- Graduate unemployment
- Involuntary unemployment
- Jobless recovery
- Phillips curve
- Recession
 - Great Recession
 - Job losses caused by the Great Recession
 - Lists of recessions
 - Recession-proof job
- Reserve army of labour
- Structural unemployment
- Technological unemployment
- Types of unemployment
- Unemployment benefits
- Unemployment Convention, 1919
- Unemployment extension
- List of countries by unemployment rate
- Employment-to-population ratio
 - List
- Wage curve
- Youth unemployment
- Workfare
- Unemployment insurance
- Make-work job
- Job creation program
- Job creation index
- Job guarantee
- Employer of last resort
- Guaranteed minimum income
- Right to work
- *Historical:*
 - *U.S.A.:*
 - Civil Works Administration
 - Works Progress Administration

Public programs

Comprehensive Employment and Training Act

See also

- Bullshit job
- Busy work
- Credentialism and educational inflation
- Emotional labor
- Evil corporation
- Going postal
- Kiss up kick down
- Labor rights
- Make-work job
- Narcissism in the workplace
- Post-work society
- Presenteeism
- Psychopathy in the workplace
- Sunday scaries
- Slow movement (culture)
- Toxic leader
- Toxic workplace
- Workhouse

See also templates

- Aspects of corporations
- Aspects of jobs
- Aspects of occupations
- Aspects of organizations
- Aspects of workplaces
- Corporate titles
- Critique of work
- Organized labor

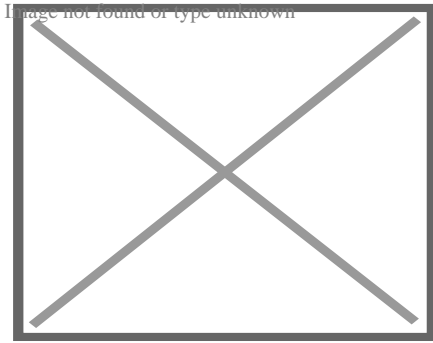
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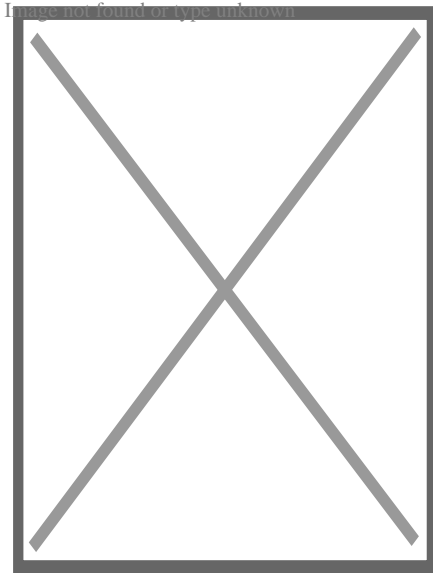
- Japan

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About Heat exchanger



Tubular heat exchanger

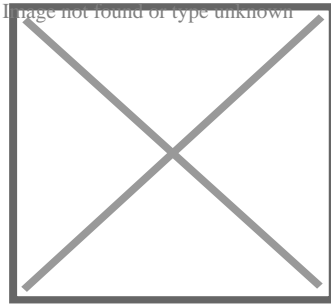


Partial view into inlet plenum of shell and tube heat exchanger of a refrigerant based chiller for providing air-conditioning to a building

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 exchanger, single pass (1-1 parallel flow)

○

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

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

○

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

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.

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]

Fig. 3: Shell and tube heat exchanger

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

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

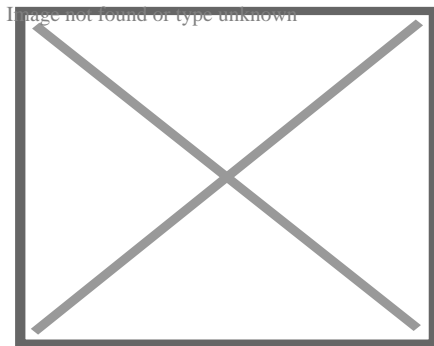
condensation. Surface condenser is the most common type of condenser where it includes a water supply device. Figure 5 below displays a two-pass surface condenser.

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.

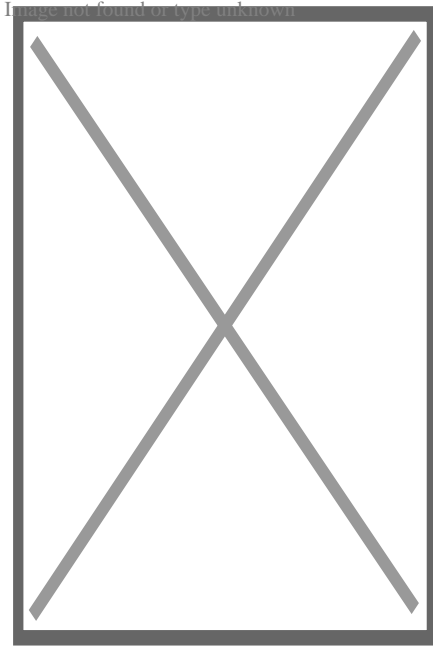
Shell and tube

[edit]

Main article: Shell and tube heat exchanger



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

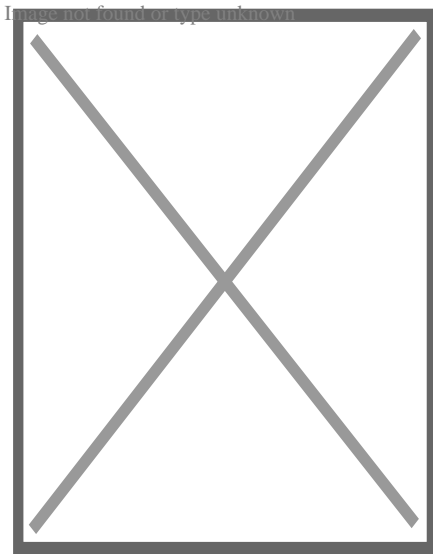
heat transfer area on air side. For this function fins can be added on the tubes to increase heat transfer area on air side and create a tubes & fins configuration.

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*).

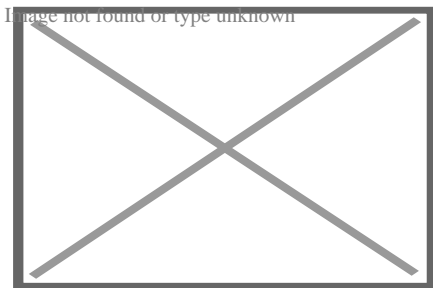
Plate

[edit]

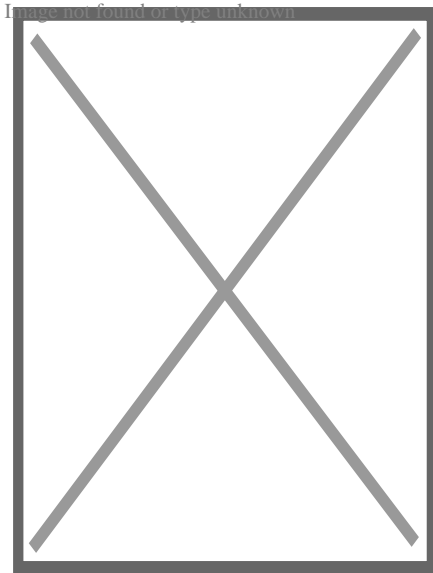
Main article: Plate heat exchanger



Conceptual diagram of a plate and frame heat exchanger



A single plate heat exchanger



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]
- 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.

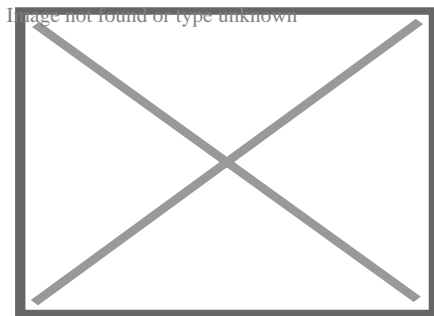
Dynamic scraped surface

[edit]

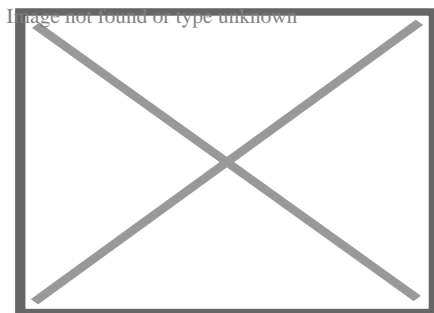
Another type of heat exchanger is called "(dynamic) scraped surface heat exchanger". This is mainly used for heating or cooling with high-viscosity products, crystallization processes, evaporation and high-fouling applications. Long running times are achieved due to the continuous scraping of the surface, 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 Liquid flow	No	Spray coolers/quenchers
			Yes	Spray condensers/evaporation, jet condensers
	Liquid	Gravity	No	Bubble columns, perforated tray columns
			Yes	Bubble column condensers
		Forced Gas flow	No	Gas spargers
			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*.

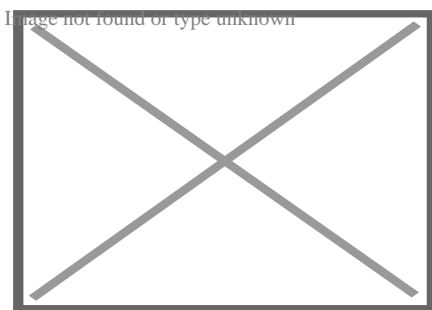
For many climates, water or steam HVAC coils can be exposed to freezing conditions. Because water expands upon freezing, these somewhat expensive and difficult to replace thin-walled heat exchangers can easily be damaged or destroyed by just one freeze. As such, freeze protection of coils is a major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



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.

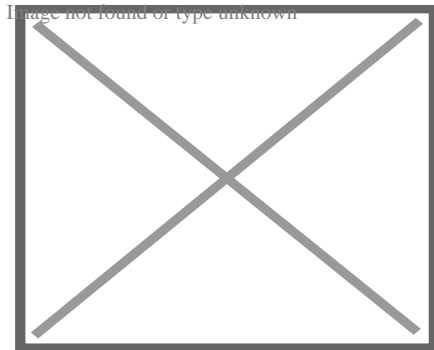
These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s, using

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

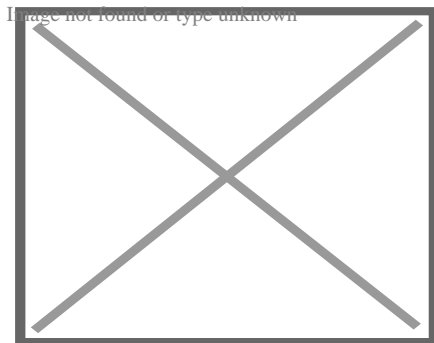
[edit]

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 needed*] These are used to transfer the heat.

Selection

[edit]

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

[edit]

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.

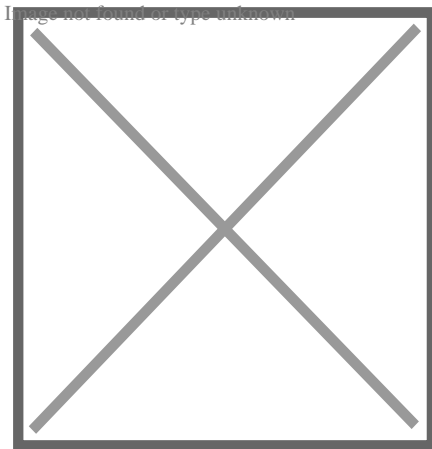
Integrity inspection of plate and tubular heat exchanger can be tested in situ by the conductivity or helium gas methods. These methods confirm the integrity of the plates or tubes to prevent any cross contamination and the condition of the gaskets.

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

Fouling

[edit]

Main article: Fouling



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

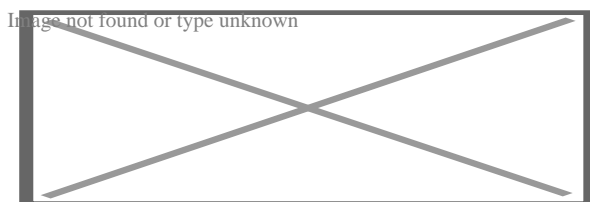
[edit]

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 C (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 \dot{m}_i (per unit time), where the subscript i applies to pipe 1 or pipe 2.

Temperature profiles for the pipes are $T_i(x)$ and $T_j(x)$ 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:

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

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

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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 γ)
 γ is the thermal energy per unit length and J 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:

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

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

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where J is the "thermal mass flow rate". The differential equations governing the heat exchanger may now be written as:

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

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

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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:

$$T_1 = A - \frac{Bk_1}{k}, e^{-kx}$$

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$$T_2 = A + \frac{Bk_2}{k}, e^{-kx}$$

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where $k = \frac{\gamma}{J_1 + J_2}$

$$k = k_1 + k_2$$

(this is for parallel-flow, but for counter-flow the sign in front of k is $-k$ so that if $k_2 = -k_1$ "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 $(T_2 - T_1)$)
 counter-current 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_1 and T_2 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:

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

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

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Using the solutions above, these temperatures are:

$$T_{10} = A - \frac{Bk_1}{k} \quad T_{20} = A + \frac{Bk_2}{k}$$

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$$T_{1L} = A - \frac{Bk_1}{k} e^{-kL} \quad T_{2L} = A + \frac{Bk_2}{k} e^{-kL}$$

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$$\overline{T}_1 = A - \frac{Bk_1}{k^2L} (1 - e^{-kL}) \quad \overline{T}_2 = A + \frac{Bk_2}{k^2L} (1 - e^{-kL})$$

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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:

$$\frac{dU_1}{dt} = \int_0^L \frac{du_1}{dt} dx = J_1 (T_{1L} - T_{10}) = \gamma L (\overline{T}_2 - \overline{T}_1)$$

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$$\frac{dU_2}{dt} = \int_0^L \frac{du_2}{dt} dx = J_2 (T_{2L} - T_{20}) = \gamma L (\overline{T}_1 - \overline{T}_2)$$

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By the conservation of energy, the sum of the two energies is zero. The quantity $\overline{T}_2 - \overline{T}_1$ 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

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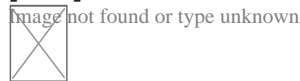
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External links

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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)

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Heating, ventilation, and air conditioning

Fundamental concepts

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

Technology

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

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

**Measurement
and control**

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

**Professions,
trades,
and services**

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

About Royal Supply Inc

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Things To Do in Jefferson County

Photo

Jefferson Barracks Park

4.8 (2321)

Photo

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Jefferson County Convention & Visitors Bureau

4.4 (30)

Photo

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Jefferson Landing State Historic Site

4.5 (95)

Photo

Visit Jefferson County Tennessee

5 (3)

Photo

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Jefferson County Historical Village

4.7 (145)

Photo

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Cole County Historical Museum

4.5 (16)

Driving Directions in Jefferson County

Driving Directions From AT&T Store to Royal Supply Inc

Driving Directions From Target to Royal Supply Inc

Driving Directions From Barnes & Noble to Royal Supply Inc

Driving Directions From Tower Music to Royal Supply Inc

Driving Directions From E-Cig Mania to Royal Supply Inc

Driving Directions From Butler Supply to Royal Supply Inc

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Reviews for Royal Supply Inc

Royal Supply Inc

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Ae Webb

(5)

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

Royal Supply Inc

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Gidget McCarthy

(5)

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

Royal Supply Inc

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Toney Dunaway

(5)

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

Royal Supply Inc

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bill slayton

(1)

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

Royal Supply Inc

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Terry Self

(1)

Horrible workmanship, horrible customer service, don't show up when they say they are. Ghosted. Was supposed to come back on Monday, no call no show. Called Tuesday and Wednesday, left messages both days. Nothing. Kinked my line, crooked to the pad and house, didn't put disconnect back on, left the trash.....

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Royal Supply Inc

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