Four Seasons
CONTROLLED CLIMATES LTD.

PilotLight

A magazine for the valued customers of Four Seasons Controlled Climates

Summer 2001

Gearing up for Summer!

- **Preventing Heat illness at Work**
  What employers need to know
- **Thermoelectric Cooling**
  New products based on an old principle
- **Smart Ventilation**
  Improve air quality and save money
- **New HVAC unit, big savings at DSC Security Systems**

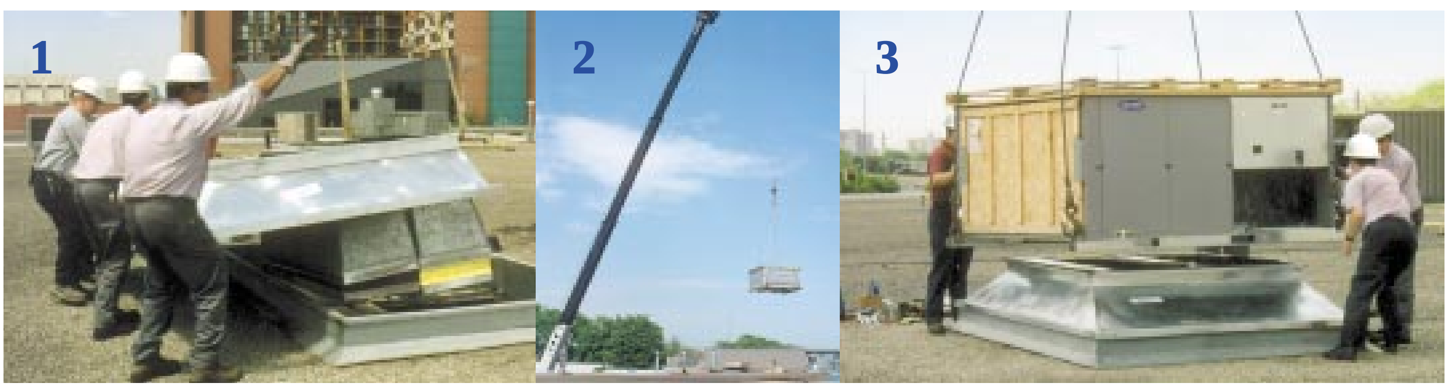
PLUS : Old Willy, Bodilee Functions, and MORE!

CASE STUDY

Adapting For a 40% Savings in Energy at DSC Security Systems

Digital Security Controls Ltd. is a worldwide leader in the development, manufacturing, and distribution of commercial and residential security systems. Over the last 6 years the DSC Group of Companies has enjoyed 580% growth.

Behind that success is a commitment to continually bring new standards of performance, reliability, and value. Over 200 engineers and technologists contribute to ongoing R&D projects, providing high quality, cost effective, and innovative products such as intrusion alarm systems, burglar and fire detection devices, home systems, alarm communication, and closed circuit television.



1. DSC Maintenance Manager, Michael Lilley (first from the left) lends a hand to set the curb adapter in place. 2. The new heating/cooling unit gets a lift onto the roof. 3. Setting the new unit onto the curb adapter.

While DSC has locations all over the world, our story concerns the company's North York facility. Looking at the building's expansive rooftop with it's myriad HVAC units, one can easily see that maintaining the facility's heating and cooling systems is a big job; it's one that Michael Lilley, DSC Maintenance Manager performs with constant vigilance.

Part of that vigilance involves keeping a watchful eye on the costs associated with operating the rooftop HVAC units. Though many of the units at DSC have served the company well for many years, they are starting to show their age in the form of higher maintenance and repair costs. Lately, costs have been high enough on some units to justify replacing them.

Last summer, with the help of Four Seasons Controlled Climates, the first in a series of replacement units was installed. For the same cooling capacity the new HVAC unit was considerably smaller than the 25-year-old unit it replaced. Given that the new unit was to be installed onto the same curb that supported the old unit, a few modifications were required. The most notable modification was the addition of a custom-made curb adapter. A curb adapter does exactly what its name implies: it adapts an existing curb to fit a new unit. The use of a curb adapter avoided the expense of modifying the roof and necessitated only minimal changes to internal ductwork.

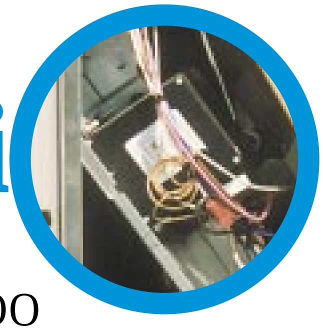
We can go on about the fine details of the job, but the real point of this story is how much energy the new units will save. Thanks to advances in heating and cooling technology, the new unit is at least 20% more efficient in heating mode and at least 40% more efficient in cooling mode than the old unit.

Things look even better when you consider that the higher efficiency rating doesn't take into account the savings that can be achieved with the new unit's built-in economizer. Economizers are devices that optimize the amount of fresh air HVAC units allow into a building. Regulating fresh air intake reduces cooling and heating loads, resulting in considerable energy savings (see "Smart Ventilation" below).

With more new replacement HVAC units being installed this season, DSC will dramatically cut its energy bills while continuing to provide its employees with a healthy, comfortable working environment. But then that's just the kind of proaction you'd expect from a worldwide leader.

HOW IT WORKS

Smart Ventilation



IMPROVE INDOOR AIR QUALITY AND SAVE ENERGY TOO

These days indoor air quality and energy costs are on the minds of more and more building owners and managers. Study after study point to a link between indoor air quality and employee health. At the same time, rising energy prices are increasing the operating costs associated with heating and air conditioning.

Indoor air quality and CO_2

One of the most common and easily detectable indoor air contaminants is carbon dioxide (CO_2). While the extreme effects of CO_2 poisoning are generally not a concern in most buildings, elevated levels of CO_2 are common and can cause drowsiness, fatigue, and headaches among occupants.

As a by-product of respiration, CO_2 levels inside buildings are affected by the number of occupants, their level of activity, building tightness, ventilation rate, space volume, plants, and building construction. Furthermore, and perhaps even more important is that CO_2 levels typically correlate with other air contaminants such as volatile organic compounds, particulates, bacteria and viruses. This means that if high levels of CO_2 are detected inside a building, chances are good there are high levels of other contaminants as well.

One of the most effective ways to reduce indoor air pollution is by increasing ventilation. However, this causes something of a conundrum: if you increase ventilation, indoor air quality will improve but you will use more energy—bringing in outdoor air means there is more air to heat during the winter and more air to cool during the summer. If, on the other hand you seal the building, you will reduce energy consumption but indoor air quality will degrade. What is a cost conscious but conscientious manager to do? One very cost effective solution is…

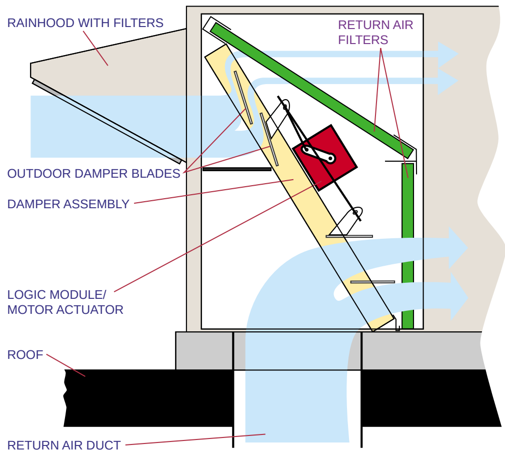
Smart ventilation

Smart ventilation is another term for the more technical sounding *"demand control ventilation."* Simply stated, demand control ventilation involves varying the amount of ventilation in a building according to certain parameters in order to achieve better indoor air quality and reduced energy consumption by the HVAC system. The technology behind smart ventilation is a device called an *economizer.*

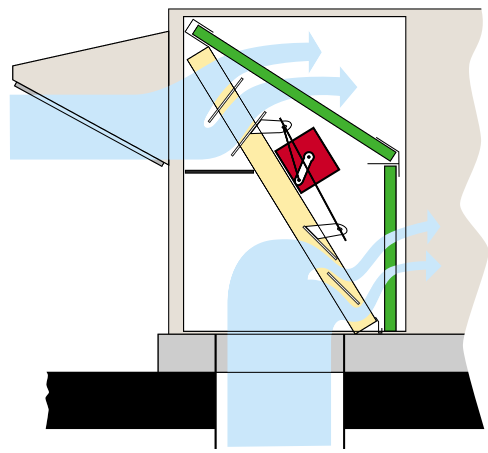
How an economizer works

When installed into a rooftop unit, an economizer optimizes the amount of outdoor air introduced into a building for cooling and ventilation. It does this by regulating the position of the outdoor air damper blades in the HVAC unit. Sensors mounted at various points inside the unit monitor variables, such as temperature and humidity inside and outside the building, as well as CO_2 and perhaps other pollutants inside the building. These variables serve as inputs to a *logic module/motor actuator* which automatically adjusts the angle of the damper blades in the out-

TYPICAL ROOFTOP UNIT EQUIPPED WITH AN ECONOMIZER



Outdoor damper blades are automatically set to the minimum position to reduce ventilation rates when
- mechanical heating is engaged;
- outdoor humidity is high and cooling is engaged.



Outdoor damper blades are angled to allow more fresh air into the building
- during warmer weather, if the outdoor air is cooler than the indoor air, or;
- if the indoor CO_2 level is too high.

door damper assembly to the optimum angle. When indoor air contaminants reach unacceptable levels or when the outdoor temperature makes the outdoor air suitable for "free cooling", the economizer allows more fresh air into the building. When mechanical cooling or heating is engaged or when outdoor humidity is high, the economizer reduces the amount of fresh air intake to conserve energy.

Other features and benefits

Aside from optimizing ventilation rates, economizers have other benefits as well:
- Automatic operation;
- They protect coils from freezing;
- No programming required;
- Versatile ventilation strategies, such as built-in purge, air change and shutdown, and additional exhaust and supply fan control functions;
- Durable solid-state circuitry give economizers a field-proven minimum 10 year life span.

Cost-effective upgrades

Today economizers are pre-installed into most new rooftop HVAC units, but many older units are not equipped with this simple yet effective device. Economizers can be purchased as kits and they can be inexpensively installed into older units. They are a cost-effective way to improve indoor air quality and conserve energy.

"Uh...Don't quote me on that."

"I'm not going to have some reporters pawing through our papers. We are the President."
– Hillary Clinton on the release of subpoenaed documents

"Outside of the killings, Washington has one of the lowest crime rates in the country."
– Marion Barry, mayor of Washington D.C.

"It isn't pollution that's harming the environment. It's the impurities in our air and water that are doing it."
– Dan Quayle, former V.P. of United States

"Smoking kills. If you're killed you've lost a very important part of your life."
– Brook Shields

"I haven't committed a crime. What I did was fail to comply with the law."
– David Dinkins, former mayor of New York

"Whenever I watch TV and see those poor, starving kids all over the world, I can't help but cry. I mean, I'd love to be skinny like that but not with all those flies and death and stuff."
– Mariah Carey, pop star

Thermoelectric Cooling Devices

Today, thermoelectric cooling is used in a growing number of devices such as personal cooling systems, electronics, and portable refrigerators. Will your home or office one day be cooled by a thermoelectric air conditioner?

Aside from supplying energy to power machines, devices and lights, electricity and its related phenomena are behind the actual workings of some of the most pervasive technologies in history.

In 1883, while developing his most famous invention, Thomas Edison noticed that when a negatively charged wire inside a vacuated glass tube got hot enough, it emitted a stream of electrons. Edison didn't know it at the time but his illuminating discovery would form the foundation for the field of electronics. Out of that field came inventions such as radio, television, computers, and a plethora of other products that today are as common as light bulbs.

Before Edison lit the way for electronics, other scientists and engineers discovered other interesting and useful properties of electricity. In the 1820s German physicist Thomas Seebeck discovered that if you take two strips of different metals and join the ends to form a loop or circuit, then make one junction sufficiently warmer than the other, voltage is induced. The effect he discovered is known as the Seebeck effect; the device he invented is the *thermocouple*.

In 1834, French physicist Jean Peltier discovered an effect that was the inverse of the Seebeck effect. Peltier found that if you pass a current through a thermocouple, heat flows from one junction to the other. If the polarity (direction of the current) is reversed, the direction of heat transfer is also reversed. Peltier's discovery is known, appropriately, as the Peltier effect. The Peltier effect and the Seebeck effect are two properties of the phenomenon called *thermoelectricity*.

Applications of thermoelectricity

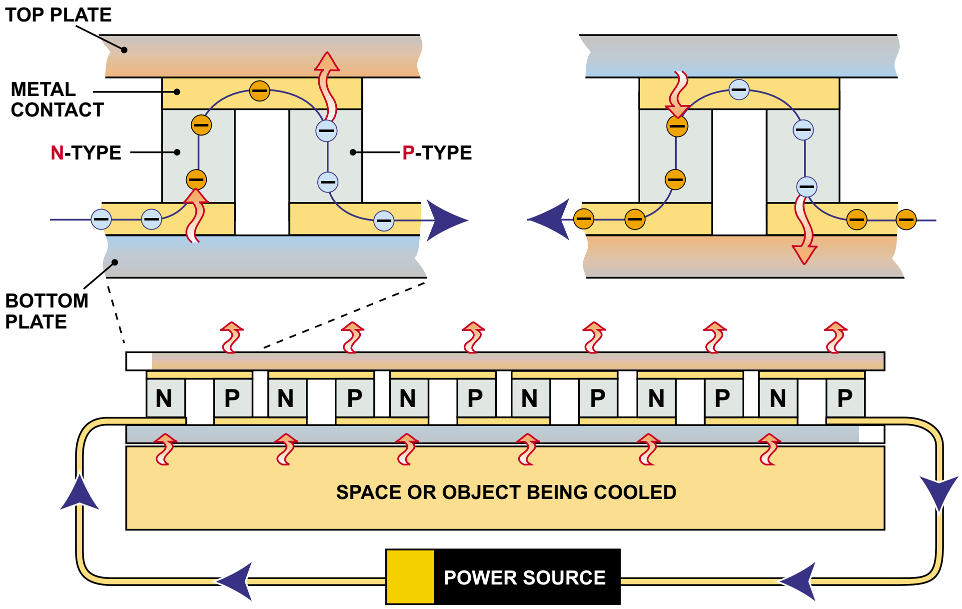
Thermocouples are the basis for all thermoelectric devices. Thermocouples were initially utilized as temperature sensors in laboratories and inside furnaces. In the 1950s it was found that using semiconductors instead of metals made for better thermocouples. The semiconductors are differentiated by their charge. One semiconductor has an excess of electrons, giving it a negative charge. The other semiconductor has a deficit of electrons, giving it a positive charge. The two semiconductors are called *n-type* and *p-type* respectively.

One of the main applications of semiconductor-based thermocouples is cooling. Thermoelectric cooling devices are essentially very simple heat pumps that operate on the Peltier effect. (A heat pump is a device that can transfer heat energy from one medium or space to another.)

How thermoelectric devices work

A thermoelectric cooling device is made up of an array of semiconductors connected in series in an alternating pattern of n-type and p-type. The top of the first semiconductor in the series is connected to the top of the second via a metal contact. Similarly, the bottom of the second semiconductor is connected to the bottom of the third. The top of the third is connected to the top of the fourth, and so on. The first and last semiconductors in the series are connected to segments of wire. The open ends of the wires are linked to an electrical power source, creating an electrical circuit. The semiconductors are sandwiched between two ceramic plates. Ceramic is used because it is a good conductor of heat but not electricity.

When electricity flows through the array, depending on the direction of flow, one of the plates will absorb heat from the other plate. The heat is transferred by the moving electrons. As electrons enter an n-type semiconductor they "jump" to a higher energy state. The



A thermoelectric cooling device is made up of a series of alternating n-type and p-type semiconductors linked by metal contacts. The entire array of semiconductors is sandwiched between ceramic plates. Electrons alternately absorb and release heat as they pass from semiconductor to semiconductor in the series. This heat is absorbed from one plate and transferred to the other. If the flow of electrons is reversed, the direction of heat transfer is also reversed.

closer of the two ceramic plates supplies the energy needed to make the jump. As the electrons continue, they flow from the n-type semiconductor to a p-type semiconductor. When the electrons enter the p-type semiconductor they fall to a lower energy state and release energy. The other ceramic plate absorbs this energy. Electrons flow from semiconductor to semiconductor, alternately absorbing heat from one plate and releasing heat to the other plate.

The plate that supplies the electrons with energy becomes colder than its surroundings. Since heat flows from hot to cold, the cold plate draws in heat from the air or directly from warmer objects that are in contact with it. If the direction of the electric current is reversed, the direction of heat flow is also reversed, as if the array was turned up side down.

Thermoelectric cooling devices

Common thermoelectric cooling devices available today include medical and pharmaceutical devices, such as coolers that preserve blood plasma and antibiotics during storage and transport, as well as devices for treating hypothermia and hyperthermia in patients. Thermoelectric cooling is also widely used in spectroscopy systems, detection systems, electronic equipment, portable refrigerators, beverage coolers, chilled food and beverage dispensers, drinking water coolers, and personal cooling systems.

Thermoelectric air conditioning?

The heat pumping capacity of a thermoelectric cooler is proportional to the current and the number of semiconductors in the array. However, simply creating very large thermocouple arrays for cooling large spaces like buildings and homes is not yet practical. One reason is low efficiency. The thermoelectric cooling process is woefully inefficient compared to the vapour compression process—the process used by most air conditioning systems. New materials with better characteristics need to be developed before thermoelectric cooling can become a viable alternative. However, if practical thermoelectric air conditioning systems could be manufactured, they would be far more reliable than vapour compression systems, primarily because they have no moving parts. Furthermore, thermoelectric cooling devices do not require refrigerants, making them more environmentally friendly.

Thermoelectric beverage coolers, like the one pictured here from Coleman, are becoming increasingly popular. A more recent innovation is the personal cooling device from Sharper Image.

Despite its limitations, thermoelectric cooling has proven a beneficial and sometimes lifesaving application of that phenomenon we call electricity.

We think Edison would have approved.

Dangerous Summer

How to protect your employees from potentially deadly heat stress.

Over 200 people in the United States die from heat illnesses every year. During heat waves the number has gone as high as 1,700. Although the chances of literally dying from the heat are far lower in Canada, heat stress should still be a concern for employers during the summer, especially those who operate facilities with high heat loads or inadequate cooling. Inattentive employers risk injuries, downtime, lost work days, and poor productivity.

Heat Stress

The body experiences heat stress when it absorbs more heat than it can easily dissipate. Heat can come from various sources; our own bodies generate heat through metabolic processes and muscle movement. External factors that can affect the level of heat stress include air temperature, humidity, air movement, and sources of radiant heat.

Body Heat Control

The human body functions best within an internal temperature range of 97˚ to 100˚F (about 36˚ to 38˚C). If external heat sources cause the temperature of the blood to exceed 98.6˚F, the body initiates heat shedding actions. The first response involves increased cardiovascular activity. The heart pumps more blood to the upper layers of the skin, allowing excess heat to dissipate into the air.

If the air temperature is too high, blood circulation through the skin will not provide adequate cooling. In this circumstance, sweat glands start to release moisture. When sweat evaporates off skin it removes large quantities of heat in a process called *evaporative cooling*. (A pearl-sized bead of sweat can cool nearly one liter of blood by 1.8˚C.)

If humidity is high, sweat does not evaporate because the surrounding air is already saturated with moisture and cannot absorb any more. Under these conditions the heart responds by pumping even more blood to the skin. Even if the body is at rest, the heart will beat faster. This is why you feel tired after a long day of just lying on the beach; your heart was working overtime all day to cool your body.

If heat stress is high enough such that the body loses large enough amounts of fluid and minerals, a person could develop a heat illness.

Types of Heat Illnesses

There are many types of heat illnesses; they vary according to severity.

Heat fatigue

With so much blood going to the external surface of the body during the heat shedding process, relatively less goes to the active muscles, the brain, and other internal organs. This causes a decline in strength and stamina, and fatigue sets in. Workers may find their comprehension, retention of information, alertness, coordination and vigilance reduced.

There is no treatment for heat fatigue except to remove the individual from the heat source before a more serious heat illness develops.

Heat rash

Heat rash, or *prickly heat* occurs on skin that is kept wet by sweat trapped under restrictive clothing. It manifests as red papules (bumps on the skin). As sweating increases, these papules cause a prickling sensation. Papules may become infected if they are not treated. In most cases, heat rashes will disappear when the victim retires to a cool environment.

Heat cramps

Heat cramps can occur in people who have been exerting themselves in hot, humid weather. The depletion of minerals through sweating causes muscles to spasm after the person has stopped moving. A person suffering from heat cramps needs fluids, extra salts, a cooler environment, and rest.

Heat exhaustion

Heat exhaustion occurs when a person has lost either too much water or too much salt through sweating. Depending on the cause, the victim may or may not have a higher than normal temperature. Symptoms include thirst, weakness, nausea, headaches, confusion, vertigo, and giddiness. If not treated in time the victim may pass out.

A heat exhaustion victim needs to lie flat in a cool place and given water or electrolyte fluids to drink as soon as he or she regains consciousness. The victim should also be encouraged to get adequate rest.

Heatstroke

Heatstroke occurs when body temperature reaches 104˚F (40˚C) or higher. Heatstroke is nothing short of a medical emergency.

The symptoms of heatstroke include confusion; irrational behavior; convulsions; hot, dry skin; an abnormally high body temperature; faintness; hallucinations; seizures and loss of consciousness. Heatstroke can be severe enough to cause death.

If a worker shows signs of possible heatstroke, professional medical treatment should be sought immediately. Until professional medical attention is given, the worker should be placed in a cooler area and the outer clothing should be removed. The worker's skin should be wetted and air movement around the worker should be increased to improve evaporative cooling. Fluids should be given as soon as possible. The medical outcome of an episode of heatstroke depends on the victim's physical fitness and the timing and effectiveness of first aid treatment.

Safety Problems

Aside from the health effects, heat stress can also be a safety issue. Heat promotes accidents due to problems such as the slipperiness of sweaty palms, dizziness, or the impairment of vision due to the fogged up safety glasses.

According to the National Institute for Occupational Safety and Health (NIOSH), the frequency of accidents appears to be higher in hot environments than in more moderate environments. One reason is the aforementioned affect heat has on mental alertness and physical performance. Increased body temperature and physical discomfort also promote irritability, anger, and other emotions which can be distracting and cause loss of concentration and good judgement.

Risk Factors

Indoor operations involving high air temperatures, high humidity, radiant heat sources, close proximity to hot objects, or strenuous physical activities have a high potential for inducing heat stress. Outdoor operations conducted in hot weather, especially those that require workers to wear protective clothing, are also likely to cause heat stress among exposed workers.

Certain health conditions can increase a person's risk of heat illness. These include: high blood pressure; low blood pressure; obesity; sweat gland diseases; diabetes; dehydration; malnutrition; and heart disease. Older adults are more likely to have one or more of these health problems.

Older adults also are more likely to take medicines that impair the body's ability to regulate heat by slowing down perspiration. These include antihistamines (for allergies) and diuretics (for high blood pressure). Some medications restrict blood flow to the skin, impairing the body's ability to release heat. These include cardiovascular drugs, such as vasoconstrictors and beta blockers.

The use of illicit drugs, such as LSD, cocaine and amphetamines also increases the risk. These drugs increase muscle activity and body heat. Alcohol causes the body to lose water, leading to dehydration.

While all the above-mentioned factors increase the risk of heat illness, it is difficult to predict just who will be affected and when, because individual susceptibility varies.

Preventative Measures

Acclimatization

Acclimatization is the human body's ability to adapt to increased heat exposure over time. After a period of acclimatization, a person will experience less heat stress because of reduced cardiovascular demands and more efficient sweating.

A properly designed and applied acclimatization program basically involves exposing employees to work in a hot environment for progressively longer periods. According to NIOSH, workers who have had previous experience in jobs where heat stress is an issue should be place on a regimen of 50% exposure on day one, 60% on day two, 80% on day three, and 100% on day four. For new workers who will be working under the same conditions, the regimen should be 20% on day one, with increases of 20% each additional day.

Fluid Replacement

Cool water or non-alcoholic beverages should be made available for workers to drink in small amounts frequently, e.g. one cup every 20 minutes.

Engineering Controls

Ventilation, air cooling, fans, shielding and insulation are the main types of engineering controls used to reduce heat stress in hot work environments.

Ventilation

Ventilation is used to dilute hot air with cooler air that is brought in from the outside. Central ventilation systems are used to handle large areas or entire buildings. Portable or local exhaust systems may be more effective for venting heat from specific areas.

Central air conditioning

Air conditioning differs from ventilation because it regulates the actual temperature of the air inside a building. A major advantage air conditioning has over ventilation is the removal of humidity, a prime factor in comfort.

Cool rooms

Cool rooms are air conditioned rooms or enclosures where employees can rest for a period of time after working in a hot environment.

Fans

A very popular and inexpensive method to reduce heat stress is to increase the air flow around workers using fans. Changes in air speed can help workers stay cooler by increasing the exchange of heat between the skin and the surrounding air—an effect commonly referred to as 'wind chill'. Fans also help sweat evaporate faster. Because fans do not actually cool the air, the moving air must have direct contact with the worker's skin. Furthermore, fans are not effective above 32˚C and 35 percent humidity. In fact, under such conditions, fans can make the worker feel even hotter.

Heat shields and insulation

Shielding and insulation can be used to block the path between a source of radiant heat, such as an oven, and nearby workers. Highly reflective, polished surfaces make the best shields, although special glass or metal mesh surfaces can be used if visibility is an issue.

A surface does not need to be extremely hot in order to cause heat. Surfaces that exceed just 35°C emit infra-red radiation. While infra-red radiation is itself not heat, it causes heat when it is absorbed by people and objects. These objects then become sources of heat themselves.

Auxiliary Body Cooling

Other cooling methods and apparatus include: reflective clothing, such as aprons, jackets, and full-body suits; ice vests; wetted clothes, water-cooled garments and personal cooling systems that circulate air around the body.

Employee training and work practices

Training is the key to good work practices designed to reduce the threat of heat stress. According to NIOSH, a good heat stress training program should include at the following components:

- Knowledge of the hazards of heat stress;
- Recognition of causal factors and symptoms;
- Knowledge of first-aid treatments for heat illness;
- Understanding the dangers of drug and alcohol use in hot workplaces;
- Use of protective clothing and equipment, and;
- Purpose and coverage of environmental and medical surveillance programs, and the advantages of worker participation in such programs.

Monitoring Workers

Any worker who is at risk of heat stress should be monitored. Monitoring can be done by checking heart rate, oral temperature, or body water loss.

To check the heart rate, count the radial pulse (the pulse at the wrist) for 30 seconds at the beginning of the rest period. If the heart rate exceeds 110 beats per minute, shorten the next work period by one third and maintain the same rest period.

Oral temperature should be checked after work but before the employee drinks water. If the oral temperature taken under the tongue exceeds 37.6°C, shorten the next work cycle by one third.

Body water loss can be measured by weighing the worker on a scale at the beginning and end of each work day. The worker's weight loss should not exceed 1.5% of total body weight in a work day. If weight loss exceeds this amount, fluid intake should be increased.

As we have seen, heat stress is a potential problem that should not be taken lightly, as it can compromise both employee health and performance. However, with many ways to avoid or reduce heat stress, heat illness is certainly preventable.

THE HUMIDEX:
It's Canadian, eh!

Did you know that the humidex was invented by Canadian meteorologists? First used in 1965, the humidex combines the temperature and humidity into one number to reflect how hot it actually feels to the average person. Because it takes into account both temperature and humidity, the humidex is a better measure of comfort than either temperature or humidity alone. The Americans have their own version of the humidex called the *heat index*.

The humidex is widely used in Canada, even though extremely high readings are rare except in the most southernly regions of the country. Of all Canadian cities, Windsor, Ontario has had the highest recorded humidex measurement: 52.1 on June 20, 1953. (They must have calculated it retroactively.)

An extreme humidex is one that is over 40 (see chart below). *Environment Canada* recommends that in such conditions, all unnecessary activity should be ceased. If the reading is in the mid to high 30s, then certain activities should be toned down or modified, depending on the age, health and physical condition of the individual, as well as the type of clothes worn.

While the humidex does not offer the same level of empirical precision as temperature and humidity measurements, it remains a popular means of determining how hot it actually feels outside.
"It's not the heat, it's the humidex!"

HUMIDEX CHART

RELATIVE HUMIDITY (%)

AIR TEMPERATURE (°C)	40	45	50	55	60	65	70	75	80	85	90	95	100
38	47	49	51	52	54	56	58	60	62	63	65	67	69
36	44	45	47	48	50	52	53	56	57	58	60	62	63
34	40	42	43	45	46	47	49	50	52	53	55	56	58
32	37	38	40	41	42	43	45	46	47	49	50	51	53
30	34	35	36	37	38	40	41	42	43	44	45	47	48
28	31	32	33	34	35	36	37	38	39	40	41	42	43
26	28	29	30	31	32	32	33	34	35	36	37	38	39
24	25	26	27	27	28	29	30	31	32	32	33	34	35
22	22	23	24	24	25	26	27	27	28	29	30	30	31

No discomfort | Some discomfort | Great discomfort, avoid exertion | Dangerous | Heat stroke imminent

Data Source: Environment Canada

Old Willy & Friends

Every Day a Cool Day
Willis Carrier

Whenever it's a cool, comfortable 21 degrees inside while outside it's a soggy, scorching summer day, perhaps you should say a quiet "thank you" to the man responsible for the technology we call ***air conditioning***. That man was Willis Carrier.

Born in 1876, Willis Haviland Carrier grew up on a farm in Angola, New York. He was the only child in a family with strong New England roots (One of his ancestors was hanged as a witch in Salem).

After graduating high-school, Carrier was awarded a four-year scholarship to Cornell University. In 1901 Carrier received a Masters in Engineering. Shortly thereafter he landed a position at the Buffalo Forge Company, a manufacturer of heating systems. After less than a year, his hard work and engineering talents earned him the title: Head of Experimental Engineering.

In 1902 a Brooklyn printing company approached Buffalo Forge with a problem: humidity and temperature changes were damaging the company's printed materials. To solve the problem, Carrier designed a machine that sucked in the humid air, passed it over coils filled with brine, then forced the air back into the room. In 1906, a modified version of this machine was awarded U.S. Patent #808897. Carrier dubbed the device: "apparatus for treating air." It was actually a textile engineer named Stuart Cramer who coined the term "air conditioner."

In 1914 Buffalo Forge decided to eliminate its engineering department, so Carrier left to start his own company with about $33,000 in starting capital. He took six other engineers from Buffalo Forge with him. The company was called the Carrier Engineering Corporation; its slogan was "Every Day a Good Day."

In 1924 the J.L. Hudson Department Store in Detroit, Michigan, hired Carrier to install three centrifugal chillers to keep the air in the store dry and cool during the hot Detroit summers. As shoppers flocked to the air conditioned store, other companies quickly caught on to the benefits of air conditioning and in short order the number of installed systems, and Carrier's business, grew dramatically.

In 1928 Carrier developed the first air conditioner for home use, but it wasn't until after World War II that the residential air conditioning market took off. Today the vast majority of homes, businesses and automobiles have air conditioning. Although air conditioning is not without its downside (most notably the environmental effects), air conditioning has had many benefits, such as higher worker productivity, higher production yields, and lower mortality rates during summer heat waves.

During his lifetime, Carrier obtained more than 80 patents. Willy was proud of his prolific friend, and was said to have forged a strong friendship with Carrier. Few details of their relationship are actually known, but there has been speculation that Willy was one of the six engineers who left Buffalo Forge to join Carrier's company. Some even claim (though there is no real evidence to back it up) that the *Rational Psychrometric Formulae*—the basis for all calculations in the air conditioning industry—were not developed by Carrier but that they were actually Willy's doing.

Although Carrier was considered a genius by many, he was apparently not gifted with verbal flair (calling his invention of the air conditioner the "apparatus for treating air" is cold proof). However, Carrier, who passed away in 1950, did leave Willy with some sound advice.

One day while looking back over his life, Carrier remarked: "I never could be an expert golfer. That, too, is education—to learn where one lacks aptitude." Carrier took his lack of success at golf as a valuable lesson: while you should always strive for success, you must also be able to accept your limitations with grace and humility.

These are words that Willy never forgot.

A really "far out" cooling system for a guy who's way out there

On April 22 astronaut Chris Hadfield became the first Canadian to walk in space. Hadfield's starlit stroll was part of a NASA mission to install the Canadarm2 on the International Space Station. The robotic arm will play a pivotal role in the station's completion.

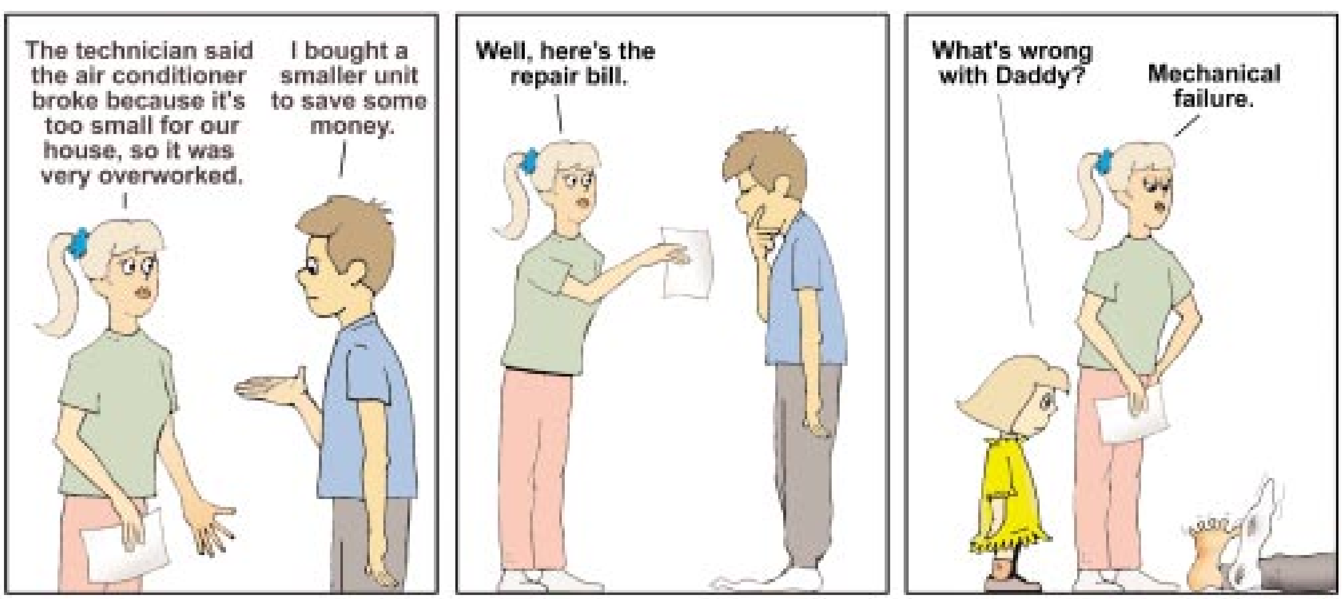
Aside from the tremendous personal achievement for the astronaut, a space walk is also an incredible technical achievement. The apparent ease of spacewalks, as viewed from our television sets, belie the complexities and dangers involved.

Hadfield's space walk was made possible thanks to the sophisticated $12 million (U.S.D.) space suit he wore. Aside from housing systems for communication, respiration, and ingestion, one of the most technically interesting systems in these "mini space ships" is the cooling system. If you're going to work in an environment where temperatures can reach 120˚C you need the ultimate in personal cooling.

The core of a space suit's cooling system is the Liquid Cooling and Ventilation Garment (LCVG) (shown here). The LCVG is a full body suit that is laced with about 90 meters of thin plastic tubing. The tubing conveys water that is cooled by a device called a sublimator, which is contained in the suit's large back-pack.

In the cooling process, feedwater first passes through a pressure regulator to reduce its pressure. The water then passes through the sublimator where it freezes at porous, stainless steel plates and then sublimates (changes directly from ice to vapour). The sublimation cools the LCVG water that flows adjacent to the plates. The cooled LCVG water is then recirculated throughout the suit.

Bodilee Functions



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