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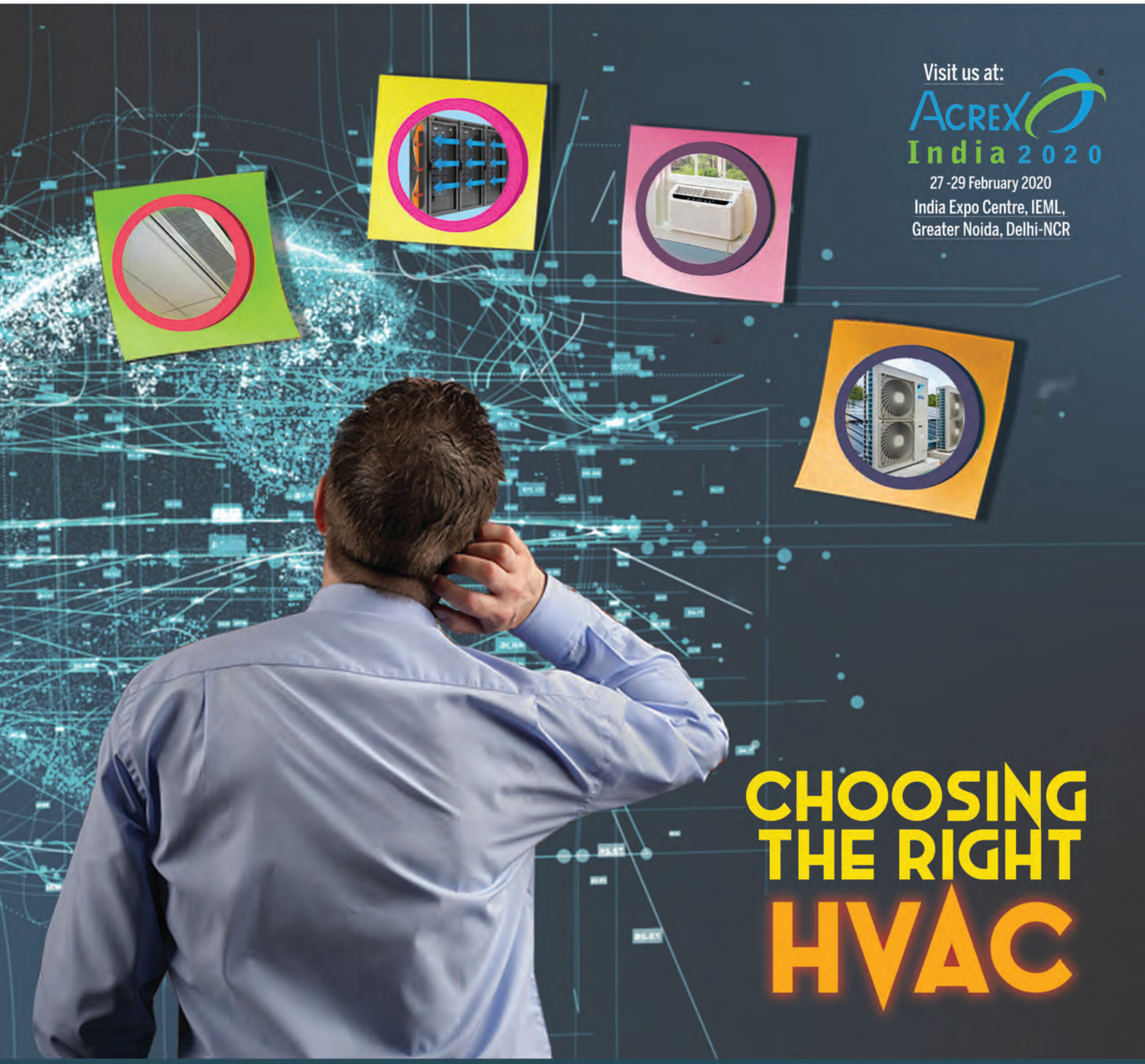
Cooling India

India's foremost Monthly dedicated to the growth of HVACR Industry



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Publisher's Letter

Hello, wishing you all a happy and prosperous new year and we are pleased to welcome you back for the first 2020 edition!

Heating, Ventilation & Air Conditioning (HVAC) infrastructure in today's buildings is a critical piece of the puzzle that goes into making buildings green and eco-friendly. Thus, HVAC has become an integral to modern idea of buildings. Selecting the right HVAC design for this can make all the difference to the carbon emissions levels of the buildings. This time, our cover story focuses on the key considerations for selection of an HVAC system as the proper selection is directly related to human health and level of comfort.

Moving on, the ill-effects of indoor air pollution result in about 2 million premature deaths per year, wherein 44 per cent are due to pneumonia, 54 per cent from chronic obstructive pulmonary disease (COPD), and 2 per cent from lung cancer. The most affected groups are women and younger children, as they spend maximum time at home. The article titled 'Effects of IAQ in Residential & Commercial Buildings' highlights the health impacts of indoor air pollution as compared to those of outdoor air pollution.

The HVAC market in India is expected to witness exponential growth on account of increasing number of high-rise buildings, shopping complexes and malls, and hypermarkets in Tier-II cities. Reports suggest that the market to reach $5.9 billion by 2024, registering a CAGR of 7 per cent, during the forecast period.

On this note, in February, Cooling India will come up with a special issue that will focus on how companies are making strides with advanced technology. Based on the theme HVAC&R INDIA 2020, the Cooling India February issue will feature the Cutting-edge HVAC&R companies to watch out for in 2020.

During 27th – 29th February 2020, India will host the HVAC industry extravaganza ACREX India 2020 at India Expo Centre, Greater Noida, Delhi-NCR. Being the media partner for this international event, Cooling India will have detail pre-event coverage. We invite your participation in this special issue. For more information, please write to me at pravita@charypublications.in

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Editor: Mahadevan Iyer

COVER STORY

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LOUVER TYPE MIST COOLING SYSTEM

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2	Chilled Water Temp in °C (Assumed)	5°C	5°C
3	Supply Temp. from CT / LTMCS	33°C	30°C
4	Approach to WBT	4°C	1°C
5	**ΔT for Chiller**	**28°C**	**25°C**
6	Chilled Water Compressor Motor Kw for 1200 TR	720	643
7	Energy Saved in %	-	10.7%
8	**Energy Saved in Kw**	**-**	**77 Kw/Hr**
9	Total Running Hours per Annum	8640	8640
10	**TOTAL POWER SAVED PER ANNUM**	**-**	**6,65,280 Kw**

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Chemours announces suspension of R-404A and R-507A supply in EU

The Chemours Company (Chemours), a chemistry company with leading market positions in titanium technologies, fluoroproducts, and chemical solutions announced that to support the market transition driven by the European Union F-Gas regulation to lower GWP alternatives and prepare for the next quota phase down in 2021, the company will be suspending supply of high GWP refrigerants R-404A (GWP 3922) and R-507A (GWP 3985) in the European Union as of January 1, 2020.

The F-Gas Regulation mandates specific prohibitions of use, as outlined in Annex III of the legislation. As of January 1, 2020, there will be a prohibition of the use of stationary refrigeration equipment that contains, or whose functioning relies upon, HFCs with GWP of 2,500 or more (except equipment intended for applications designed to cool products to temperatures below -50C).

In addition, the regulation reduces the amount of HFCs placed on the market over a 15-year period with the next quota phasedown taking effect as of January 1, 2021. This can be achieved by transitioning away from high-GWP refrigerants such as R-404A and R-507A to lower-GWP refrigerants such as those in the Opteon portfolio. Chemours offers several options for a smooth and effective transition: Opteon XP40 (R-449A) and Opteon XL40 (R-454A) and XL20 (R-454C).

Opteon XP40 (R-449A), an A1 class refrigerant with a GWP of 1397 by AR4 measurement, is currently the refrigerant of choice among supermarkets, retailers, contractors, distributors and end-users in the EU for retrofit. It delivers improved performance and energy efficiency with a more sustainable environmental footprint and offering over 65 per cent reduction in GWP compared to R-404A. ■

Toshiba develops app for R32 refrigerant AC design compliance

Toshiba has developed an online tool that automatically checks R32 refrigerant-based air conditioning designs for compliance with the safety requirements of European Standard EN378.

EN378 sets limits for refrigerant charge size in occupied spaces. These vary according to the toxicity and flammability of the refrigerant, the size of the occupied space, the accessibility of the area, and the scale of possible exposure by individuals and the public in the unlikely event of a refrigerant leak.

"The calculation for specific projects under EN378 becomes quite complex, due to the number of variables involved," said Oliver Sanders, TCUK's new equipment pre-sales manager. "The tool enables designers to quickly input the key details for a project and simply hit return; it automatically calculates whether the proposed system is compliant or not."

If a proposed design proves to be non-compliant, the tool suggests practical mitigation measures that can be used to ensure the project meets the requirements. These may include installation of a fixed refrigerant monitoring and alarm system, use of isolation valves, and/or installation of ventilation fans in the area affected by a potential leak.

"It is a really useful tool for air conditioning system designers, particularly, given the adoption of R32 refrigerant as a mainstream solution," said Sanders. "Our own pre-sales design team uses it as part of their standard process for carrying out compliance checks on proposed designs. It provides designers, consultants and contractors with reassurance and useful options to ensure systems are within safety requirements." ■

McDonald announced as keynote speaker for Greenbuild Europe

The US Green Building Council (USGBC), creators of the LEED green building rating system, announced that registration is now open for Greenbuild Europe. The conference will be held March 24-25, 2020 in Dublin, Ireland, at Croke Park and features a keynote from former Irish Times editor and author Frank McDonald, as well as remarks from USGBC and Green Business Certification Inc. (GBCI) President and CEO Mahesh Ramanujam.

Now in its third year, Greenbuild Europe is the flagship event for sustainability professionals helping to shape the future of green buildings, cities and communities. The conference offers a forum for the region's growing green building community to share the best practices, learn about the latest LEED and green building developments, and connect with peers and market leaders. Europe is currently home to more than 6,500 LEED projects, representing more than 185 million gross square meters of space. In 2018, Turkey, Germany and Spain were among the top 10 countries and territories globally for LEED green building.

"Opening registration for Greenbuild Europe is always exciting for me and officially starts the countdown to what will be a powerful conference experience," said Kay Killmann, Managing Director of GBCI Europe. "In just over 100 days, Europe's best and most talented changemakers will participate in a program designed to drive the future of green building in a market that consists of more than 40 countries with diverse perspectives on sustainability and green building. Climate change is one of the biggest challenges we face and it knows no border. Greenbuild Europe is our community's chance to show the world how we are a part of the solution."

The reasons for building green vary country by country, but the level of green building activity in Europe is expected to grow through 2021. Greenbuild provides the building, design and construction industry a method for staying updated on the latest practices and strategies. ■

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Emerson Named to Food Logistics' 2019 FL100+ Top Software and Technology Providers

Food Logistics, the only publication exclusively dedicated to covering the movement of product through the global food supply chain, has named Emerson to its 2019 FL100+ Top Software and Technology Providers list.

The annual FL100+ Top Software and Technology Providers serves as a resource guide of software and technology providers whose products and services are critical for companies in the global food and beverage supply chain.

"Whether you're using sensors to monitor critical temperatures for perishables or a WMS to manage inventory flows in your warehouse, software and technology are playing a vital role in the food and beverage industry," remarks John R. Yuva, editor for Food Logistics and its sister publication, Supply & Demand Chain Executive. "The transparency and safety of the digital global food supply chain would not exist without innovations in software and technology. Our FL100+ recipients help drive supply chain compliance and regulatory changes that benefit everyone from the farmer to the food processor to the consumer." ■

Pulleyn Transport adopts Carrier Transicold Supra 1150 units

Pulleyn Transport has specified a Carrier Transicold Supra 1150 undermount unit for a specialised new rigid truck to transport musical instruments for the Philharmonia Orchestra. The new addition is the latest in a long line of Carrier-cooled trucks and trailers delivered into the company's commercial vehicle fleet dating back more than 20 years. Carrier Transicold is a part of Carrier, a global provider of innovative heating, ventilating and air conditioning (HVAC), refrigeration, fire, security and building automation technologies.

The Carrier Transicold Supra 1150 unit is mounted on a new high-spec 26-tonne Mercedes-Benz Actros, with bespoke bodywork from Wessex Vehicle Services. Featuring a dual discharge evaporator, the powerful Supra 1150 unit is used to maintain a set point between 18 and 20 degrees Celsius, removing any internal condensation to provide the consistent, dry environment that is vital for the welfare of the instruments.

"Similar vehicles often use heating systems that rely on ducting beneath the floor," said Ryan Pulleyn, Managing Director, Pulleyn Transport. "These just don't provide the same level of consistent airflow around the interior of the body that we get from the Supra unit – it is a much

more efficient way of maintaining the precise set point."

Based at the Royal Festival Hall in London, the Philharmonia Orchestra also takes to the road to perform around the UK and across Europe. These journeys can begin and end with very different ambient temperatures outside, potentially creating condensation inside the truck. The Supra 1150 unit's ability to maintain continuous airflow – independent of the truck's engine speed – makes it the ideal solution for the orchestra's high-value musical instruments.

"Everything about this vehicle is designed to protect the cargo, from the bespoke-built shelving and load locking to the fully padded and carpeted interior. We then specified the Supra unit for its ability to keep tight control of the internal environment at all times, day or night," added Pulleyn. ■

Johnson Controls extends Hattiesburg AHU Plant

Johnson Controls has broken ground on an expansion of its air handling unit manufacturing facility in Hattiesburg, Mississippi. The 22,000 square feet expansion is predicted to create 40-50 new assembly jobs in the plant which manufactures both York and Miller-Picking brand systems.

The expansion, which will increase the facility's size to 120,000 square feet, includes the relocation of several sub-assembly cells and opens more manufacturing space in the main plant. Johnson Controls will also install a new crane system that will move products during the manufacturing process. The project is expected to be completed in May. Johnson Controls currently employs 225 workers at the facility which was built in 1968. The last building expansion was completed more than 20 years ago.

The plant complements the company's Airside Center of Excellence in York County, Pennsylvania, which features 40,000 square feet of office space and 285,000 square feet of manufacturing space. ■

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Daikin signs up with Honeywell to distribute R448A in Japan

Honeywell has announced that it has entered an agreement with the Chemicals Division of Daikin to distribute its R448A (Solstice N40 HFO) in Japan to meet increasing demand for lower GWP refrigerants in the region. Daikin will sell the product under the Creard brand.

The manufacturer noted that Solstice N40 is the supermarket industry's most widely-accepted, lowest-GWP, non-flammable replacement for legacy HFCs such as R404A and R22, globally'.

Masahiro Nitta, Senior Manager of Refrigerants, Daikin, said: "At Daikin, our commitment is to provide our customers products that best fits their needs. This led us to identify R448A from Honeywell as the widest accepted replacement for R404A and R22 in refrigerated food retail applications. R448A is a product that complements Creard R407H in our product range and allows our customers to comply with existing and proposed requirements of the Japanese market, while benefiting the environment and economy."

Honeywell added that strict GWP reduction targets set for the Japanese food retail industry have prompted retailers to seek practical solutions like Solstice N40, 'for its ease of use and proven energy savings'. In Japan, the HFC phasedown will mainly impact refrigerated condensing units and must be established by 2025. ■

VÖTSCH receives three millionth Bitzer Schkeuditz product

The specialist for refrigeration and air conditioning technology BITZER produces at 16 locations worldwide. Now the BITZER plant in Schkeuditz near Leipzig manufactured its three millionth product (compressors and condensing units). The anniversary product was received by Vötsch Industrietechnik GmbH, which uses it in one of its screening devices for environmental simulations.

They have been business partners for over 20 years: Vötsch Industrietechnik, which belongs to the Weiss Technik Companies, and BITZER. BITZER has been manufacturing reciprocating compressors and condensing units at the Schkeuditz site for a similar period of time since 1991. In November 2019, local production broke the three-million barrier – the anniversary product was received by Carsten Bräuer, Head of Development and Testing at Vötsch in Balingen, Germany. With Vötsch, Balingen is home to the competence center for standard test equipment of the Weiss

Technik Companies. Bräuer sums up, "We greatly appreciate BITZER as a supplier for compressors, condensers and oil separators. BITZER is our preferred supplier in this area. Products and support are equally reliable. In 2018, for example, we purchased around 1,000 products from BITZER for our German locations." Vötsch in Balingen develops and builds test systems for quality assurance in the field of environmental simulation. This is also where BITZER comes into play: Vötsch uses BITZER products for air conditioning applications in test rooms with temperature ranges from -10C to +95C and in temperature ranges from -80 C to +180C. ■

A-Gas urges rapid switch to reclaimed refrigerant

A-Gas is urging installers and end-users not to waste time in switching to reclaimed refrigerants now that the use of virgin R404A is banned. The company has spoken out following the latest restriction imposed by the European F-gas regulations. Since January 1 virgin HFC refrigerants with a GWP greater than 2500 have been banned from use to service or refill refrigeration or freezer systems with a refrigerant charge size of 40 tonnes of CO2e or more. This equates to around 10.2kg of R404A, a common refrigerant in medium sized systems. Smaller and hermetically sealed systems should be unaffected by this ban. The ban will also include R507 and the R22 replacement gas R422D, both of which have GWPs in excess of 2500. The ban applies across Europe.

This rule also applies to companies who may have stockpiled these refrigerants before that date. Reclaimed or recycled refrigerant will still be able to be used until 2030. "As a refrigerant supplier, we have been increasing our capacity to handle reclaimed R404A which we believe will be a stepping stone to the new generation of low GWP refrigerants," A-Gas said. A-Gas says it has invested heavily in expanding its reclamation facilities in the UK and in Europe and insists that, with the major refrigerant suppliers removing all stocks of virgin R404A and R507A from sale in the Europe, the importance that the switch to reclaimed gases must gain pace if the industry is to manage this change.

"It is also key that installers and end users understand the difference between reclaimed and recycled refrigerants," it says. "Recycled refrigerant is a handy quick-fix which is cleaned up and can only be used on site. While reclaimed refrigerant is product that has been reprocessed by a licensed facility to the industry standard AHRI 700 to match that of virgin product. It is purified, certificated and guaranteed to be returned to the same standard as virgin material. ■

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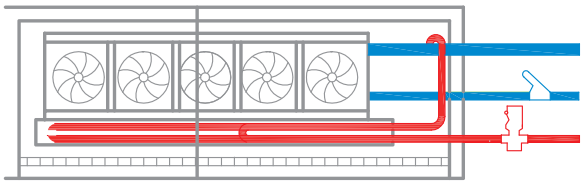

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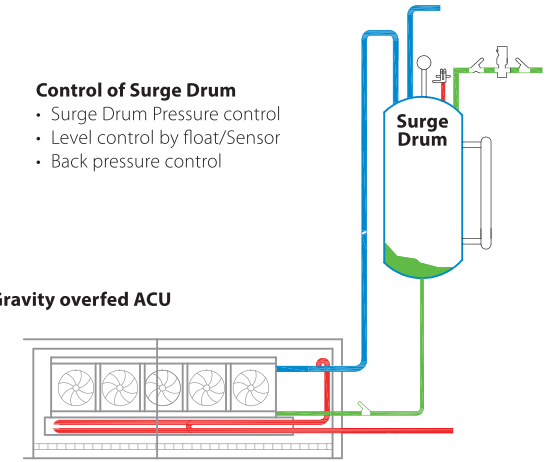

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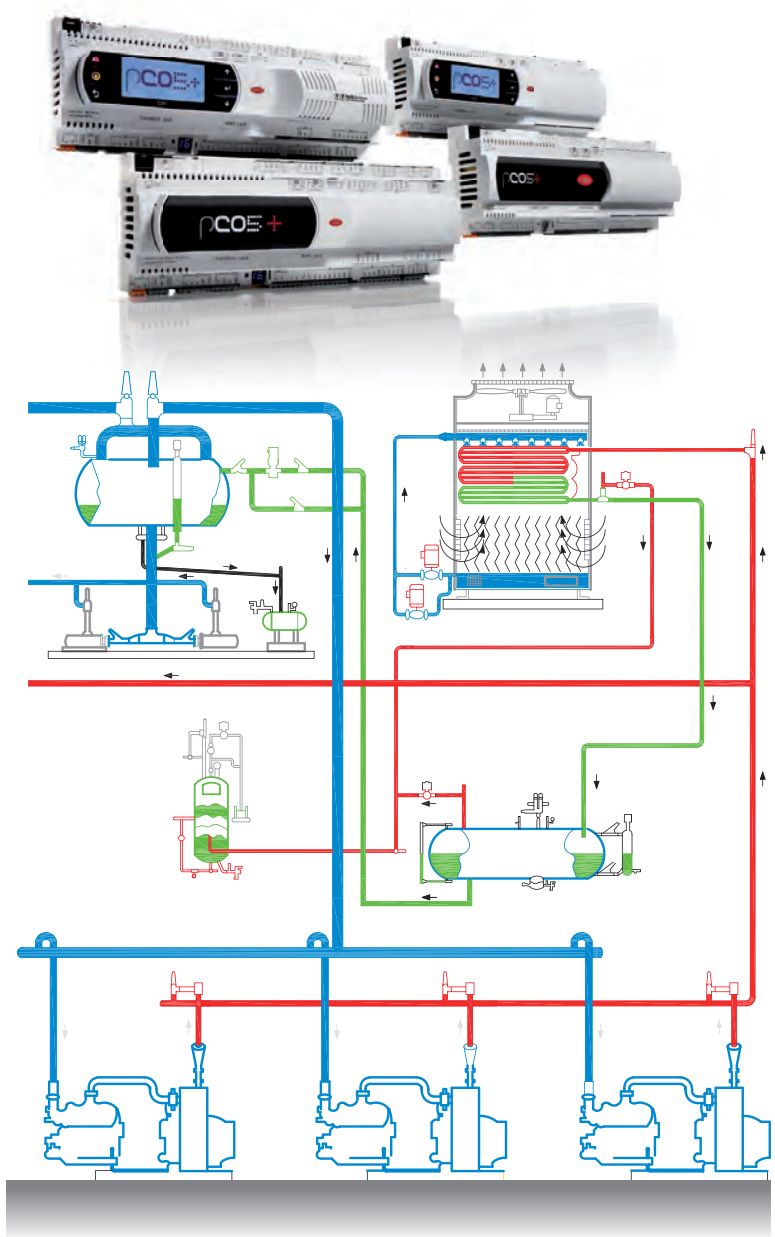

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Ingersoll Rand Introduces Future Climate Company, Trane Technologies

Ingersoll-Rand introduced its pure-play climate company, announcing the new company name, strategy and executive leadership team.

The climate company will be named Trane Technologies plc,1 elevating its market leading Trane brand and celebrating the power of technological innovation. Trane Technologies will be a global leader in climate control and is expected to trade on the New York Stock Exchange under the ticker 'TT.' Through its strategic brands, Trane and Thermo King, and portfolio of climate-focused innovations, Trane Technologies will create efficient and sustainable solutions for buildings, homes and transportation.

"Global megatrends are pushing climate action to the forefront of the world's agenda," said Michael W Lamach, Chairman and CEO of the current Ingersoll Rand and of the future Trane Technologies. "We excel where these megatrends intersect with our advanced technologies and powerful innovation. Building on our leadership in sustainability, Trane Technologies will redefine the status quo for our industry and challenge what is possible for our customers and the world."

Lamach added: "Our focus will be on sustainable businesses that directly address these megatrends and create customer value, a proven business operating system that generates productivity and execution excellence and a winning culture that empowers people to deliver their best. As a global leader in climate markets, Trane Technologies will have greater focus, more targeted investments and a simplified business model that will allow us to increase speed and agility and deliver value for shareholders, customers and employees." ■

Indian Govt makes mandatory 24C temperature for ACs

The Central Government in consultation with the Bureau of Energy Efficiency (BEE) has notified new energy performance standards for Room Air Conditioner (RACs) on 30th October 2019.

The 24C default setting has been made mandatory from January 1, 2020 for all room air conditioners covered under the ambit of BEE star-labelling program vide this notification. Additionally, the Indian Seasonal Energy Efficiency Ratio (ISEER) as per the new standards will range from (3.30 - 5.00) for split and (2.70 – 3.50) for window air conditioners, which will be applicable from 1st January 2021 onwards.

The notification states, "All brands and types of star labelled room air conditioners, namely, multi-stage capacity air conditioners, unitary air conditioners and split air conditioners which are rated from one star to five star, based on their relative energy efficiencies up to a rated cooling capacity of 10,465 watts (9,000 kcal/hour) and manufactured, commercially purchased or sold in India, shall ensure default setting of temperature in the room air conditioners at twenty-four degrees Celsius with effect from the 1st January 2020."

BEE launched the voluntary star labelling program for fixed-speed room air conditioners (RACs) in 2006, and this program became mandatory on 12th January 2009. Thereafter, in 2015, voluntary star labelling program for inverter room air conditioners was launched and which was made mandatory with effect from 1st January 2018. The BEE star labelling program for room air conditioners now covers both fixed and inverter RAC up to a cooling capacity of 10,465 watts (2.97 TR). Continual enhancement in ■

International workshop by BEE on 'Energy Efficient Cooling'

As part of 'Energy Conservation Week', being celebrated from 9th to 14th December 2019, Bureau of Energy Efficiency (BEE), a statuary body under the Ministry of Power, conducted an International Workshop on 12-13th December 2019 on 'Energy Efficient Cooling' at Scope Convention Centre, New Delhi. The two-day international workshop was organised in association with International Energy Agency (IEA) under SEAD initiative of Clean Energy Ministerial (CEM).

Commenting on the development and implementation of cooling sector, policies and programs, Secretary, Ministry of Power, Sanjiv Sahai, said, "The rising demand for space cooling in buildings, vehicles and cold chain sector is a challenge to be addressed. There is a need to have effective policies and schemes in this sector for deployment of new efficient technologies. BEE has been implementing initiatives towards promoting Energy Efficient Cooling and has conducted several studies for developing policy framework in new sectors like cold chain."

The workshop served as a platform for global experts, industries, and policy makers to explore opportunities to accelerate deployment of energy efficient cooling, across different sectors and establishments. Objective of the workshop was to chart out steps towards accelerating the development and deployment of efficient cooling appliances, equipment and systems. It helped to explore policies, technologies, innovation, new approaches and business models across space cooling and cold chains. The event highlighted action plans, international best policy practices, measures to stimulate innovation and deliberations on steps forward. These initiatives and knowledge sharing sessions help in framing the best policies and support industry bodies to adopt technologies from across the globe. ■

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Carrier's HFO chiller racks up the awards

Carrier has won its fifth major award for its AquaEdge 19DV water-cooled centrifugal chiller using the low GWP refrigerant R1233zd. First launched in Asia in 2016, this latest HFO chiller won Carrier the Innovative Manufacturer or Supplier of the Year in the Chillers category at the recent Climate Control Awards in Dubai. This most recent award builds on the long list of global accolades for the chiller: Green Product of the Year 2019 in the Energy Management category at the Middle East and North Africa (MENA) Green Building Awards (United Arab Emirates); Air Conditioning Product of the Year in the System or Standalone category at the 2019 RAC Cooling Industry Awards (UK): Consulting-Specifying Engineer 2019 Product of the Year Awards in the Boilers & Chillers category (USA); SEC-Senoko Green Innovation Award 2018 at the Singapore Environmental Achievement Awards (Singapore). ■

CAREL Adriatic Gets Golden kuna award

CAREL Adriatic was awarded the Golden kuna, the Croatian Chamber of Commerce award that recognises success stories from the region, and encourages them to continue with the strategies adopted. The awards ceremony, held at the Istrian Parliament, was attended by Jasna Jaklin Majetić, President of the County Chamber of Pula, Loris Peršurić, Mayor of Poreč, Miro Dodić, Member of the Chamber of Commerce, and Eni Modrušan, Chair of the Labin city council.

The winners were selected based on economic indicators taken from 2018 financial reports. In particular, the type of business, business growth and contribution to the development of the Croatian economy were all taken into consideration.

"CAREL was recognised as one of the winners for the added value it brings to the region", commented CAREL Group Chief Operations Officer Pietro Rossato, who was present at the awards ceremony together with Raffaele Rossi, CAREL Adriatic Plant Manager and Sanja Radas, CAREL Adriatic Human Resources Manager. "We are very pleased to be recognised as a company that boasts excellent performance and invests in technology, innovation and development. In less than five years, we have stood out for our investments aimed at supporting business development, particularly in Europe, creating employment and industrial culture, and close synergies with the local community". ■

The market is buoyed by several factors, predominantly increasing government initiative across the globe, coupled with overall growth in the construction sector.

HVAC Market is expected to reach $136.5 bn by 2024

According to the market research report published by P&S Intelligence, HVAC market is expected to reach USD 136.5 billion by 2024, registering a CAGR of 3.9 per cent during forecast period. The market is buoyed by several factors, predominantly increasing government initiative across the globe, coupled with overall growth in the construction sector. Furthermore, rising average global temperature is propelling the year over year (YoY) growth of the market.

Global warming, particularly due to greenhouse emission, has led to rise in temperature and has been a major driving force for the rising demand for HVAC systems, across the globe. According to NASA's Goddard Institute of Space Studies (GISS), since 1980, the average global temperature increased by 0.5C per year. Additionally, some countries in regions such as Middle East and Africa (MEA) and Asia-Pacific (APAC) experience subtropical and hot climate, resulting in intensely hot and humid summers; thereby, making them heavily dependent on HVAC systems for their cooling requirements.

On the basis of HVAC type, the global HVAC market is segmented into heating, ventilation, and cooling, wherein cooling category is further segmented into variable refrigerant flow (VRF), ducted split or packaged unit, split unit, chillers, and room air conditioners (RACs). Of which, split unit system accounted for the largest revenue share in 2018. Increasing preference towards ductless air conditioning systems have been one of the major drivers for its growth. Commercial and residential were the prime sectors for continued demand in HVAC systems. As of 2018, more than 60 per cent of the US households are estimated to have deployed central air conditioning system. On the basis of end-user type, the market is segmented into commercial, industrial and residential, wherein industrial is further segmented into food and beverage (F&B), automotive, energy and utilities, and oil and gas. Of these categories, food and beverage category recorded highest revenue share in the industrial HVAC market in 2018. F&B manufacturing unit requires properly designed air handling system to control airborne particulates and odours. Whereby the system isolates food from outdoor airborne contamination infectious pathogens like Salmonella, Listeria, and E. coli. Further, strict guidelines from agencies such as Food Safety Modernisation Act (FSMA) lead to renovations or expansions in the F&B sector in US.

North America region has been one of the largest consumers of HVAC system. The region exhibits very high temperature during peak summer, where the use of these systems becomes a critical need. Further, populace in the region has a high purchasing power parity (PPP), wherein according to the statistics provided by the World Bank, the US, and Canada recorded annual per capita income of USD 59,531.6 and USD 45,032.1 in 2017. Also, in 2017, the construction industry displayed a 6 per cent increase in investment from previous year, predominantly led by residential and commercial building construction.

In commercial buildings, HVAC system consumes 40 per cent of the total power consumption. The OEMs in the market are investing in launching new and innovative products, in order to increase the efficiency level of HVAC systems. ■

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CHOOSING THE RIGHT HVAC

The article talks about the key considerations for selection of an HVAC system as its proper selection is directly related to human health and level of comfort.

- Supriya A Oundhakar, Associate Editor

The surge in industrial growth and technological advancements has resulted in a widespread move into cities and the expansion of city limits. By 2050, the number of urban residents is expected to increase exponentially (6.3 billion). Cities account for 60-80 per cent of global energy consumption and 75 per cent of carbon emissions, and this alarming growth will inevitably increase the pressure on the climate.

Heating, Ventilation & Air Conditioning (HVAC) infrastructure in today's buildings are a critical piece of the puzzle that goes into making buildings green and eco-friendly. Selecting the right HVAC design for this can make all the difference to the carbon emissions levels of the buildings.

Importance of HVAC

HVAC has become integral to the modern idea of buildings. Be it heat dissipation or cost of implementation of systems; a lot has to be considered while designing a building. Most of these aspects fall under HVAC selection for the building as it is directly related to human health and level of comfort.

"Mostly people limit this aspect to measurement of gases, particles and temperature but also moisture, humidity and radiant heat are very crucial parameters that must be considered. It is very necessary to ensure that the energy consumption is very optimal in the buildings in order to save the cost," informs Vimal Chavda, Manager – Distribution Sales, Testo India.

Today, people spend about 90 per cent of their lives in buildings – not just their own residence, but also offices, production facilities, schools and universities etc. HVAC products and solutions one needs to make these buildings habitable with safe, reliable and a comfortable atmosphere.

With large scale proliferation of computers in daily life, increasing level of particulate pollution and upgraded lifestyles, air conditioning systems (HVAC systems) are no longer luxury commodities.

Amit Bhardwaj, Business Head - Building Products, Siemens Ltd, informs, "Of the many critical solutions required for any building installation, HVAC is a key focus as it consumes more than half the energy cost. Our customers need to optimise their energy consumption, maintain a healthy and productive environment, update aging facilities and have anytime or anywhere access to their building systems."

Anuraaga Chandra, Head- Cooling Sales, India Region, Danfoss Industries, emphasises on careful scrutiny of each feature and equipment within the HVAC system during selection process. He further adds that each equipment of the system works in coordination to achieve the desired energy efficiency and long-term profitability goals of the building.

The right chillers must be selected based on their full load and part load efficiencies; variable speed solutions for fans, compressors and pumps must be used that can operate at varying loads; a dedicated outdoor air system can help reduce the energy consumption as compared to a mixed air system; close control systems are helpful to achieve higher reliability, better temperature and humidity control etc. Additionally, smart chillers with oil-free compressor technology and in-built diagnostics are available which helps in getting consistent energy performance over the years when compared to conventional technologies, he further adds.

Considerations for Selection of HVAC System

Tejwant Navalkar, MEP Design Head, Godrej - Green Building Consultancy Services states that the process of selection of an appropriate system, today remains largely rule of thumb and influenced by the AC vendors. This is true, especially, in residential and small and medium offices or shops. The selection, therefore, is oversized, to ensure that the user is never feeling hot and the result is that the user gets high electricity bills.

He briefs the following factors that affect the sizing of an air-conditioning system:

- Use of the conditioned space, whether comfort residential or office, process requirement or data centre or restaurant, banquet hall or theatre,
- Orientation of conditioned space with respect to the sun path,
- Extent of exposed walls, windows and ceilings,
- Expected population, lighting loads, equipment loads and the area and height of the space,
- Fresh air requirements in the conditioned space,
- Usage pattern of the conditioned space – is it uniformly occupied or is there a likelihood of sudden peak loads, eg a foyer in a hotel, a banquet hall, a theatre.

After selecting the size of the HVAC system, Navalkar, states the following options for choosing the type of air conditioning system that would be ideally suited for the application.

- Window air conditioners or Split Unit – ideally suited for small shops and residential flats.

Today, special purpose air conditioners are available to cater to high sensible heat applications like data centres, computer rooms, equipment room etc.

- Variable Refrigerant Flow or Volume (VRF/ VRV) systems which provide for connecting multiple indoor units to a single outdoor unit. These are ideally suited for small and medium offices.
- Ductable Package Units – generally used to provide air conditioning to large areas like shopping malls, restaurants where air conditioning load is uniform for majority of the operating periods.

The flow of data begins with networked products, sensors and actuators deliver a continuous stream of data and send it to the cloud for analytics, to turn the 'big data' that is being collected into 'smart data.

AMIT BHARDWAJ,

Business Head - Building Products, Siemens

The process of selection of an appropriate system, today remains largely rule of thumb and influenced by the AC vendors. This is true, especially, in residential and small and medium offices or shops.

TEJWANT NAVALKAR,
MEP Design Head, Godrej - Green Building Consultancy

- Precision Air Conditioning Systems (CRAC – Computer Room Air Conditioners) are also available, specifically, for server rooms, where the humidity and temperature arecontrolled in a very precise manner to meet the stringent requirements of these spaces.
- Centralised Chilled Water systems, where chilled water is used to chill the air which is circulated in the space to be conditioned. The centralised chilled water system could be either air cooled or water cooled. The choice would depend on the availability of water in the area.
- In Radiant Cooling system, the sensible heat from the space is removed by chilled water flowing in pipes embedded either in ceiling slabs or floor slabs. However, this option is the best implemented at the stage of slab casting, and this cooling has to be supplemented by the conventional systems to remove the latent heat in the room.
- One more recent trend is use of chilled beams, where chilled water flowing in pipes, passes through heat exchangers which cools the air causing convective movement of hot and cold air causing cooling in the space. The major difference in this type of approach is lack of use of fans whereby, fan energy is reduced. Chilled beam systems are ideally suited for high sensible heat applications or to supplement the conventional cooling systems.
- One of older techniques of incorporating cold wells in the centralised chilled water-based air conditioning system is being forgotten and hardly used in any of the new HVAC installations. In this approach, a large insulated tank is introduced which acts like a thermal storage, which is maintained at the desired chiller supply temperature. By introducing the thermal storage, we ensure that the chillers operate at full loads at majority of the times. The cold well, also acts like a short duration buffer in case of power outage and provides cooling during the transition from grid supply to DG supply.

He further mentions that the choice of a compressor decides the amount of energy that will be consumed in its operation. The choices for compressors are:

- **Reciprocating:** The earliest and oldest in the family of compressors, these are the most inefficient and have been virtually phased out and can be seen only in window air conditioners and smaller split units.
- Scroll: These are rotary type and are used in small AC systems upto 25TR. Most window air conditioners and split units use scroll compressors.
- **Screw:** These are also rotary type and are very efficient even at part loads. These types of compressors are mainly used in the centralised chilled water systems upto around 350-400 TR.
- **Centrifugal:** These are the most efficient compressors in the market and are ideally suited for very large sized compressors, generally above 500 TR. Traditional Centrifugal compressors are not suited for part loads and were used mainly to meet the base loads in large hotels, hospitals, airports etc. However, today the centrifugal compressors are coupled with variable frequency drives so that these compressors are efficient even at part loads.
- Compressors based on magnetic levitation (maglev) are now available, whereby, the performance efficiencies have increased, reduce use of oil lubricants, and also lowered frequent wear and tear due to virtually zero friction.
- Inverter based systems have also penetrated the market and provide a more uniform cooling experience to the user due to the fine control of the compressor as opposed to the frequent start stop operations in the conventional compressors.

IoT enabled products are getting smarter with inbuilt controls and cloud connectivity. This is paving ways for smart products and solutions which can be easily connected to the building management systems for monitoring and control.

ASOKDAS M D,
Managing Director, Systemair India

The right chillers must be selected based on their full load and part load efficiencies; variable speed solutions for fans, compressors and pumps must be used that can operate at varying loads.

ANURAAGA CHANDRA,
Head- Cooling Sales, India Region, Danfoss Industries

Energy Efficiency Key Criterion

Energy efficiency is the key criterion for selection of HVAC equipment in today's buildings. HVAC being an energy guzzler, customers are looking for energy efficient products and solutions to bring down the energy cost thereby reducing the operating cost in the buildings. Building owners are investing on green and net zero energy buildings to reduce the operating costs. Conventional HVAC systems can beretrofitted with latest energy efficient products to reduce the overall energy consumption in the buildings.

In today's scenario buildings are complex installations systems consolidated into networked products, cloud solutions and smart data. With digitalisation, building HVAC can communicate data such as energy consumption and maintenance requirement.

Vimal Chavda from Testo India informs that Testo provides a wide range of instruments that assist you in maintaining efficient HVAC system in the building and also ensure the desired IEQ level. The testo 160 wireless LAN data logger measures, monitors and documents temperature, humidity, light intensity, UV radiation and CO2 concentration in rooms, offices and malls – automatically and without interruption – hence all indoor climate monitoring parameters are covered in one. An individually designable cover is also available for each data logger which allows the logger to blend into almost any environment.

Elaborating, Asokdas M D, Managing Director, Systemair India states, "IoT enabled products are getting smarter with inbuilt controls and cloud connectivity. This is paving ways for smart products and solutions which can be easily connected to the building management systems for monitoring and control." Smart control enabled ancillary products are used efficiently to monitor and control the overall performance of the HVAC system. The focus of control is getting shifted to the products level wherein manufacturers are offering smart control enabled products to compliment the product performance with marginal increase in the cost. Smart products with an IoT enabled building management system will further enhance the overall HVAC and building performance. The future belongs to smart products with built in intelligence which will complement the overall building performance.

Amit Bhardwaj from Siemens informs, "The flow of data begins with networked products, sensors and actuators deliver a continuous stream of data and send it to the cloud for analytics, to turn the 'big data' that is being collected into 'smart data.' This makes it possible to identify consumption patterns and initiate corrective measures."

He further adds that the solution should efficiently reduce energy usage in your building, react flexibly to changes in utilisation with future upgrades, and protect your investments in the long term. It needs to provide an energy management platform to consolidate data from different disciplines (HVAC, Lighting Control, security, fire safety, etc.) in a single user interface. This makes it possible to manage, control and analyse the entire building from a central location that it can be operated economically, safely and in an energy-efficient manner. Integration of all disciplines is important to provide comfortable environment and not just HVAC alone. Building Information Modeling (BIM) is now available for use in the 'digital twin.' This digital model is used to design the building with all its disciplines and perform ongoing simulation, testing and error correction during the design phase. The benefits of this approach include optimised energy efficiency, higher cost savings and better sustainability.

HVAC systems and products from Siemens can effectively reduce your operating costs thanks to their extremely efficient use of energy. This means you can achieve up to 30 per cent savings, while still maintaining a comfortable room climate.

It is when architects, engineers, and contractors bring knowledge of the best HVAC systems to owners and developers, collaboration serves as the cornerstone of a successful building project. The right HVAC solution focuses on energy savings and achieving long-term profitability, which saves time, trouble, and money. ■

Mostly people limit this aspect to measurement of gases, particles and temperature but also moisture, humidity and radiant heat are very crucial parameters that must be considered. It is very necessary to ensure that the energy consumption is very optimal in the buildings in order to save the cost.

VIMAL CHAVDA, Manager – Distribution Sales, Testo India

Deciphering trends in technologies within scope of Industrial Refrigeration

In a free-wheeling interview, **Carsten Dahlgaard, Sr Director – Sales, Industrial Refrigeration, Danfoss (Denmark)**, speaks to Ranjana Konatt, Editor (Brand Positioning) on the trends within the industrial refrigeration sector...

Could you elaborate on Danfoss and its work within the energy efficiency sector? Concerning international markets, how is China different from Europe?

At Danfoss, we have a passion for energy efficiency. The things that matter in a cooling system is the system-type, the kind of refrigeration, and the requirement concerning installation. If you compare markets, China focuses a lot on safety, and Europe is all about energy and the cost of ownership, reliability and safety standards. Today, the focus is not on how the market is foreseen but on how customers change installation procedures depending on the client's requirement.

What are the trends in the industrial refrigeration sector globally? Are we seeing the safety and the total cost of ownership as important facets to growth within the sector?

For industrial refrigeration, the trend is that globally we are seeing that safety and the total cost of ownership are drivers within the industry, irrespective of the country we are in. For instance, concerning industrial refrigeration, we have five-points that we keep in check- global warming, safety, reliability, cost and efficiency. All these five points are used in industrial refrigeration globally. There are a lot of things going on politically concerning global warming. As we can see here there have been agreements made on calling out refrigerants. One of them we have here is R32 a new refrigerant for air-conditioning. Today, we need refrigerants that are green from the industry side.

What are the latest shifts we are seeing in solutions from the industry side?

If you take into account larger systems, we see CO2 TC systems, and they come from supermarkets. We have a green profile on ammonia and a high-efficiency. We have a graph on kilowatt cooling and also have nearly 29 kilos of ammonia. Concerning the drivers and the reactions for industrial refrigeration, energy efficiency is a hot topic and we are aware that the cost to power will not decrease. District heating and cooling is another method adopted by developed countries to be efficient with energy. We have seen the installation of large district cooling towers and projects in Denmark. With this we can detect and we have controllers in place in case of anything. ■

Hydrocarbon Refrigerants: Path to Sustainable Air Conditioning

Vapour compression-based systems are generally employed in domestic, commercial and industrial air conditioning units. The halogenated refrigerants in current use are having environmental issues such as ozone depletion and global warming potential. There is an overwhelming acceptance of the need to move from synthetic to natural refrigerants considering deteriorating global indicators like the ozone layer and global warming.

All previous protocols, Montreal (1987), Kyoto (1997), Paris (2016), have recognised the role of synthetic refrigerant in exacerbating the problem of climate change. The latest amendment- Kigali (2016), has set a binding deadline for phase out of halogen-based refrigerants such as, HCFCs and HFCs.

At present, R32 (with GWP of 650) has taken the place of R410A in air conditioners. However, the refrigerants with very low global warming (less than 150) must be preferred for use air conditioning applications.

HCR22 is the most sustainable drop-in alternative to refrigerants used in residential, commercial and industrial applications due to its great thermodynamic and thermo-physical properties with negligible global warming potential (ODP - 0, GWP < 20). The refrigerant charge requirement is also reduced by about 50 per cent as compared to R22. The performance of HCR22 in existing R22 air conditioners is found to be much better. It also enhances the life of the compressor and reduces the electricity consumption by up to 30 per cent. Furthermore, HCR22 can be used in R22 air conditioners without any modifications. It is suggested to use charging valves instead of piercing the refrigerant charging line at time of filling or servicing.

HCFC /HFC	GWP	NEW REFRIGERANT HYDROCARBON BLENDS	GWP
R-22	1700 + ODP	HCR-22	<20
R-134a	1300	HCR-134a	107
R-502	1700	HCR-502	< 3
R-404	1340	HCR-404	< 3
R-290		Pure Hydrocarbon	< 3
R-600a		Pure Hydrocarbon	< 3

Keeping in mind the safety aspects for Hydrocarbon refrigerants, composite cylinders are being used for the first time in the Indian Market for HYDREON refrigerants. These cylinders are light weight, maintenance free and extremely safe for use and have been approved by all major regulatory standards bodies including India's PESO.

HCR22 is part of the HYDREON series of refrigerants from Hans Industrial Corporation. HYDREON Refrigerants are ASHRAE listed drop in refrigerants which will replace HCFC and HFCs such as R22, RI34a, R502 and R404. Pure hydrocarbon refrigerants such as R600a and R290 with purity levels of 99.96 per cent will also be made available. ■

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Hindustan College of Engineering and Technology,
Coimbatore-641032
mohanrajrac@yahoo.co.in

HCR-22

Replacement & Retrofit for R-22

Property		HCR-22	R-22
1. Molecular Mass		44.49	86.48
2. Boiling Temperature (°C)		-42.7	-40.76
3. Heat of Vaporization of 0°C (kJ/kg)		324.95	234.12
4. Stabilities	Thermal	Stable	Stable
	Chemical	Stable	Stable
5. Flammability (LFF & UFL, %)		3.2~9.5	None
6. Toxity		No	No
7. ODP (Ozone Depletion Potential)		No	Yes
8. GWP (Global Warming Potential)		43	1700
9. Specific Gravity		0.505	1.19
10. Packing		Composite Cylinder-10Kg	

Benefits of HYDREON™ HCR-22

a. **Material Compatibility**

- HCR22 can be used as a substitute without modifications in the existing R22 air conditioners.

b. **Refrigerant cost & performance**

- Cost of HCR22 is 50% of R22.
- HCR22 has 42% lower liquid density compared to R22. Hence, the charge requirement of HCR22 has reduced by 50%.
- Power savings in the compressor is expected to be 15-30%.

c. **Lubricants compatibility**

- HCR22 is compatible with both mineral oil and synthetic lubricants.

d. **Environment friendly**

- HCR22 is the hydrocarbon mixture composed of propane and propylene with zero ozone depletion potential with negligible global warming potential.

For further details you may contact them at
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EFFECTS OF IAQ IN RESIDENTIAL & COMMERCIAL BUILDINGS

Indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials; it can be up to 10 times worse than outdoor air pollution. This is because contained areas enable potential pollutants to build up more than open spaces. Statistics suggest that in developing countries, health impacts of indoor air pollution far outweigh those of outdoor air pollution.

In the last few decades, Indoor Air Quality (IAQ) has received increasing attention from the international scientific community, political institutions, and environmental governances for improving the comfort, health, and wellbeing of building occupants. Several studies on this topic have shown both qualitative and quantitative IAQ variations through the years, underlining an increase in pollutants and their levels. To this aim, IAQ-related standards and regulations, policies for non-industrial buildings, and monitoring plans have been developed in several countries. It has been estimated that people spend about 90 per cent of their time in both private and public indoor environments such as homes, gyms, schools, workplaces, transportation vehicles, etc. Thus, IAQ has a significant impact on health and quality of life in general. For many people, the health risks from exposure to indoor air pollution may be greater than those related to outdoor pollution. In particular, poor indoor air quality can

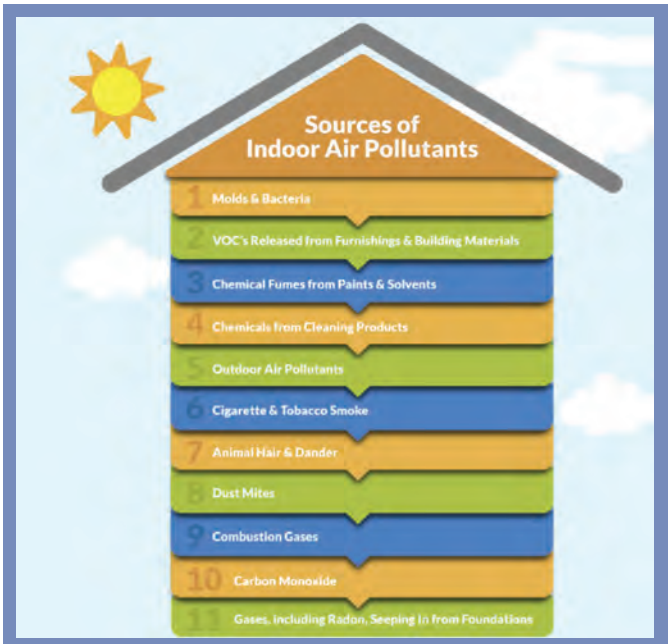

Fig. 1. Various sources of indoor air pollutants.

be harmful to vulnerable groups such as children, young adults, the elderly, or those suffering chronic respiratory or cardiovascular diseases. Indoor environments represent a mix of outdoor pollutants prevalently associated with vehicular traffic and industrial activities, which can enter by infiltrations or through natural and mechanical ventilation systems, as well as indoor contaminants, which originate inside the building, from combustion sources (such as burning fuels, coal, and wood; tobacco products; and candles), emissions from building materials and furnishings, central heating and cooling systems, humidification devices, moisture processes, electronic equipment, products for household cleaning, pets, and the behaviour of building occupants (i.e., smoking, painting, etc.). IAQ can be affected by various chemicals, including gases (i.e., carbon monoxide, ozone, radon), volatile organic compounds (VOCs), particulate matter (PM) and fibers, organic and inorganic contaminants, and biological particles such as bacteria, fungi, and pollen. The large number of variables that impact IAQ inevitably leads to a wide range of studies and scientific papers published in journals from many kinds of scientific subjects (e.g., chemistry, medicine, environmental sciences, etc.). To further underline the importance of IAQ studies, the present special issue was published. It includes 22 contributions (Figure 1) by some of the main experts in the field of indoor air pollution in public and private buildings and related health concerns.

It is essential that the hazardous impacts from environmental pollution are regularly reported and monitored. Of the various kinds of pollution, the air pollution has attracted high priority in respect of environmental regulation since the environmental damage due to such pollution mostly affects human well-being directly by way of adverse health effects on the population exposed to it. Air quality has deteriorated in cities in India, a situation driven by population growth, industrialisation and increased vehicle use. Integrated air quality management (AQM), which is an evaluation and monitoring tool, is a challenge to carry out in most developing countries because of the lack of information on sources of air pollution and insufficient ambient air monitoring data that is available in the public domain.

Effects of Indoor Air Pollution on Health

The ill-effects of indoor air pollution result in about 2 million premature deaths per year, wherein 44 per cent are due to pneumonia, 54 per cent from chronic obstructive pulmonary disease (COPD), and 2 per cent from lung cancer. The most affected groups are women and younger children, as they spend maximum time at home (Figure 2). The morbidities associated with indoor air pollution are respiratory illnesses, viz., acute respiratory tract infection and COPD, poor perinatal outcomes like low birth weight and still birth, cancer of nasopharynx, larynx, lung, and leukemia.

Fig. 2. Effects of indoor air quality on human life.

The harmful health effects of formaldehyde range from being an acute irritant, reducing vital capacity, causing bronchitis, to being a carcinogen causing leukemia and lung cancer. The indoor air pollutants have potential health effects. The particulates cause respiratory infections, chronic bronchitis, COPD, and also lead to exacerbation of COPD. Sulfur dioxide and nitrogen dioxide cause wheezing and exacerbation of asthma. In addition to this, nitrogen dioxide causes respiratory infections and deteriorates lung functions. Sulfur dioxide has an additional etiological role in exacerbation of COPD and cardiovascular disease. The risk of poor perinatal outcomes, viz., low birth weight and perinatal death increases from exposure to carbon monoxide. Biomass smoke, especially, metal ions and polycyclic aromatics, leads to development of cataract. Polycyclic aromatic hydrocarbons lead to development of cancers of lungs, mouth, nasopharynx, and larynx. As a consequence of poverty, factors such as living conditions, sanitation, and access to water are associated with solid fuel use, and should be considered while measuring impact of solid fuel on child survival (Fig. 3).

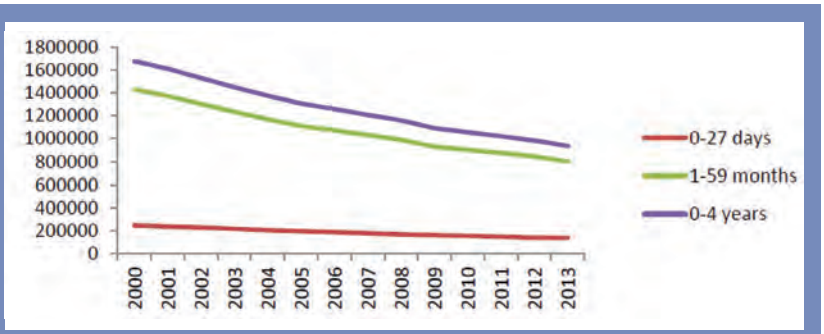

Fig. 3. Number of global deaths in children due to acute lower respiratory infections. (Source: WHO, 2015)

Control Measures

- **Public awareness:** One of the most important steps in prevention of indoor air pollution is education, viz., spreading awareness among people about the issue and the serious threat it poses to their health and wellbeing. The education should help people in finding different ways of reducing exposures with better kitchen management and protection of children at home. People should also be educated about the use of alternative cleaner sources of energy to replace direct combustion of biomass fuel. The stakeholders must include not only public, but also politicians and administrators to ensure their commitment and increase their awareness about health effects of indoor air pollution.
- **Change in pattern of fuel use:** Fuel use depends on ones' habit, its availability, and most importantly, its affordability. At present, majority of low-income families rely solely on direct combustion of biomass fuels for their cooking needs as this is the cheapest and easiest option available to them; however, this could be rectified by promoting the use of cleaner energy sources such as gobar gas which utilses cow dung to produce gas for cooking.
- **Modification of design of cooking stove:** The stoves should be modified from traditional smoky and leaky cooking stoves to the ones which are fuel efficient, smokeless and have an exit (e.g., chimney) for indoor pollutants. A good example is the one designed by the National Biomass Cook Stoves Initiative of the Ministry of New and Renewable Energy under a special project on cook stove during 2009-2010, with the primary aim of enhancing the availability of clean and efficient energy for the energy deficient and poorer sections of the country.
- **Improvement in ventilation:** During construction of a house, importance should be given to adequate ventilation for poorly ventilated houses, measures such as a window above the cooking stove and cross ventilation through doors should be instituted.
- **Intersectoral coordination and global initiative:** Indoor air pollution can only be controlled with coordinated and committed efforts between different sectors concerned with health, energy, environment, housing, and rural development.
- **Air conditioning systems:** Many kinds of AC systems are used to improve indoor thermal comfort and IAQ. In this regard, current recent research is mainly focused on dedicated outdoor air system (DOAS), independent control of temperature and humidity system (ICTHS), desiccant assisted air conditioning (DAC) and cooling ceiling and displacement ventilation systems (CC/DV) to improve the indoor air quality.
- **Indoor air purification:** Indoor air purification is an important method of removing indoor pollutants and improving IAQ under the circumstances that the ventilation and the control of pollution sources are impossible. The major methods of indoor air purification include filtration, adsorption, photo catalytic oxidation (PCO), negative air ions (NAIs), and non-thermal plasma (NTP).
- **Solar passive techniques in a house construction:** The Solar Paneled Pyramidal Roof House constructed for a hot climate should take measures to reduce heat radiation inside the house by orienting house to minimum exposure in west and east and larger size window. Three windows of size 0.9 x 0.6 m and one window of size 1.2 x 0.6 m are provided. Apart from that, two ventilators are constructed honey combed brick work (with fly ash bricks) to allow the natural ventilation inside the house. This house roof is constructed in pyramidal shape to have minimum sunlight effect on the building. The total roof area of the pyramidal portion is 16.4 square meter with an angle of 38° inclination to the horizontal. The plinth area of the green house is 8.196 sqm.

Conclusion

Though evidence exists for increase in indoor air pollution in India and its association with both increased morbidity and mortality, there is still a need of further studies to assess the exposure levels of indoor pollutants and to further strengthen the evidence for their association with outcomes like tuberculosis, cataract, asthma, cardiovascular health, and cancers. At the same time, effective interventions, starting from education, change in fuel patterns, proper designing of stoves and houses, to a committed and determined intersectoral coordination towards promotion of public health is the need of the hour. ■

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Government Engineering College, Dahod, Gujarat Technological University – GTU, Ahmedabad

Rolling Shutters Protecting Entrances from Damage

Rolling Shutter

Installing rolling shutters can protect external entrances from damage during severe weather. In some hurricane-prone states, new homes or ones doing major improvement projects are required to install approved rolling shutters. In other parts of the country, they are also popular for energy savings and security benefits.

Energy savings with a rolling shutter can be significant, especially, over large windows and glass doors. Considering only the insulation value of the shutter slats, a rolling window shutter can triple the R-value of a standard window. Additional savings come from the dead air space which is created, reducing air leakage and blocking the sun's heat and fading rays during summer.

A rolling window shutter operates similarly to an old roll top desk. It is mounted in outdoor vertical tracks on each side of a window or door and rolls up into a small box mounted above the window or door. The individual slats are often only 1 to 2 inches tall and interlock with each other. The mechanism to raise and lower them is indoors. There also is an emergency hand crank rod that can be used outdoors.

When the shutter is lowered to cover the entire window, some shutters still allow natural light to come indoors. Each interlocking flange connecting the slats together has long narrow holes. When the shutter is completely lowered against the sill, these holes are hidden. As the shutter starts to lift, the slats separate to expose the holes while the bottom slat is still resting on the window sill.

There are several slat designs options. The least expensive is made of hollow rolled sheet metal. Metals become stronger and stiffer from the rolling and forming operation. Another option is this same type of roll-formed slat with insulation in the cavity. This makes it a little stronger and provides more insulation. The strongest and the most expensive slats are heavier extruded metal.

The type of opening device and controls will be determined by the type and size of the rolling shutter installed and the level of convenience desired. If a shutter is difficult and inconvenient to open and close, the user will end up just not using it as often as he or she should for the greatest energy savings and storm protection.

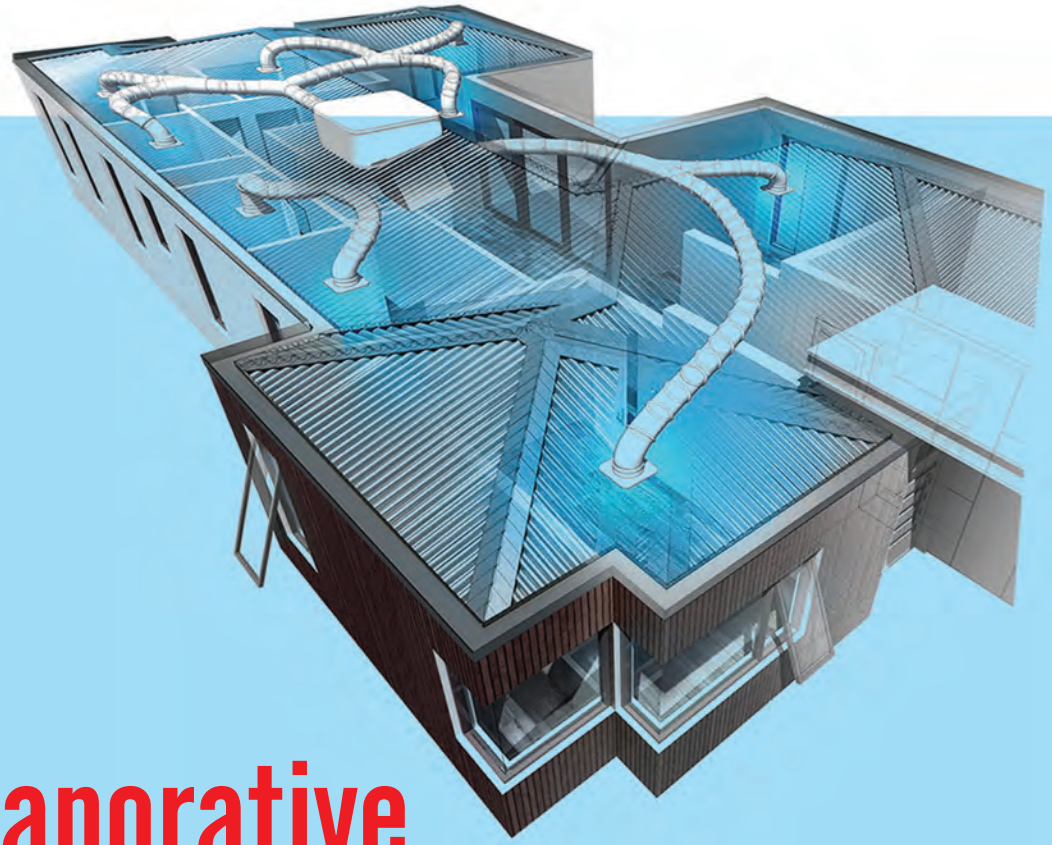
When installing a shutter over a normal-size window, an inexpensive pull strap operator is effective. For larger shutters or heavier extruded ones, a hand crank is a good choice. This is still reasonably priced and easy to use. For the most convenience, electric operators are available. With modern electronics, groups of shutters can be operated from just one control.

Motorised Rolling Shutters by Gandhi are typical, are perfect for circumstances where side room is less and security is required. The company's rolling shutters need very less headroom above the structural opening. They combine strength with elegance along with toughness and are designed for both external and internal applications. Automatic Rolling Shutters are made up of interlocked galvalume, galvanised insulated and non-insulated, stainless steel, patented aluminum profiles and

patented bright steel bar rolling grills. Automatic Rolling Shutters are strongly built to endorse trouble-free process and long life. The Motorised Rolling Shutters can also be planned as per customer's conditions or conforming to IS6248.

All Rolling Shutters are automatic using vigorous drive expertise with manual override in case of power failure and are dense, noiseless, and dependable with low decibel level.

The company can manufacture motorised rolling shutters to a maximum width of 30,000 mm and height of 40,000 mm with boundless array of choices to please both artistic deliberations as well as working prerequisite. ■



Evaporative Cooling Technologies for Buildings

Multi-mode evaporative cooler (changing of operating mode based on ambient wet-bulb temperature) can be a promising and economical option for the composite climate in India.

There is a growing demand for space cooling in hot climates as people seek to raise their standards of living and improve work performance, resulting in an increasing demand for energy during the day. The vapour compression refrigeration system dominates modern cooling technology. These systems consume around 40-50 per cent of the domestic power supply and contribute to local as well as global warming. As looking for substitutes, evaporative cooling is one of the oldest and eco-friendly technologies, which find applications in hot residential and industrial environments where the use of conventional air conditioning systems becomes prohibitively expensive. Evaporative cooling has been in use for many centuries in countries such as India for cooling water and for providing thermal comfort in hot and dry regions. The evaporative cooling (EC) technology is based on heat and mass transfer between air and cooling water. This system is based on the principle that the moist but unsaturated air loses the sensible heat

(gets cooled and humidified) due to evaporation of water from the wetted surface and this cooling effect can be directly or indirectly used for providing thermal comfort. The cooling potential for evaporative cooling is dependent on the wet-bulb depression, the difference between dry-bulb temperature and wet-bulb temperature.

Advantages of evaporative cooling over modern air conditioning:

- Lower equipment and installation costs
- Lower operating and power costs (energy savings can be as high as 75 per cent)
- Ease of fabrication and installation
- Lower maintenance costs
- Ensures very good ventilation due to the large air flow rates involved
- Better air distribution in the conditioned space due to higher flow rates
- The infiltration of outside air is prevented
- Very environment-friendly as no harmful chemicals are used
- Disadvantages of evaporative cooling over modern air conditioning:
- Not applicable when the low humidity level in conditioned space is required
- Create high noise levels in conditioned space due to higher flow rates
- Precise control of temperature and humidity in conditioned space is not possible
- May lead to health problems due to micro-organisms

The classification of the evaporative cooler is presented in Figure 1. The evaporative cooler is in-general two types: direct evaporative cooling (DEC) and indirect evaporative cooling (IEC). A semi-indirect evaporative cooler is the modification of indirect evaporative cooler and the hybrid evaporative cooler is the combination of these two or/and combination with other technologies. In this article, various evaporative cooling technologies and its applicability or suitable selection for various climate zones in India are discussed in detail.

Direct Evaporative Cooler (DEC)

In the direct evaporative cooling, the process or conditioned air comes in direct contact with the wetted surface and gets cooled and humidified. Figure 2 shows the schematic of the direct evaporative cooling system and the process on a psychrometric chart. The unsaturated warm inlet air (1) enters in a pad that is sprayed with water and gets cooled and dehumidified due to the simultaneous transfer of sensible and latent heats between air and water. The heat is transferred by the air stream as sensible heat and is absorbed by the water as latent heat. The temperature of the outlet air (2) decreases due to the sensible heat transferred by the air, but the enthalpy of the outlet air will be the same with the enthalpy of inlet air as the effect of the latent heat recovered into the air as moisture. The working process (1-2) is realised at constant enthalpy as it can be observed on the chart. Again DEC may be active or passive. In the active system, the fan or blower is used for air flow and the pump is used for water flow. The most commonly used evaporative cooling system in north India is the active DEC (also swamp cooler, swamp box, desert cooler and wet air cooler) consisting of water, evaporative pads, a fan and a pump. In the passive system, no external energy is needed (air flow is natural). The use of wetted wick material or pad in window and pond around the buildings are some examples of passive DEC.

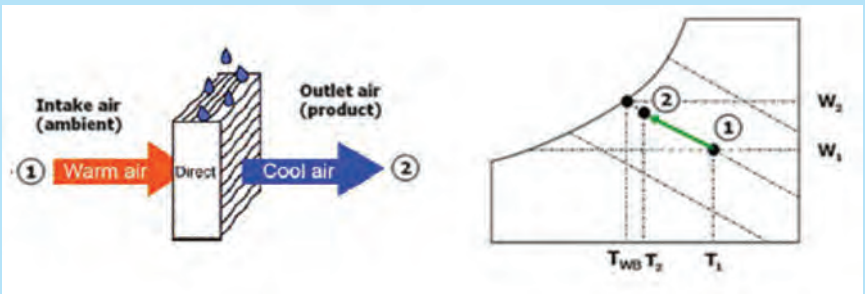


Figure 2: Layout of DEC and process on psychrometric chart

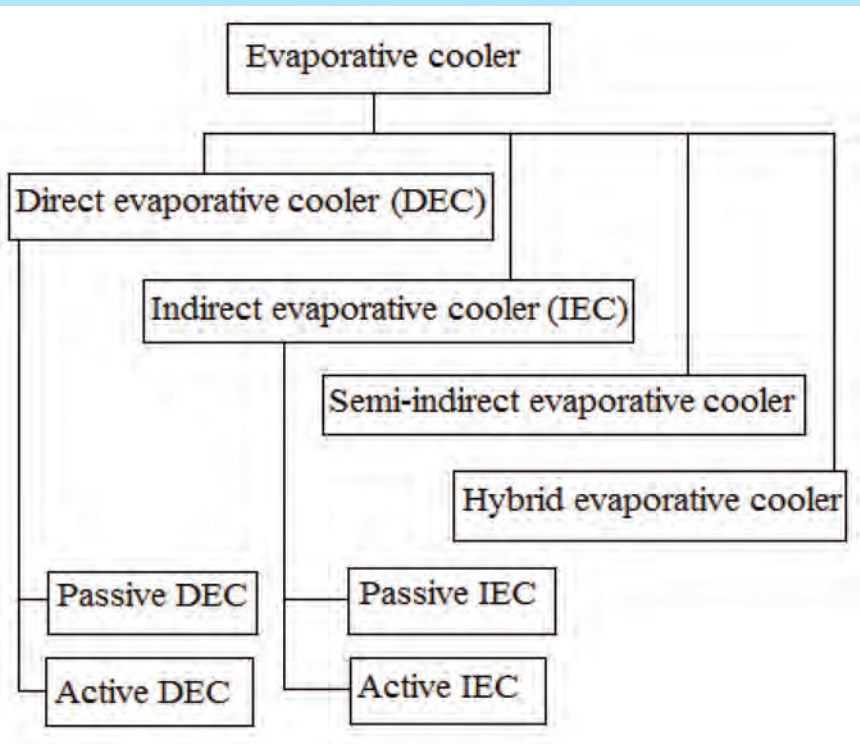


Figure 1: Classification of evaporative cooler

For buildings and areas that do not have a central air conditioning system, direct air evaporative cooling can be a very economical and achievable way to reduce the temperature. The main advantage of DEC is represented by the very simple construction of the equipment. If not properly designed direct type evaporative coolers may pose the following problems: The cooled air may be excessively humid, may result in discomfort; The high rate of air flow and a large number of air changes, which are necessary for effective cooling, cause large variation in the air speed and the associated thermal sensation within the cooled space. This results in a waste of energy, which has been used to cool the discharged air.

Indirect evaporative cooler (IEC)

In indirect evaporative cooling (IEC), the indoor air is cooled without any moisture addition (i.e. moisture contentment will remain constant; the temperature will decrease) and hence, the wet-bulb temperature of air decreases. Therefore, the IEC is more effective for humid climate and it is gaining popularity because it cools air more than DEC. IEC may be classified as passive and active. Roof pond is one example of passive IEC. Roof ponds provide cooling benefits through indirect evaporative cooling or radiant cooling. The roof acts as a heat exchanging element which is cooled by evaporation on its surface, long-wave radiation to the sky, or both. It then functions as a heat sink which absorbs indoor heat and the heat penetrating into the building. Since the ceiling is thermally coupled to the roof pond, the interior space is also cooled by radiation and convection. Driving forces behind evaporation and radiation are respectively, the difference between vapour pressure at water surface temperature and vapor pressure of surrounding air and difference between water surface temperature and effective sky temperature. Since the roof acts as a heat exchanging element, roof pond cooling does not elevate the indoor moisture content of the air.

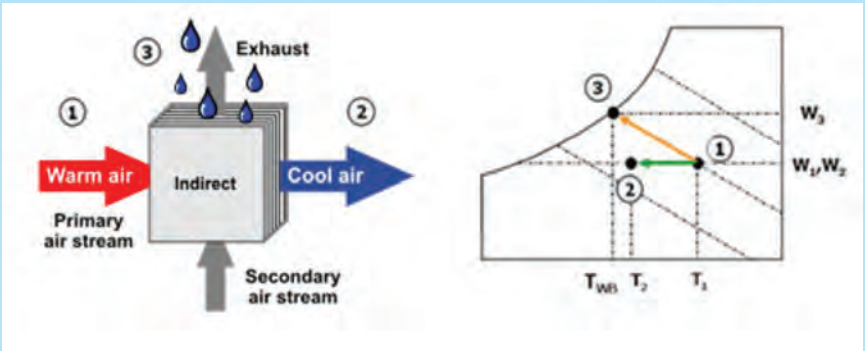


Figure 3: Layout of active IEC and process on psychrometric chart

The active IEC involves two air streams: primary air and secondary air as shown in Figure 3. The air directly cooled by water evaporation in the wet channel is called the secondary air. The cool and moist secondary air is used to cool the primary air (the air to be supplied to air-conditioned space) by a heat exchanger. At the outlet, the primary air will have a lower temperature as at inlet, due to the transferred heat. The secondary (working) air is flowing inside the wet channels together with the water. The behaviour of the air and water in the wet channel is similar to the DEC process. The water temperature is the wet bulb (WB) temperature of the secondary air. The heat transferred through the surface between the dry and wet channels is absorbed by the water as latent heat and a corresponding part of the water is evaporated being embedded by diffusion into the secondary air, increasing the moisture content of this air. If the secondary air arrives at the saturation state, after this stage forward the heat from the primary air is split as latent heat absorbed by the water and as sensible heat absorbed by the secondary air. Thus, the temperature of the secondary air at the outlet can be one of the following: (a) Lower than the wet-bulb temperature of the secondary air at the inlet (no saturation); (b) Equal with the wet-bulb temperature of the secondary air at the inlet (saturation is reached at the outlet); (c) Higher than the web-bulb temperature of the secondary air at the inlet (saturation before the outlet). The main advantage of the IEC is that primary air is cooled without modifying its moisture content. The main disadvantage of the IEC is that the cooling process of the primary air is limited by the wet-bulb temperature of the secondary air at the inlet. Because of this limitation, this type of equipment is also named wet-bulb IEC and the efficiency is also lower than DEC.

According to the types of heat exchanger used in IEC, there are tubular type IEC, plate type IEC and heat pipe IEC. In the plate and tubular type IEC, the first air and secondary air are separated by an air-to-air heat exchanger, while in the heat pipe IEC, the condenser section is used in the secondary air flow channel, and the evaporator section is used in the primary air flow channel. Flow arrangement between primary air and secondary air in the conventional IEC may by parallel flow, cross flow or counter flow. To avoid the wet-bulb temperature limitation of conventional active IEC, the sub-wet-bulb IEC was developed to decrease the primary air temperature at the outlet, below the WB temperature of the secondary air at the inlet. In this device, some fraction of primary cooled air is used as secondary air. This device is again two types: regenerative indirect evaporative cooler (R-IEC) and Maisotsenko indirect evaporative cooler (M-IEC). In R-IEC, some fraction of the outlet primary air stream (state 2 in Figure 3) is used as an inlet secondary air stream and there is no mixing in between. Whereas in M-IEC, there are numerous holes distributed regularly between dry and wet channels and hence, the primary air is cooled in the dry side and partially diverted to the wet side through the holes. The lowest possible temperature of the primary air at the outlet of the M-IEC is the dew point temperature of the entering

primary air. Therefore, the saturation efficiency of M-IEC based on the inlet wet-bulb temperature can be higher than 100%, and also higher than that of the conventional IEC. The main advantage of the M-IEC is that primary air is cooled without modifying the moisture content almost near the DP temperature. The main disadvantage of the M-IEC is the complex construction and flow scheme inside the equipment.

Semi-Indirect Evaporative Cooler

Semi-indirect evaporative systems with porous media are a successful attempt to improve the efficiency of indirect systems. The semi-indirect evaporative cooler (Figure 4) has two independent air flow supplies, one used for cooling, together with a second, the return air flow, in direct contact with water to favor heat and mass transfer. Water is forced against the return air flow and it is constantly circulating. The cooling effect of the impulsed air would thus be the addition of two processes: the heat exchange between the two air flows (supply and return) plus the heat exchange process, through evaporation, between the air supply and the external wall. The semi-indirect evaporative cooler works with the following mechanisms: heat and mass transfer in the return air flow, the spread of mass due to porosity and heat transport through the solid wall and evaporation or condensation as well as heat and mass exchange in the air flow supply. All of these features are presented together, thus combining heat and mass transfer, increasing the cooling effect of the air to be conditioned and achieving optimisation of the thermal process. Depending on the permeability of the wall of the solid porous cooler which separates the two air flows, there is greater or lower liquid diffusion (water) towards the air flow supply from the external pores, in all cases. The partial pressure of water vapour in the supply air is the controlling factor in this mass transport process.

Hybrid Evaporative Cooler

Several modifications are possible by combining DEC, IEC and other systems (hybridisation), which can improve the efficiency or applicability of the evaporative cooling systems significantly. Hence, the various hybrid evaporative coolers are (i) combined or multi-stage DEC and IEC, (ii) combined DEC and desiccant system, (iii) combined IEC and desiccant system, (iv) combined DEC and refrigeration system, (v) combined DEC, IEC and refrigeration system, etc. IEC yields lower cooling capacity but higher effectiveness as compared to DEC and hence, both devices are combined in a series to get both advantages as shown in Figure 5. This two-stage device is available in the market. Both DEC and IEC are not suitable for high humid conditions. For the high humid conditions, the moisture in the air needs to be removed and the desiccant system or conventional refrigeration system can be used for this purpose. In the combined DEC or IEC and desiccant systems, the

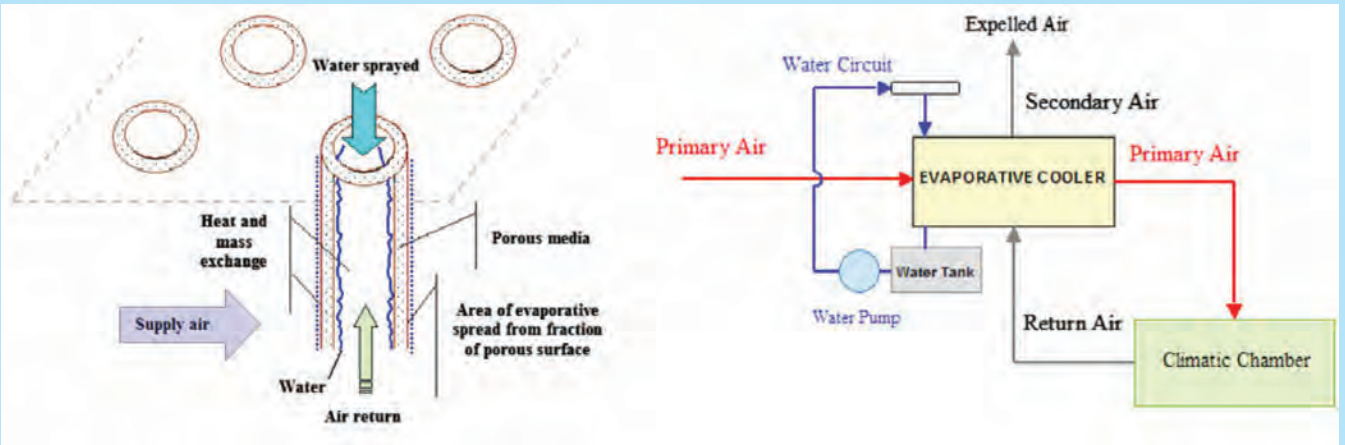


Figure 4: Working and layout of semi indirect evaporative cooler

solid or liquid desiccant systems driven by solar thermal, waste heat or other heat sources are used to remove the moisture. In the combined DEC and refrigeration system, the water used in DEC is cooled below the dew point temperature by using the refrigeration system, so that the air moisture will condense and hence, the supply air gets cooler and dehumidified. DEC is also used to pre-cool the condenser air of the conventional air-conditioning system.

Climate Zone and Cooler Selection

India possesses a large variation in climate and generally falls under five climatic zones i.e. hot-dry, warm-humid, composite, temperate and cold. Out of these, major areas undergo composite, hot-dry and warm-humid conditions. In the warm-humid climatic zone, the direct evaporative cooler cannot be applied successfully because of the high relative humidity in the summer season of about 80–90 per cent. The indirect evaporative cooler is also not so effective for this zone due to high specific humidity. Thermal comfort in this climate is possible only by using the air conditioner. In the hot-dry climatic zone, the direct evaporative cooling is more applied because of less relative humidity in the range i.e. 30–50 per cent and it has the added benefit of conditioning the air with more moisture for the comfort of building occupants. The major area of India undergoes a composite climate zone. For this zone, DEC is best applied in the dry season (March-May) and it is widely used; however, the IEC can be applicable in relatively humid season (June-July). For the high humid season (August-September), the hybrid system (with desiccant or refrigeration system) has to be used. Hence, we can recommend the cooling option for various climatic conditions as follows: (i) Dry or low wet-bulb temperature – DEC, (ii) Medium humid or medium wet-bulb temperature – IEC, semi-indirect or hybrid and (iii) High wet-bulb temperature – hybrid system. To avoid the use of different options in different seasons of composite climate, a single multi-mode evaporative system can be used, which can operate in a required mode based on the ambient humidity level or wet-bulb temperature. We have developed such a system (dual-mode evaporative cooler) in our laboratory. Now, we can summarise the climate-zone-wise recommendation of cooling options: (i) Hot-dry climate zone (ex. Jodhpur) – DEC or indirect-direct evaporative cooler, (ii) Composite climate zone (ex. Delhi, Varanasi) – Multi-mode system, and (iii) Warm-humid climate zone (ex. Mumbai, Kolkata, Chennai) – hybrid (with desiccant or refrigeration/ air-conditioning) system. DEC is the cheapest, followed by IEC, semi-indirect and hybrid systems. ■

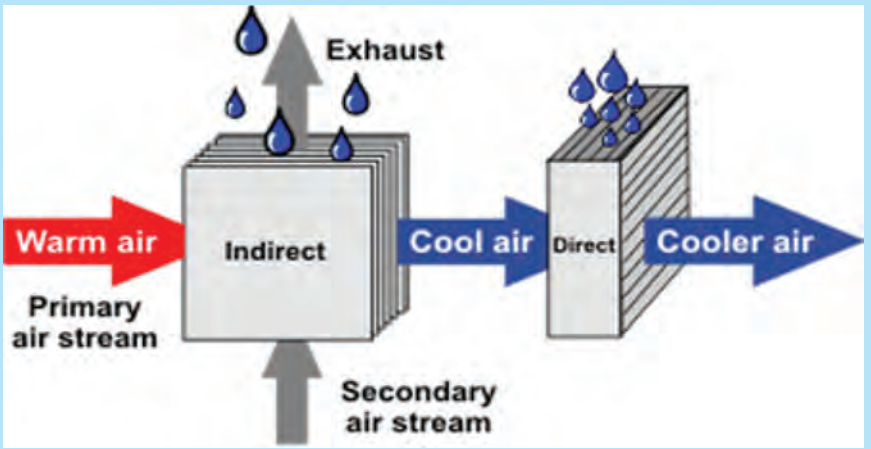


Figure 5: Indirect-direct evaporative cooler

Dr. Jahar Sarkar,
Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology, Varanasi,

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New Approach to HVAC & Building Automation Using LPWAN

The article describes LPWAN (Low Power Wide Area Network) systems integrated with IoT devices and how the HVAC and building industry will benefit from this technology soon.

Modern chillers have sophisticated control systems and highly advanced load management programs. The chiller controls are integrated with the Building Management Systems (BMS) which have control and monitoring capability, depending upon the complexity and requirements of the HVAC system. Typically, the BMS system would cover AHUs, temperature sensor in the workplace, air quality sensors etc. and allow the operator to monitor and control the entire HVAC system operations from one location. The BMS is connected to the sensor or equipment through wiring laid out throughout the building at the construction state.

However, BMS systems rarely work at the level of sophistication and complexity that they were designed for. The reasons are many – the BMS system not commissioned or not commissioned properly due to cost or time constraints, faulty sensors that don't get replaced, poor support from OEMs for the software upgrades etc. The problem gets

more acute in older buildings where the BMS system is a legacy one and spare parts are not easily available. Changing a BMS system is also not an option as the wiring is not easily accessible in older constructions.

A new wireless technology is now helping designers and operators to get free from the "wires" literally and use low frequency radio waves to communicate between sensor and the control systems wirelessly. LPWAN (Low Power Wide Area Network) systems integrated with IoT devices can cover wider distances, use less power and the radio waves can pass through building walls. This article describes in brief what is LoRaWAN and how the HVAC and Building industry will benefit from this technology soon.

What is LPWAN

The Low Power Wide Area Network is an alternate to the cellular and Wi-Fi networks that are currently used to connect sensors and devices. The LPWAN system uses LoRa technology (owned by SEMTECH) based devices that use the LoRaWAN protocol which has been developed by the LoRa Alliance, a non-profit industry organisation that oversees the development of the protocol. There are over 100 countries where LoRaWAN applications are in use across various industries.

LoRa technology uses the unlicensed radio spectrum and the LoRaWAN protocol lays down the standards for data packet transmission and sharing. The key advantages of a LoRa are

- Low power: The technology uses very minimal power compared to current technologies and hence, allows batteries of remote IoT devices to last longer, even up to multiple years.
- Range: This is one of the key features of the technology as the range is as far as 5 km in urban settings and 15 km in open rural areas.
- Cost: Since the coverage is wider and the protocol is based on unlicensed radio frequencies, the cost of setting up a network is substantially lower than a wired or Wi-Fi based system.

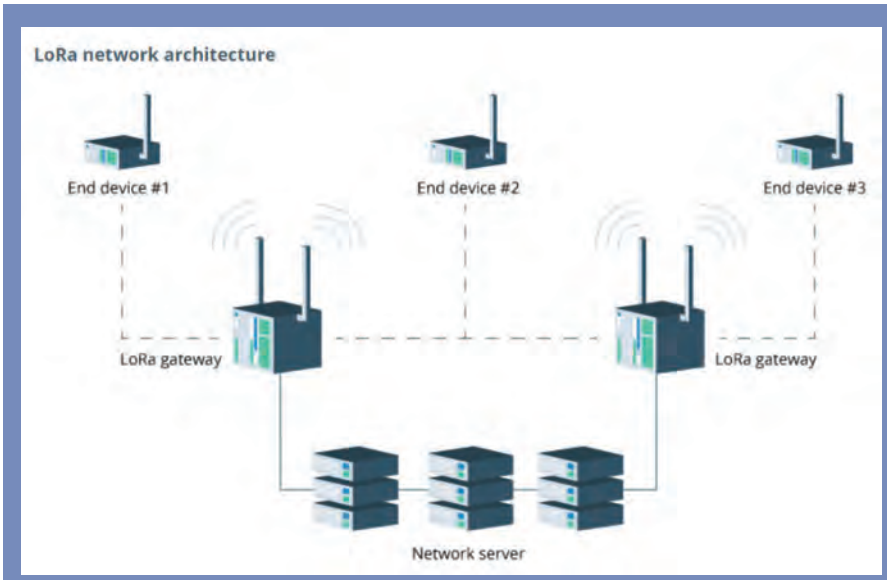

Fig.1: LPWAN Architecture

How does a LPWAN Work?

The architecture of a LPWAN based network is very similar to wired systems. Figure 1 shows the physical configuration of such a system.

The LPWAN based sensors use the LoRa technology to generate the wireless communication signals of the real-world data (temperature, pressure, location etc.). These are transmitted to the LoRa Gateway. A single gateway can connect from 8 – 64 devices and the data are then transmitted to the network servers. Once data is online, then it can be analysed using data analytics programs to both control and monitor the end equipment's systems.

Applications of LPWAN

There are many use cases of this technology and with over 100 million IoT devices already deployed, the number is only growing. Due to the wider range and reach of the technology, deployment in smart cities will see more uptake soon. For the building and HVAC ecosystem, the use cases are multitude. The key barrier

Fig. 2: LPWAN Use Cases in Building Services

to automating HVAC system operations has been the high cost and effort associated with installation of wired BMS systems in buildings. With the LPWAN approach, this barrier can easily be overcome as the cost of installation and deployment is relatively low and fast. The setting up of the system is also much easier and faster, with local systems being set up in under an hour. Some of the areas where LPWAN systems are being used in the HVAC and building environment are shown in figure 2:

HVAC Retrofit Applications

Many older buildings and HVAC systems do not have capabilities to integrate with online systems and still depend on highly manpower intensive approaches for operations and maintenance. This not only increases the cost of the operations, it also does not give the operator enough time for responding to breakdowns and emergencies. Installing a BMS system into an existing building is a very laborious task as well as expensive due to the large amount of cabling that needs to be done. Wi – Fi based systems have also not been very effective due to the low penetration of the signals across floors and walls of the buildings. To take advantage of the power of data analytics and machine learning even in such legacy systems and older building, the LPWAN approach is ideal. The quick set up times and lower cost allow an existing building to quickly turn into a smart building with connected systems and online data collection. Legacy chillers, AHUs, pumps, cooling towers can all be connected to a central management tool using the LoRa based sensors that capture temperature, pressure, flow etc. The LoRaAlliance has helped developed a large array of sensors to suit almost any requirement in the HVAC industry and the open protocols allow for new sensors to be developed in short timelines.

Conclusion

Building engineers operating legacy systems in older buildings have always faced a challenge of upgrading these systems and bring them 'online' so that the operations can be more effective and efficient. The key issue has been the difficulty in upgrading the wired BMS system or adding on more sensors to the system due to both cost and complexity. The LoRa based systems are an answer to this problem as it frees the system from wiring and at the same time, at an affordable cost. The system reliability is not as high as a wired system but in non-mission critical systems, this slight disadvantage can be compensated by better system design. Data is the new oil in today's technology driven world and it has the power to transform operations of HVAC systems. This new technology has the power to automate as well as digitize legacy systems and get them onto the data highway. ■

Aneesh Kadyan,
Executive Director - Operations, for a leading real estate services firm

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VOC Emission
and IAQ in Office Spaces

The quality of air within our buildings has a great effect on our bodies. This article explains the impacts of volatile organic compounds on indoor air quality in office buildings.

Sick Building Syndrome (SBS), an ailment known to occur among building occupants, was discovered nearly four decades ago. It comprises a group of loosely associated symptoms known to persist among more than 20 per cent of building occupants with cause(s) not recognisable, and complaints/symptoms relieved after exiting the building. These symptoms include headaches; eye, nose, and throat irritation; a dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odours. SBS is known to have reduced work productivity and increase absenteeism.

The problematic trend of sick buildings, which began in the western world, can be traced back to the oil embargo in the 1970s. The new energy efficient buildings built then were sealed and insulated from the external environment. The National Aeronautics and Space Administration (NASA), Washington, DC, reports that these sealed buildings have less exchange of fresh outdoor air for stale indoor air causing higher concentrations of toxic chemicals in indoor environments, brought about by emissions from a great variety of building components and materials.

Table 1: Classes of indoor air pollutants	
Pollutant Class	Typical Examples
Combustion products	Carbon monoxide, nitrogen dioxide, sulphur dioxide, carbon dioxide, tobacco smoke components
Volatile organic chemicals	Pesticide and fungicide components, alcohols, benzene, esters, chloroform
Respirable particulates	Asbestos, fibre glass, inorganic and organic dusts, frayed materials, pollen
Respiratory products	Water vapour, carbon dioxide, Water vapour, carbon dioxide
Biologics and bio-aerosols	Moulds and fungi, bacteria, viruses, nonviable microbial particulates
Radionuclide	Radon, radon progeny
Odours	Odours associated with any of the above
(Source – Hong Kong University Department of Architecture, IAQ Lecture series)	

Such office spaces are now rapidly mushrooming in commercial buildings in Indian cities. These buildings are often sealed glass envelopes that are incapable of breathing. The environment inside is often devoid of vital oxygen, natural light and ventilation, and still worse, laden with harmful gases such as Nitrogen Di-oxide, Volatile Organic Compounds (VOCs), ozone, hazardous chemicals and disease-causing microorganisms that are released and contained within the building's envelope. SBS has the potential to develop into a serious and expensive liability when these toxins become concentrated inside sealed buildings.

Indoor air pollutants that contribute to SBS can be broadly classified as biological and chemical contaminants, particulate matter, combustion gases, VOCs, radionuclide and bio-aerosols. Table 1 provides the different classes of indoor air pollutants.

Why is Indoor Air Quality (IAQ) Important in Offices?

ASHRAE (American Society for Heating Refrigeration and Air Conditioning Engineers) defines IAQ through concentrations of air pollutants that are known or suspected to affect people's comfort, environmental satisfaction, health, work or productivity.

Typical sources of contaminants unique to indoor environments in offices include VOCs and suspended particulate matter from paints, carpets, office equipment, floor and surface cleaning agents, ceiling, furniture and pesticides; bio-aerosols and micro-organisms from furnishings, human activities (bio-effluents); and build-up of gases such as carbon di-oxide and carbon monoxide from poor ventilation.

Health effects from indoor air pollutants may be acute or chronic and, experienced soon after exposure or, possibly, years later. Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to some indoor air pollutants (The Inside Story – A Guide to Indoor Air Quality, US Environmental Protection Agency, 2012).

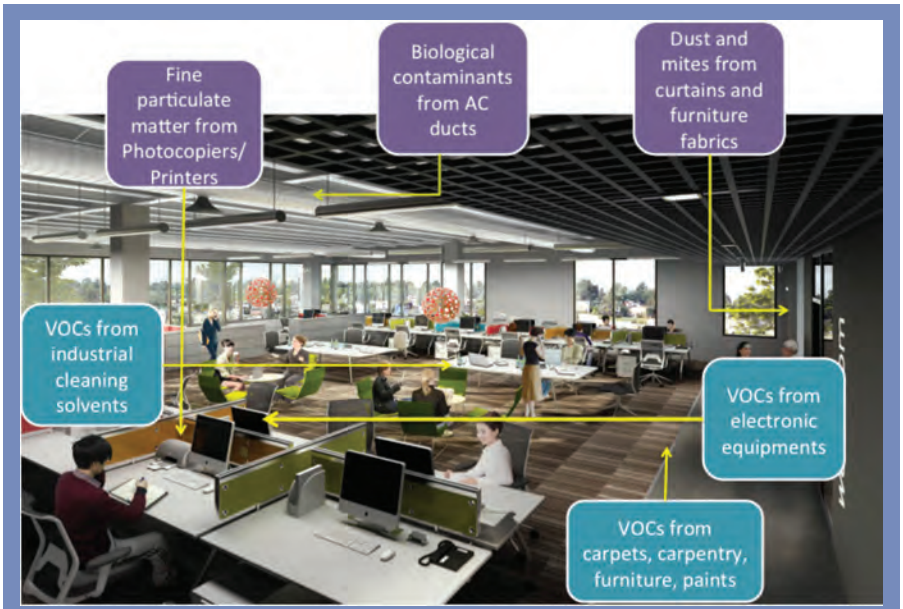

Fig. I: Typical sources of Indoor Air Quality contaminants in offices

Volatile Organic Compounds (VOCs)

VOCs are a large and diverse family of chemicals that contain carbon and hydrogen. VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals some of which may have short and long-term adverse health effects. A VOC is any organic compound having an initial boiling point less than or equal to 250-degree C (482-degree F) measured at a standard atmospheric pressure of 101.3 kPa and can do damage to visual or auditory senses.

VOCs are sometimes categorised by the ease they will be emitted. For

Sl	Case 'A'		Case 'B'		Case 'C'		Case 'D'	
	Name of Material	Percentage	Name of Material	Percentage	Name of Material	Percentage	Name of Material	Percentage
1	Laminate	25.08	Paint	28.06	Paint	26.58	Paint	32.13
2	Paint	18.26	Gypsum Ceiling	19.14	Gypsum Ceiling	19.38	Gypsum Ceiling	19.60
3	Kota flooring (considered as Carpet)	17.7	Metal powder coated paint	14.91	Carpet	13.08	Carpet	16.19
4	Gypsum Ceiling	15.34	Carpet	19.14	Laminate	7.14	Laminate	10.45
5	Metal powder coated paint	5.93	Laminate	6.11	Metal powder coated paint	3.92	Veneer-Melamine polished	2.85
6	Fabric	6.93	Fabric	5.01	Fabric	5.40	Fabric	2.96

example, the World Health Organization (WHO) categorises indoor organic pollutants as very volatile, volatile, and semi-volatile. The higher the volatility (lower the boiling point), the more likely the compound will be emitted from a product or surface into the air. Very volatile organic compounds (VVOCs) are so volatile that they are difficult to measure and are found almost entirely as gases in the air rather than in materials or on surfaces.

IAQ Standards Related to VOCs

At the international level, many organisations have set up standards for IAQ. These include Greenguard, BIFMA, NIOSH, EPA and WHO. The Greenguard acceptable limits for TVOC is ≤ 0.5 mg/m3 and for formaldehyde is ≤ 0.05 ppm. BIFMA provides individual VOC concentration limits at 336 hours. For example, the maximum allowable concentration of formaldehyde in workstations as per BIFMA is 17 mg/ m3 and the maximum allowable concentration of formaldehyde for open plan office as per BIFMA is 11mg/m3.

VOCs in Modern Open Offices

Modern offices have many sources of VOCs. Typical sources include volatiles and particulates from building materials, furnishings, appliances, office equipment, office/residential cleaning supplies, human activities (bio-effluents), tobacco smoke, biological organisms, and pesticides.

A study conducted by Rachana Sansad's Insitute of Environmental Architecture in collaboration with Godrej Interio included 4 modern air-conditioned open plan layout offices with more than 100 workstations in Mumbai. The proportion of various exposed surfaces in the office was ascertained using methodology specified by BIFMA, and the proportion of various VOC emitting surfaces was calculated. The results are summarised in Table 2.

From the Table 2, the five most prevalent materials contributing to VOC emissions, were enlisted. The results showed that on an average, painted surface comprised 26 per cent, gypsum ceiling comprised 18 per cent, carpet 17 per cent, laminate 12 per cent and fabric 5 per cent of the total exposed surface in office interiors.

What Can be Done?

Measurement of TVOCs in indoor office environment is the first step towards reducing and eliminating VOC emissions. Understanding the nature of emissions and their levels with respect to standards provides valuable information to product designers. Steps can be taken in the design process to eliminate VOC emitting materials and sources in furniture and product manufacture through Life Cycle Analysis (LCA) of the products. Some recommendations are suggested below:

- Finding alternatives to meet low VOC requirements as per standards of BIFMA, Greenguard and WHO
- Use low VOC adhesives in carpet tiles, laminates or any other interior product
- Reduce VOC contents in Primer
- De-gassing of furniture prior to dispatch. ■

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Dr. Ashok Joshi, Associate Professor, Rachana Sansad's Institute of Environmental Architecture, Mumbai

Ar. Ashwini Deodeshmukh, AGM, Green Initiative Cell, Godrej Interio Division, Godrej & Boyce Manufacturing Co. Ltd.

Residential or Commercial HVAC Duct Leak Issues

The Challenge

Sudden surges in electricity use can indicate a problem or series of failures within a building's HVAC system. A common source of energy loss is with leaks in the HVAC ductwork. This could mean energy bills up to 30 or 40 per cent higher than running a system without leaks. Heating and cooling professionals are tasked with diagnosing what the problem could be. This can be time consuming, since the traditional method would require inspecting each system element individually. Not to mention that some ductwork can be located in very hard to reach areas.

Highlighted Solution

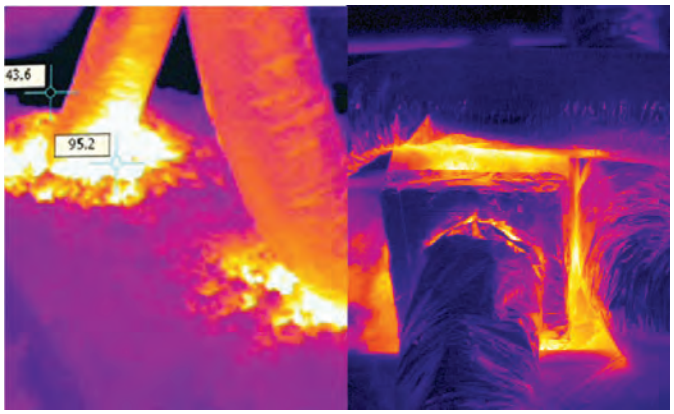
It is more efficient to use a thermal camera to scan for potential problems spots first. With a thermal camera you can detect hot and cold spots, for example, using a FLIR C3, a pocket-sized thermal camera on ducts or vents could reveal spot leaks at joints. It could also help an HVAC professional determine that the HVAC inefficiency is from insulation loss. In addition to scanning the ductwork system, a thermal camera can be used to inspect the condenser unit to see if a coil is plugged and identify exactly where on the coil the blockage is occurring. It is also ideal to detect if there are mold conditions troubleshoot airflow problems and better predict mechanical failure. The FLIR C3 includes a professional reporting software FLIR Tools and is wi-fi enabled. It is an affordable addition that will no doubt pay for itself after the first successful job.

The Results

A thermal imaging can help you quickly and efficiently scan the complete ductwork for leaks and disconnections. Thermal imaging can detect small leaks and areas where duct insulation has broken down causing hot/cold air to escape. What would have taken a whole day of crawling in hot attics and tight crawl spaces or inspecting a large system can be accomplished in a fraction of the time. Once detected, the leaks can be fixed so the HVAC system runs efficiently again. In the ned, thermal imaging helps HVAC professionals solve problems faster and save customers money. ■

For more information, visit: www.flir.in/c3

When duct work is improperly installed or develops air leaks, HVAC systems will run inefficiently



Thermal imaging cameras provide a fast, easy way to identify air leaks, so repairs can begin immediately

- Specify Correct

Ramesh Paranjpey, Fellow ASHRAE Life Member and Past President ISHRAE Pune Chapter lists all the specifications of refrigeration equipment that need to be considered for the benefit of a buyer/consultant.

In any vapour compression refrigeration system, there are four major components-whether it is an air conditioning or refrigeration plant and it is essential that while ordering these components either from manufacturer or through consultant/ contactor, the end user customer must check whether the specifications of these four equipment have been correctly specified.

In almost all instances, the supplier makes an offer highlighting only the positive points of his equipment and hides the drawbacks. The buyer, should therefore check all the technical specifications and then make the comparison between two or more offers received. If he does that, then he does not have to regret later on, and his decision then would be based on proper assessment, rather than deciding only for the lowest priced basis.

Here, all the specifications that need to be considered for proper assessment of the major components have been given for the benefit of the buyer/consultant.

The four major components of any vapour compression refrigeration system are

- Compressor
- Condenser
- Evaporators
- Metering devices.

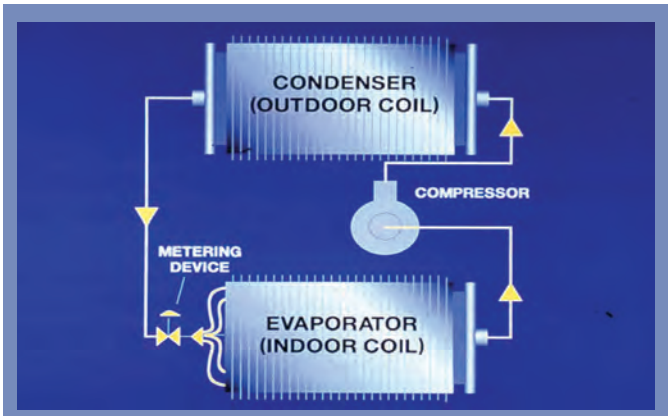


Fig 1 showing major components of the system

In this article I am covering specifications required for these components used in refrigeration systems with Ammonia as refrigerant for cold storage applications.

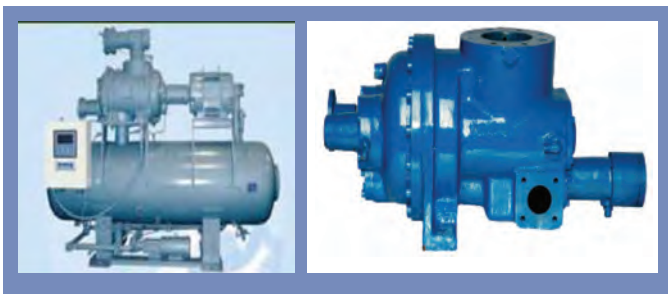
Compressors

The first and most important as well as most expensive component is compressor and normally two types of compressors are used in the systems

- Reciprocating piston compressors
- Screw compressors.

We shall start with specifications of reciprocating compressors first.

Fig 2: Reciprocating compressor



We shall now look at specifications of screw compressors.

Most of the parameter mentioned above also need to be considered, besides which additional points mentioned in Table 2 need to be taken in consideration.

Table 1

Sr. No.	Specifications	Remarks
1	Required Refrigeration Capacity-kW	
2	Saturated Suction Temperature (SST)-Deg. C	This is different than Evaporating temperature and should be lower by 1 or 2 deg. C Than evaporating temperature, depending upon suction line losses, distance of evaporator from compressor etc
3.	Saturated condensing temperature -Deg. C	The design and selection should be done at 4 Deg. C higher than water outlet temperature. For example, water inlet temperature 28 Deg. C, outlet 36Deg. C then condensing temperature 40 Deg. C
4.	Liquid subcooling-Deg. C	Many manufacturers declare capcity with certain degree of sub-cooling. It should be noted that there is nothing built in the compressor to give sub cooling. Many manufacturers do this so that their power consumption per kW output appears lower than the competitor (whose ratings are without sub-cooling). Subcooling increases capacity without increase in power consumption and hence C.O.P. looks better. Buyer must ensure that capcity indicated in Sr. No. 1 is with Zero sub cooling and then compare
5.	Super heat- Deg. C	This also should be also Zero Deg. C, although one can do selection with 5 or 10 Deg. C super- heat based on location of equipment. Super heat decrease compressor capcity.
6.	Compressor Speed in R.P.M.	Check whether the speed is maximum allowable or lower than maximum speed. Lower could be preferred but not necessarily.
7.	Compressor number of cylinders	A multi cylinder compressor runs with less vibrations than one- or two-cylinder compressors since primary and secondary forces and movements are evened out better.
8.	Number of compressor capacity control steps	More the steps, it would allow more flexibility and one can match the load requirements more accurately.
9.	Whether compressor capcity can be regulated through step controller or requires VFD	A step controller is more economical option and also power consumption is less. One can use VFD for in between steps to match load requirement correctly if greater accuracy is needed.
10.	Compressor Shaft power consumption-kW	To decide motor selection
11.	Recommended motor rating-kW and whether 4 Pole or a greater number of poles like 6 or 8 for direct drive option	Normally 10% higher than maximum power consumption, but requires many other parameters to be checked before selecting correct motor size.
12.	Starting of compressor	Whether fully unloaded or with minimum load. With fully unloaded start, the starting current (Amps)is less.
13.	Whether belt driven or direct drive.	With belt drive, and if selection is at lower than maximum R.P.M. there is a possibility of increasing compressor capacity if one falls short of the to some extent. When selection indicates lower RPM than maximum, there is no need to select direct drive and then reduce RPM with VFD. This is more expensive and more power consuming option.

Table 2		
1	Whether single screw or twin-screw design	
2	Compressor speed-RPM	Screw compressors are normally direct drive compressors.
3	Compressor Capacity-kW, Without economizer	With economizer the capcity looks better, but if the load is less and the port of economizer is at 70% or at higher point, the benefit of economizer is only when load is between 70 to 100%. when the slide valve moves beyond this point the economizer gets bypassed and no benefit is available., unless one uses VFD for capcity control instead slide valve control
4	COP with and without economizer	This is dimensionless values
5	Oil quantity and guaranteed oil carry over in discharge gas	Screw compressors have large quantity of oil since rotors are flooded in oil and oil separator efficiency is very important. If the oil carry- over is more the percentage of oil in refrigerant -oil mixture is more & then it affects plant performance adversely since it is refrigerant which gives cooling and oil has no contribution in cooling.
6	part load capcity and power consumption at 20%, 40% 60% and 80% load	This is important as part load performance of screw compressors is not as good as step controlled multi- cylinder reciprocating compressors.
7	Whether variable VI or fixed VI ratio	Screw compressor design is constant compression ratio based on manufactured component, and hence when the suction or discharge conditions vary, there is always over or under compression leading to higher power consumption.

Condenser

Condenser is a device where heat is rejected to the atmosphere from the system. Normally, evaporative condensers are most popular for ammonia refrigeration systems and they can be mounted outside the machine room wherever place is available.

Condenser is the most neglected device in the entire system, since it is generally not in the machine room and one does not know whether it is functioning properly, till the discharge pressures start rising beyond the design limits.

Evaporative condensers are available in many different designs with counter flow or concurrent flow. They can be with separate de-superheat section; Evaporative condensers can also be either entirely plain tubes with either round or elliptical tubes or partially wet pads and partially tubes. New deigns with falling water over the plates are also available. The casing can be either S.S. or Powder coated steel or FRP. Etc.

Table 3	
Content	**Required**
TDS	500-to 700mg/l max.
PH value	6.5 to 9 max.
Total Hardness (in mg/l as CaC03)	50 to 500 mg/l max.
Total Alkalinity (in mg/l as CaCO3)	750mg/l max.
Chloride (in mg/l as CL)	100 mg/l max.
Chlorides (ppm like NaCL)	250 mg/l max.
Sulphates (ppm like SO4)	125mg/l max
Silica	150ppm max.
Conductivity	3000μS/cm
Total suspended solids	20mg/l max.
Total dissolved solids-ppm	1500 max.

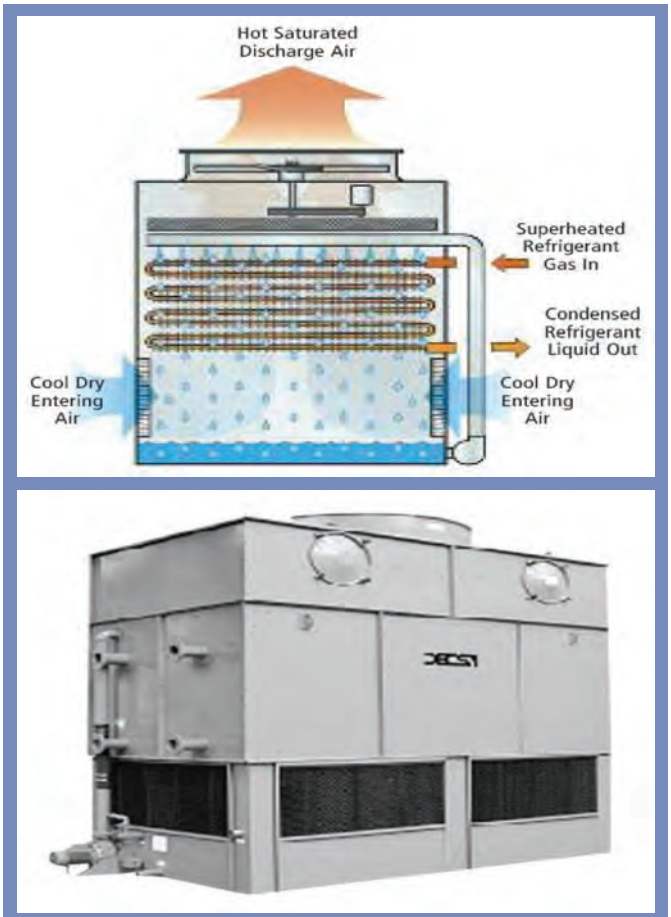


Fig 3: Evaporative Condenser

While asking for the offers from evaporative condoner manufacturer, the end-user should specify weather conditions such as maximum wet bulb temperature during monsoon at the place of erection, altitude and most importantly the quality of water available

Table 4		
Sl	**Specifications**	**Remarks**
1	Location-City	
2	Altitude above sea level -m	
3	Heat Rejection Capacity-kW	This is equal to compressor capacity plus compressor shaft power. Do not select condenser only for refrigeration tonnage. The work done by compressor also is converted as heat and has to be rejected in addition to refrigeration capacity
4	Wet bulb Temperature-28Deg. C	Normally wet bulb temperature is highest in monsoon and select condenser on the basis of wet bulb temperature and not Summer highest dry bulb temperature
5	Condensing temperature-40 Deg. C	This is based on the designer of plant. It is suggested that it should be 38-degree C and compressor selected for 40-degree C so that one has enough margin available when condenser tubes get fouled with water impurities.
6	Total air flow-m3/hr	
7	Effective air inlet area- Sq.m	
8	Air inlet Velocity-m/sec	
9	Air outlet velocity-m/sec	
10	Total water flow-m3/hr	The ratio of Sr. No.10 to Sr. No. 6 is known as L/G ratio
11	Spray Water Quantity-LPS	
13	Evaporator Water Loss-LPS	
14	Working noise level at 5m-db(A)	This depends on quality and number of fans used
15	Fan motor kW Each	
16	Number of fans& total power-kW	
17	Fan diameter-mm, fan efficiency	
18	Type of fan, Fan RPM	
19	Type of power transmission to fan	Belt drive or direct drive, with or without speed control
20	Transmission Power loss	
21	Noise level at 3 to 5m distance - dBA	
22	Water pumps 2=(1W+1S)	Normally these are monobloc pumps and please ask supplier to supply evaporative condenser fitted with both pumps complete with piping
23	Pump motor -kW each	
24	Type of condenser – counter flow or co-current	Counter flow for condensers is the best choice
25	Construction of tubes – hot dip galvanised or stainless steel	Many use galvanized steel tubes. However, it should be ensured that these are hot dip galvanized and not spray galvanized. It is suggested to be sure, It is better to select S.S. tubes
26	Casing and water tank material	If low cost is important, one can use powder coated steel casing, FRP casing however if the atmosphere corrosive and contain corrosive gases, it is better to use Stainless steel
27	Overall dimensions Lx W x H-m	
28	Empty weight of condenser-Kg	

with water analysis certificate. The performance of evaporative condenser and water bleed rate depends largely on water quality.

The selection of evaporative condenser should be done for maximum wet bulb temperature during the year which is normally in monsoon. Many engineers select condenser for highest dry bulb temperature in summer and then face problems of performance during monsoon as it falls short of capacity.

The preferred water quality for evaporative condensers is specified in Table 3.

Evaporator or air cooler

The third most important equipment is evaporator or air cooler for cold storages. The evaporator is the most crucial component within any refrigeration system being responsible for removal of the heat from product and maintaining uniform temperature and air distribution to ensure no stagnant area exist or no appreciable weight loss takes place.

The evaporator is a device for absorbing heat into the refrigeration system. The evaporator receives cool, low pressure

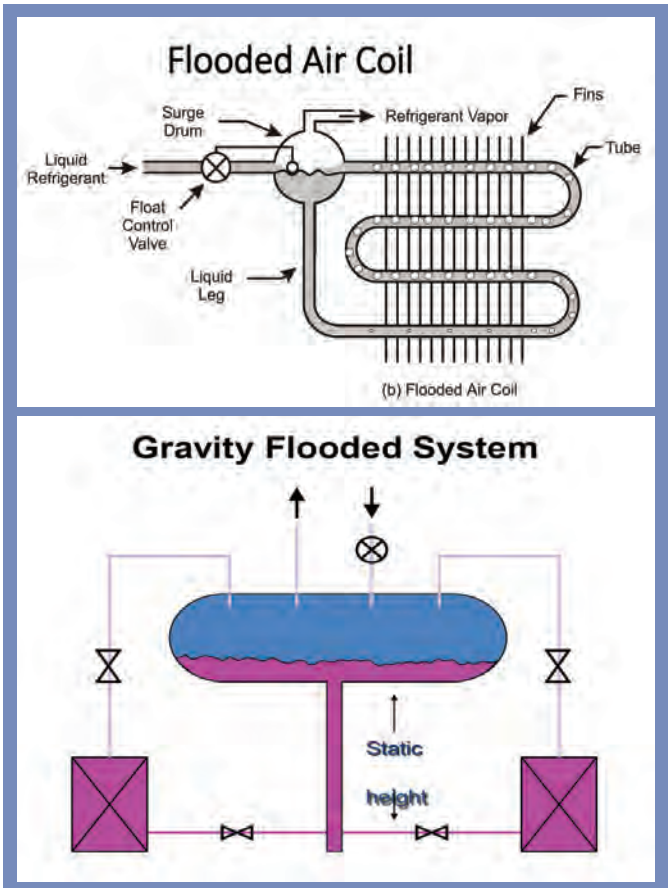


Fig 4: Gravity flooded and pump circulation air coolers

refrigerant liquid from the liquid metering device and changes into refrigerant vapour as a superheated vapour.

Fig 5: Typical Air Cooler

The heat of substance being cooled is removed by air as stored products come in contact with cold air.

Air coolers can be gravity flooded type or pump circulation type.

Air cooler specifications and selection is most important as the quality of product stored depends upon selection of air cooler. The product should be able to remain in the cold room without deterioration or without weight loss and hence proper temperature and humidity needs to be maintained in the cold room. Also, it should ensure that there is not more than 2-degree C temperature variation in any part of the cold room.

We have covered specification requirement of major items except the fourth one which is expansion valve. This item falls under the category of controls and hence selection of it depends on various design parameters of the system. The types normally

Table 5

Sl	Specifications	Remarks
1	Capacity-kW of each cooler	Based on cooling load calculations and based on room dimensions one can decide whether one cooler is sufficient or a greater number of coolers are required.
2	Evaporating temperature in coil-Deg. C	This is equal to cold room temperature to be maintained. It could be between 2 to 6-degree C for positive temperature cold rooms or (-) 20 to (-) 25-degree C for frozen products.
3	Type-floor mount or ceiling suspended	Mostly ceiling suspended preferred.
4	Pump circulation or gravity flooded	For small and compact plants gravity flooded. For large plants with many air coolers and larger distance between machine room and cold rooms as well as for low temperature projects, pump circulation preferred.
5	Coil details, number of rows, face area	For low humidity applications a greater number of rows deep coil is required so that moisture is removed from air effectively
6	Number of fins per inch or fin spacing	For low temperature applications, less number of fins/inch or maximum 3 fins/inch and for positive temperature application, 4 fins/inch can be accepted.
7	Coil length without headers-m	This is required. Do not compare only overall sq. ft. area. Coil, through refrigerant flows, should be adequately long to accommodate required refrigerant charge
8	Coil internal volume without headers-	Higher the volume better it is, overall sq. ft. area of coil is misleading. A cooler with higher overall sq. ft. area may be undersized compared with cooler with lower overall sq. ft. area but having higher internal volume or longer tube length.
9	Tube diameter and thickness-mm	

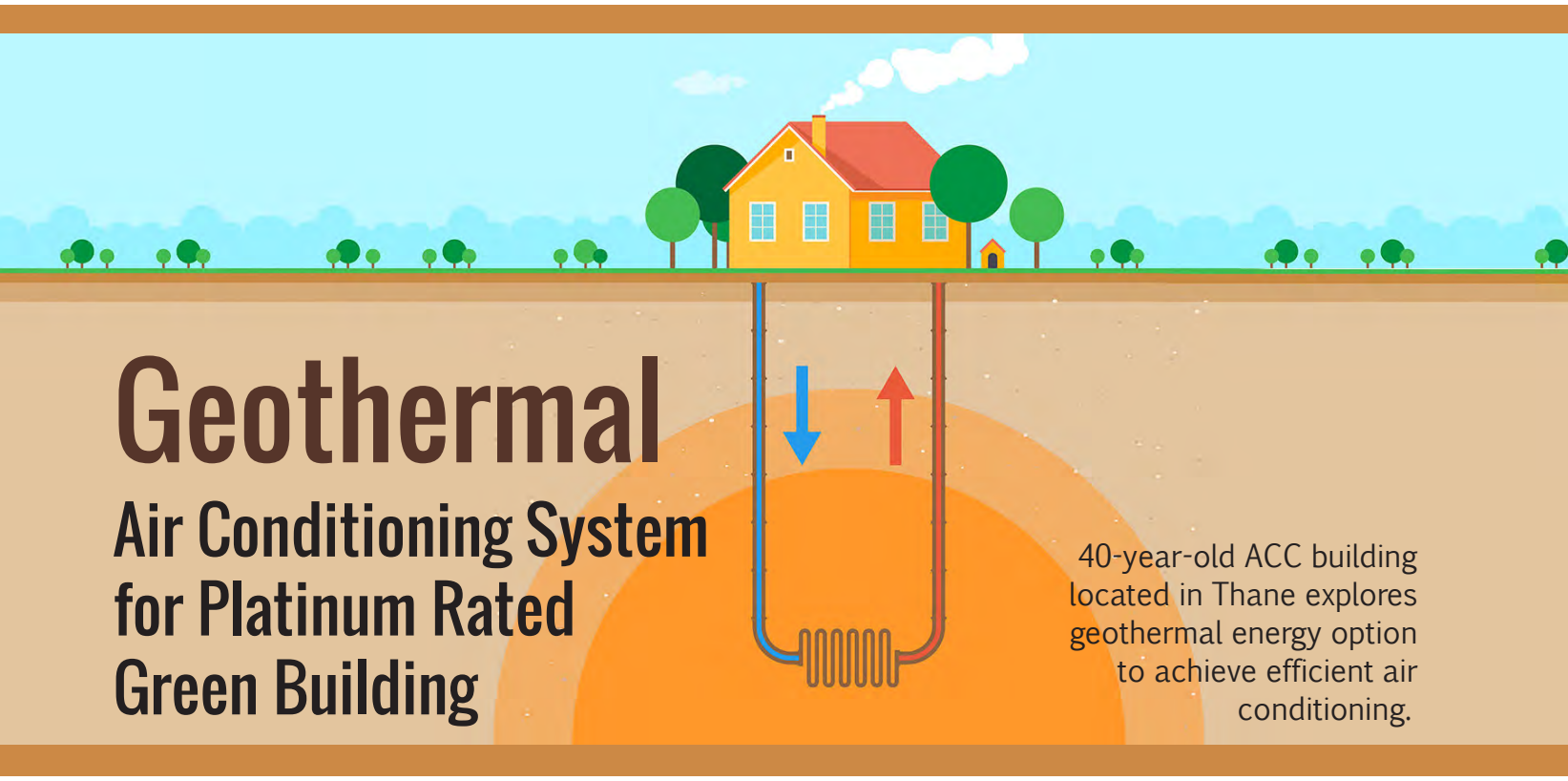
10	Tube arrangement-Triangular pitch or square pitch	Triangular pitch is better as it has better heat transfer and air cooler becomes compact. However, pressure drop is more and defrosting takes longer time
11	Fin thickness and type-mm	Corrugated for enhanced area or plain plates
12	Coil side refrigerant pressure drop -Pa	Bigger tube diameter has lower pressure drop. Pressure drop value helps in selecting compressor saturated suction temperature
13	Coil sq. ft. area including fins	This is not so important, more surface area does not mean better coil, more important is coil internal volume as indicated in Sr.No.8
14	Air quantity available for distribution-m3/hr	This is after the fans at the coil outlet and not fan volume. More the better to ensure uniform air distribution in the cold room. Higher velocity over the product may lead to dehydration in products requiring high humidity.
15	Number of fans and KW of each fan	Some manufacturers provide VFD to control fan speed if less air quantity is required once the product gets cooled and initial heat is removed.
16	The air cooler is draw through arrangement or blow through	Fan is after the coil in draw through design, in blow through design fan is before the coil and is better arrangement as fan heat gets added before and LMTD increases. In other words, coil is visible in the cold room and fans are at back side.
17	Fan diameter - mm	
18	Fan external static pressure available for air circulation-Pa	This value is important and not the fan static pressure as there would be pressure drop across the coil.
19	Fan noise level combined-dBA	
20	Air throw-m	To ensure air reaches up to opposite wall, the air velocity at 90% should be 0.5m/sec
21	Air spread	To ensure air is reaching across the cold room
22	Air side pressure drop across coil-Pa	Higher rows more pressure drop, triangular fin pitch-more pressure drop, more fins per inch-more pressure drop, corrugated fins -more pressure drop-More pressure drop means more fan power to overcome the same.
23	Air inlet temperature -Deg. C	This is normally cold room temperature.
24	Air outlet temperature-Deg. C	This is supply air temperature
25	Coil designed TD	Difference between refrigerant temperature in coil and cold room air return temperature. This should be between 2.8 to 4-degree C for high humidity products and maximum 5-degree C for freezing., however 4-degree C is preferred. This is the most important parameter in air cooler selection. Selection on the basis of LMTD leads to undersized air cooler.
26	Coil defrost method for coolers operating below zero temperature	Hot gas defrost or water defrost or on/off defrost-Hot gas defrost is preferred. In case of hot gas, some manufacturers provide louvers at the coil outlet so that hot air is not circulated in the cold room. The lours close during defrost.
27	Air cooler casing material	
28	Liquid inlet connection/outlet connection-OD mm	Ensure outlet connection big enough to allow gas formed is taken out without any restriction so that fresh liquid can come easily in the coil. For bottom entry air coolers.
29	Air cooler overall dimensions-LxWxH-mm	
30	Air cooler dry weight-KG	

used in ammonia plants are level controllers with had expansion valve, or level controller with motorized expansion valve or high side float for low charge refrigeration systems etc. The specifications for expansion valve are not covered in this document.

Conclusion

The above information gives detailed specifications for ordering out major equipment and for comparison of quotations received from different manufacturers/suppliers. Effort should be made to make comparison from offers received, on equal technical specifications basis and then the price should be negotiated. This would lead to proper equipment selection and efficient operation of plant with no regrets later on. ■

Ramesh Paranjpey,
Fellow ASHRAE Life Member
Past President ISHRAE Pune Chapter



Geothermal

Air Conditioning System for Platinum Rated Green Building

40-year-old ACC building located in Thane explores geothermal energy option to achieve efficient air conditioning.

HVAC industry has seen so many changes and new ideas in last few decades. Because of the comfort requirement and resources available, day by day new alternatives are also coming to limelight. Geothermal air conditioning system is a new gift to this.

Heat Load

In the initial stages of designing, various options of air conditioning have evaluated along with different options to reduce the building load as well. This 40-year-old ACC building in Thane building was not air conditioned earlier as it was used as a staff quarter. Now when it was converted into a high-end hostel facility, air conditioning options were worked out. As a thump rule, the initial load was coming around 150 square feet/TR which was increasing the supplied electrical load for the building resulting to apply for new electric connection from state electricity board. To reduce the heat gain, first roof insulation was added with U value of 0.21 watt/sqmtr degree Kelvin. After that wall insulation has added in all side of the rooms which could further reduce the load. Then glass was changed to double glazed sandwiched type of U value 2.1 watt/sqmtr degree Kelvin. In each case 3 or 4 types of different materials have checked in thermal simulation software. The electrical fittings have changed by LED type fixtures which further reduced the heat load. Again, fresh intake locations have altered. Instead of directly taking near fan coil units, it has drawn from the window panel, landscape area where the outside temperature is already down because of water bodies in surrounding. CO2 sensors have installed in these rooms to check the fresh air level in these rooms. By doing more than 20 alterations in thermal simulation, 675 sqft/TR load have achieved.

Now, once we achieved, the load, various options of air conditioning also worked out. With the help of ACC staff, and expertise in the industry, this geothermal energy option has worked out.

Working Principle

While doing survey of the project, soil investigation and water taste have carried out and the water temperature in summer has found to be 28C (max). Now, it was almost certain to go for some system utilising the low temperature water below ground. Geothermal heat pump (chiller) collects the Earth's natural cold through a series of pipes, called a loop, installed below the surface of the ground. Fluid circulates through the loop and carries the heat to the building. There, an electrically driven compressor and a heat exchanger concentrate the Earth's energy and release it inside the building at a lower temperature. Chilled water is distributed to different rooms in MS pipes. Fan coil units are provided in different rooms which cools those rooms.

The underground loop draws excess heat from the building and allows it to be absorbed by the Earth. The system cools the building in the same way that a refrigerator keeps your food cool - by drawing heat from the interior, not by blowing in cold air.

The geothermal loop that is buried underground is typically made of high-density polyethylene. Open type geothermal system has carried out by drawing the low temperature water from ground by three bore wells in three corners of the building. This water kept in an insulated underground tank connected with a submergible

pump. Another MS pipe carries this low temperature water (28C) up to the heat pump (chiller) and cools the condenser. The return line of this loop is connected to one more tank, which further utilised for landscape and water body.

As with any heat pump, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

History of Geothermal Air Conditioning System

Geothermal Heating and Cooling uses the Earth's constant temperature to achieve EER's (Energy Efficiency Ratings) in the 30C. The heating COP (Coefficient of Performance) is approaching 5C. A 5C COP indicates that the Geothermal Systems are producing 5 units of energy for every unit of electricity consumed. The other 4 come from the Earth. That's why this technology is called renewable. It is now widely used in different countries. In India, there is a great scope of this type of system and since last decade, many designers are showing interest in these types of systems.

A heat pump is a device that transfers energy from a low temperature source to a higher temperature sink. It differs from a pure refrigeration cycle in that the end result of the application could be either to heat or cool depending upon the direction that the refrigerant is currently flowing through the system. Figure 1 shows a schematic of heat pump system.

Open Loop Heat Pump: Open loop heat pump system contains three loops; first loop is on the load side (chilled water loop). The second loop is the refrigerant loop inside the heat pump. The third loop in the

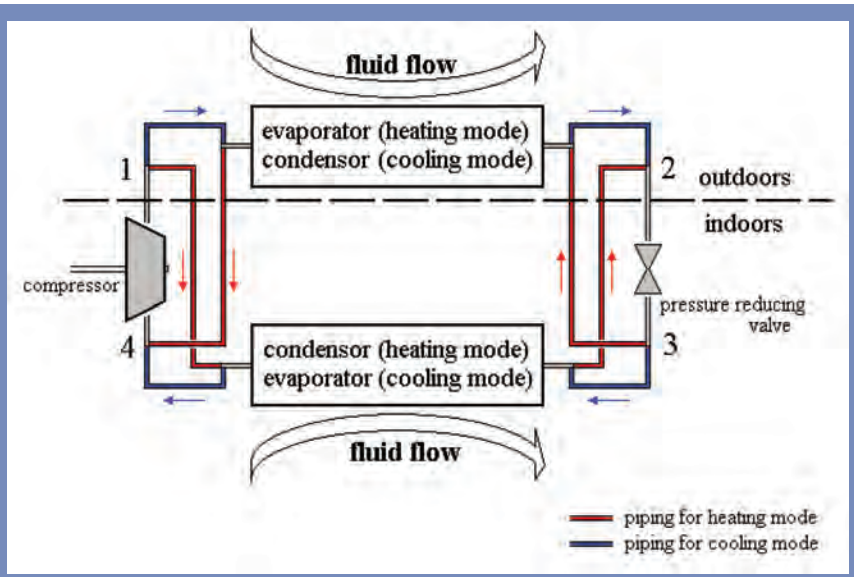


Figure 1 – Heat Pump - 1

system is on the source side (Cooling water loop) in which ground water exchanges heat with the refrigerant and to the earth.

As shown in figure 2 in the first loop the chilled water is circulating between AHUs / FCUs coil inside the building and evaporator of heat pump through the chilled water pump; chilled water takes the heat from the building and transferred this heat to the low pressure liquid refrigerant into the evaporator; by absorbing this heat refrigerant changes its state from liquid to vapour phase. Refrigerant vapour then goes in to the compressor; to increase its pressure. High pressure vapour refrigerant which is carrying the heat rejected by chilled water and the heat of compression then entered in to water cooled condenser where this total heat added in to the refrigerant is transferred to the cooling water coming from the underground tank.

As shown in figure 2, the cooling water will be supplied to the underground (UG) tank by three bore wells. UG tank

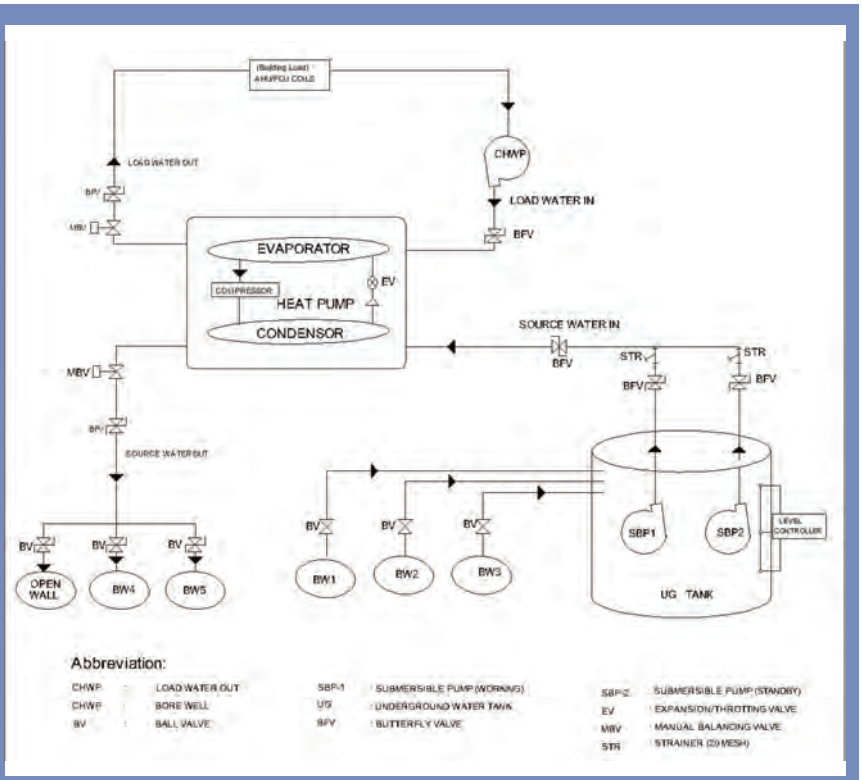


Figure 2: Heat Pump - 2

submersible pump (one working and one standby) will supply this low temperature water to the condenser of heat pump. After exchanging heat, the return hot water will be discharged into the ground via two bore wells and one open well or it can be used for any hot water application.

UG tank is having one level controller which will sense high and low water level into the tank to On or Off bore well pump and to regulate the water supply from the bore well to UG tank.

The heat pump machine is having in built control panel with multiple protocol interface board which will allow monitoring various performance parameters at a remote computer. Available protocols are BACnet MS/TP, Modbus, or Johnson Controls N2. The choice of protocol will be field selectable or changeable via the use of a simple selector switch. ■

Note: Selected model of heat pump for ACC Thane project is TMW 340 AUT 20 N0 CS. Capacity is 20 TR and the manufacturer is Climate Master of USA.

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Venue: Orange County Convention Centre, Orlando
Date: 3rd to 5th February 2020
Website: www.ahrexpo.com

Global Logistics Show
Venue: Somaiya International Convention Centre, Mumbai
Date: 20th to 22nd February 2020
Website: www.globallogisticsshow.com

ACREX India 2020
Venue: IEML, Greater Noida, Delhi NCR
Date: 27th to 29th February 2020
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