ONSET®

Monitoring HVAC Performance with Data Loggers

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Introduction

Building operators and managers have the difficult job of providing comfortable working conditions and coaxing aging mechanical equipment to operate at peak performance while minimizing energy costs. If the mechanical equipment is old or has inadequate controls, maintaining comfort at a reasonable cost may prove difficult or impossible. Although energy costs typically represent only 1% of a building's operating expense when occupant salaries are included, they are easily managed expenses. Energy cost savings flow directly to the bottom line as increased profits.

In many areas, utility companies and state governments provide incentives for energy efficiency upgrades that reduce operating costs and often improve comfort. Federal tax incentives are also available for commercial building improvements. Identifying opportunities and verifying savings from self-implemented efficiency upgrades remains a challenge for those with limited resources and experience.

Increasingly, building owners are seeking Leadership In Energy And Environmental Design (LEED) designation for their buildings; certification requires meeting specific energy use and indoor environmental quality targets that improve comfort and reduce operating costs, while adding value to the building.

All of these goals have a common theme: one must understand how a building and its systems are operating.

Data loggers provide unbiased evidence of system operations - good and bad. They can help locate the source of comfort problems, diagnose HVAC equipment operation, identify potential energy efficiency upgrades, verify savings, and contribute to achieving LEED certification. This guide provides an introduction to assessing and diagnosing common comfort, environmental quality, and mechanical problems.

Comfort and Indoor Environmental Quality Assessment: People First

People spend most of their lives indoors and expect buildings to provide comfortable conditions under all circumstances. The purpose of an HVAC system is to maintain the space temperature within a set range, control humidity, and provide fresh air.

Comfort

Results of scientific studies quantifying comfort will come as no surprise to anyone charged with operating a building: you cannot please everyone. Even in conditions where most people are comfortable, up to 20% of the population may still be too hot or cold. People vary in their desired comfort range depending on age, gender, activity level, and clothing.

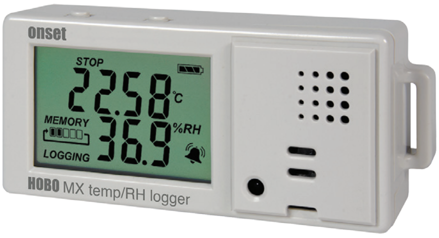
The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) conducted research that led to Standard 55: Thermal Environmental Conditions for Human Occupancy. Standard 55 describes how to assess comfort from specific measurements and predict when most people will be comfortable.

One of the primary factors affecting comfort is occupant dress. Clothing provides insulation; people wearing more clothing are comfortable at cooler temperatures. ASHRAE defines the insulating properties of clothing in units of “clo,” where a man’s suit with jacket has a clo value of 1; a woman’s knee-length skirt, short sleeve top, and sandals has a clo value of 0.5.

Another factor affecting comfort is physical activity. “Met” defines units of metabolic activity; a sedentary office worker expends about 1 met, while someone at the gym may be exerting 3 to 5 mets. Knowing how people are dressed and how active they are is necessary to understanding whether they will be comfortable within a specific temperature and humidity range.

“It’s not the heat, it’s the humidity” is not just a cliché; it’s the truth. Humans rely on evaporative cooling – sweating – to maintain comfort. People feel cooler in dry conditions because of the enhanced evaporation. Excessive humidity is perceived as being uncomfortable, either “clammy” when cool or “sticky” when hot. This is why measuring relative humidity is critical when evaluating space comfort.

ASHRAE Standard 55 describes how to assess comfort from specific measurements and predict when people will be comfortable.



The HOBO MX1101 Bluetooth Low Energy data logger is a standalone logger for high-accuracy temperature and relative humidity monitoring.

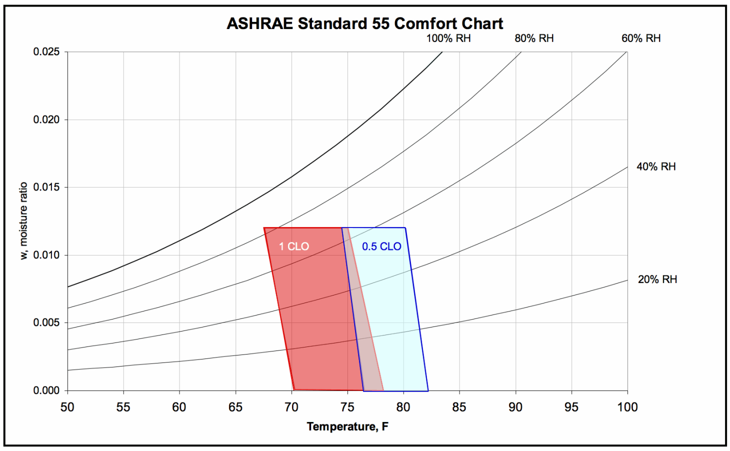
According to Standard 55, temperatures of 71°F to 78°F at very dry conditions should satisfy 80% of a sedentary population wearing 1 clo. This temperature range drops to 68°F to 75°F when the relative humidity is in the 70% to 80% range. For people wearing 0.5 clo, the acceptable temperature range is about 5°F higher.

Onset's HOBO MX1101 Bluetooth Low Energy data logger provides concurrent temperature and relative humidity measurements needed to evaluate whether space conditions will be considered comfortable.

If space conditions – based on temperature and humidity measurements – can be considered comfortable, but complaints persist, it should be investigated whether the temperature and humidity are appropriate for the clothing being worn. People dressed for the outdoors will be uncomfortable in conditions suitable for 1 clo.

Data loggers provide time-based information that can indicate whether a zone is recovering from thermostat setback or setup at the beginning of the day, or experiencing solar gain in the afternoons. If conditions are out-of-bounds for a few hours or only at specific locations, then corrective steps become obvious. Reprogramming thermostats, adding window shading, or balancing airflow are possible solutions.

ASHRAE Standard 55-2004 defines the range of temperature and humidity conditions at which 80% of the occupants will be comfortable, assuming sedentary activity. The red region is the comfort zone for 1 clo; the blue region for 0.5 clo. The zones tilt to the left because people are comfortable at cooler temperatures when the humidity is higher, an effect of evaporative cooling from the skin.



When evaluating a space for comfort, use a data logger that records air temperature and relative humidity in 15-minute intervals and compare the results to the Standard 55 comfort chart. When placing data loggers, consider the following factors:

- At least one data logger should be located in the center of the room or space; additional loggers should be located 3 feet from the largest window and in other areas expected to have high or low temperatures. Usually only one humidity measurement is necessary.
- Windows affect local temperatures. Solar gain causes localized heating; cold outdoor temperatures cause radiant cooling. Measure temperatures near problem areas.
- If the thermostat is not in the center of the room, place a data logger next to the thermostat to ensure that it is working correctly.
- Place an external temperature sensor in the supply air register to measure the delivered air temperature.

ASHRAE Standard 55 defines measurement locations (relative to the floor) when evaluating a space for temperature stratification, another factor that affects the perception of comfort. Warm air rises and most spaces will experience some level of stratification. Small temperature differences between head and foot are acceptable, but a temperature difference of 6ºF between head and foot would be uncomfortable to 40% of the population. Having the thermostat at the correct height and providing sufficient air motion to reduce stratification are important to maintain comfortable conditions.

In addition to its integrated temperature and relative humidity sensors, multi-channel data loggers such as Onset's HOBO U12-013 have provisions for two external probes that can measure temperatures near the floor and the ceiling in order to determine the extent of stratification.

Increasing airflow to the space can significantly reduce stratification. If the air handlers or rooftop unit cannot be adjusted, ceiling fans may be an option. Even a slow-moving ceiling fan can provide enough mixing action to reduce stratification – a strategy especially effective in high-bay areas.

In extreme cases, cooling systems can "dump" cold air on the occupants below – a severe case of reverse stratification. Ceiling-mounted diffusers are designed to move cool air along the ceiling where it mixes with warmer room air. If the supply air is too cold relative to its discharge velocity, the cold air may fall to the floor before mixing fully. Ceiling registers with perforated metal grills may be especially susceptible to this problem because they do not provide adequate velocity along the ceiling. The mathematics behind this phenomenon is quite involved, but it is sufficient to say that if such a condition exists, it will be readily apparent. Deploying a HOBO U12-013 with an external temperature sensor in the diffuser can track the supply air temperature to see if it drops below 55°F.

Increasing airflow to the space can significantly reduce stratification. If the air handlers or rooftop unit cannot be adjusted, ceiling fans may be an option.

The HOBO U12-013 accepts a wide range of energy and environmental sensors.

Systems providing air below 55°F are specifically designed for cold air by using high-velocity and high-mixing-rate diffusers.

Primary Activity	Low Position	Mid Position	High Position
Sedentary / Sitting	4”	24”	43”
Active / Standing	4”	43”	67”

In the thermal image below, cold air at 45°F from a slot diffuser in the upper-right corner flows along the ceiling, but with insufficient velocity to remain on the ceiling (seen as green band). The cold air then falls from the ceiling onto the person below. While data loggers cannot provide this level of detail, they can help identify conditions where local discomfort may be a problem. Average temperature may not tell the whole story.

Photo: Mark Stetz, 1992

It is not easy to generalize at what temperature supply-air dumping may occur, but the colder the supply air, the more likely this is to happen. Systems providing air below 55°F are specifically designed for cold air by using high-velocity and high-mixing-rate diffusers. If the supply air is less than 55°F and dumping is observed, the cause of the low supply temperature will need to be investigated.

Indoor Air Quality

Another factor that affects comfort and the sense of well-being is indoor air quality. Indoor air quality is like art: you recognize it when you experience it, but it’s difficult to define what is “good.” In general, acceptable air quality lacks odors, contaminants, and “stuffiness.” Quantifying air quality as “good” or “needs improvement” is complicated by the fact that we need to measure things that don’t belong, rather than things that do.

Instead of relying on measurements of contaminants, ASHRAE Standard 62.1 recommends specific ventilation rates based on the number of occupants, building size, and activities. Fresh air is introduced into a building to remove odors and waste products emitted by people and building components.

While additional outside air improves indoor air quality, it also increases heating and cooling loads. Maintaining acceptable indoor air quality becomes a balancing act between air quality and energy consumption. HVAC systems are typically designed to provide outside air to meet peak occupancy periods, which means that by design they deliver too much outside air when the building is not fully occupied.

One way to balance outdoor air requirements with energy use is to install demand-controlled ventilation (DCV). DCV systems measure the carbon dioxide content of the building air as an indicator of occupancy and activity levels. As more people occupy a space, carbon dioxide levels increase if the ventilation system does not compensate.

ASHRAE Standard 62.1 calls for outdoor air quantities of 5 to 10 cubic feet per minute (CFM) per person, *plus* an additional 0.06 to 0.18 CFM per square foot of floor area. For many areas, this results in a delivered air rate of approximately 15 CFM per person and a carbon dioxide concentration of 1,000 parts per million (ppm). Based on this result, measured carbon dioxide concentrations of 700 ppm to 1,000 ppm usually indicate acceptable ventilation rates. Carbon dioxide concentrations below 700 ppm indicate significant ventilation rates relative to the number of occupants and suggest that adding demand-controlled ventilation may be an energy-efficiency opportunity. Concentrations above 1,000 ppm indicate poor ventilation effectiveness relative to the occupancy.

An excerpt from ASHRAE 62.1 shows the range of ventilation rates for different building and occupant activities. Note that ventilation rates are not dependent on the number of occupants alone, but on a combination of occupants and floor area. The results are additive; the combined value is the total CFM per person at the default occupant density.

Occupancy Category for non-smoking spaces	CFM / Person	CFM / ft^2	Default Occupant Density, People / 1,000 ft^2	CFM/ Person Combined Value at Default Occupancy Density
Education Classrooms, ages 9+	10	0.12	35	13
Lecture Hall	7.5	0.06	65	8
Restaurant Dining	7.5	0.18	70	10
Office Spaces	5	0.06	5	17
Shipping & Receiving	0	0.12	n/a	n/a
Libraries	5	0.12	10	17
Beauty & Nail Salon	20	0.12	25	25
Retail Sales	7.5	0.12	15	16

The indoor carbon dioxide concentration (C) is a function of the number of people, their activity level, and the amount of fresh air introduced (or building air removed) as follows:

Cbuilding = (Nperson / Vperson) + Coutdoor

Where:
Cbuilding = CO_2 concentration in the space, ppm
Coutdoor = Ambient CO_2 concentration, about 350 ppm
Nperson = Amount of CO_2 emitted by each person, 0.01- 0.04 CFM depending on activity level
Vperson = Amount of fresh air provided to each person, CFM

Rearranging the above equation allows a calculation of the outdoor air quantity being delivered on a per-person basis.

Vperson = Nperson / (Cbuilding - Coutdoor)

The HOBO MX1102 will measure temperature, relative humidity and carbon dioxide concentration as a function of time to help determine if ventilation rates are acceptable. Bear in mind this sensor does not measure all possible contaminants. Beauty salon products, cooking smells, chemical solvents, and cleaning solutions all contribute to poor indoor air quality and are difficult to quantify.

Carbon dioxide concentrations should be measured in high-occupancy spaces, even if occupancy is infrequent. Measuring concentrations in the return air duct averages out the occupancy and ventilation effectiveness in a building and does not indicate which areas may be problematic. Conference rooms, auditoriums and bars and restaurants have highly variable occupant loads. If carbon dioxide concentrations well above 1,000 ppm are noted frequently or for extended periods of time, then ventilation rates and effectiveness need to be examined to determine the cause. Increasing supply air flow rate and adding supplemental exhaust to problem spaces will improve air quality.

The HOBO MX1102 measures and displays CO2, temperature and relative humidity data simultaneously.

HVAC System Diagnostics: Finding Problems and Saving Energy Through Retrocommissioning

Retrocommissioning is recognized as one of the leading energy-efficiency and cost-reduction measures that can be implemented in a commercial building. It is the process of “commissioning” existing building systems to ensure that they are calibrated and functioning as intended; this involves diagnostics and investigation as opposed to purchasing new mechanical equipment. Financial paybacks are often measured in months – not years – and immediate comfort and indoor air quality improvements are typically realized.

Some of the more common problems that retrocommissioning studies uncover include :

- Unscheduled/additional HVAC runtime
- Poor control strategies and programming errors
- Stuck dampers causing excess outside air intake
- Valve leakage leading to uncontrolled supply-air temperatures
- Outright equipment failure

By utilizing data loggers to diagnose these problems, proper operation can be restored and, in many cases, improved relative to the original operating strategy.

Equipment Runtime

One of the easiest checks to make is equipment runtime. Buildings without control systems frequently rely on programmable thermostats or human interaction to turn HVAC systems on and off. Unfortunately, programmable thermostats are frequently improperly programmed and not adjusted for daylight savings time changes. In buildings with automated control systems, controls can be intentionally bypassed so that HVAC systems run continuously.

Time-of-use data loggers such as Onset's HOBO UX90-004 can monitor motor on/off status with no electrical connections required. It detects the presence of magnetic fields that surround operating motors. Placing this logger on a fan motor or compressor will determine when it turns on and off to verify runtime schedules.

Although the HOBO UX90-004 eliminates the need to work with electrical circuits, please exercise caution when working inside air handlers and rooftop units. Fan motors often lack belt guards and/or may be in difficult-to-reach locations. Even if the fan is off, it may start automatically. Always turn the power off before installing this data logger if there are any unshielded moving parts near the fan motor. Once installed, turn the power back on and verify that the loggers green light is blinking when the motor is operating.

HOBO UX90-004 Motor On/Off data logger records motor on/off status.

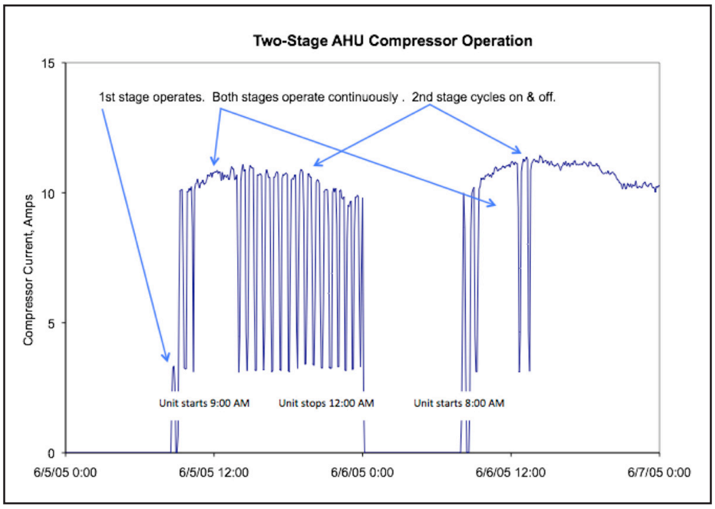
Onset CTV 20-200 Amp split-core AC current sensor

Compressor Short-Cycling

If cooling systems are oversized or the thermostat deadband is too small, compressors may operate for very short periods of time. Excessive starts and stops associated with compressor short-cycling may lead to premature equipment failure. Short-cycles also reduce the ability of the system to remove moisture, leading to poor humidity control. The HOBO UX90-004 data logger can monitor the frequency of starts and stops and runtime duration to detect short-cycling. If short-cycling is observed, try increasing the deadband of the thermostat by increasing the spread between “on” and “off” temperatures. A deadband of 1°F or 2°F may be too small – try 3°F or 4°F. However, too large a deadband may cause comfort problems from greater temperature swings.

Another way to observe rooftop unit operation is to monitor the input electrical current. This can provide information on fan and compressor operation, especially on units that have multiple staged compressors. The CTV series of current transducers used with a multi-channel data logger such as Onset’s HOBO UX120-006M can provide means of current monitoring. If short-cycling is suspected, the logging interval should be set for 1 to 5 minute readings rather than the typical values of 15 to 60 minutes. Measuring input current with a current transducer may require opening an electrical cabinet, but direct connection to the electrical system is not required. Regardless, all safety procedures for working on electrical systems should be followed.

In the figure at the top of the opposite page, the compressor current on a two-stage rooftop unit was monitored. The benefit of having two compressors is better part-load performance. While both stages are operating, the second stage cycles on and off repeatedly, which may shorten equipment lifetime and reduce dehumidification capacity. It also suggests that the second stage is oversized. Some investigation of system sizing, or possibly swapping the lead/lag configuration so that the larger compressor operates in the lead position might be necessary. Increasing the deadband (range of temperatures between on and off) will reduce cycling frequency and improve dehumidification.



Despite the advantages that economizers offer, studies have shown that 60% to 70% of existing economizers do not work at all or only work ineffectively. Failures are typically due to out-of-calibration sensors, failed actuators and/or linkages, and incorrect controller settings.

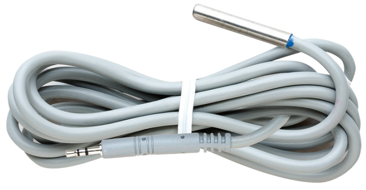
Stuck Dampers and Poorly Functioning Economizers

There are two basic types of economizer controls: temperature-based and enthalpy-based. Temperature-controlled economizers change status based on supply and return air temperatures. Enthalpy-controlled economizers consider both outside air temperature and humidity and are preferred in humid climates. Further distinctions are made in economizer types depending on whether economizing action is based solely on outdoor conditions (fixed action) or the relationship between outdoor and return air conditions (differential action).

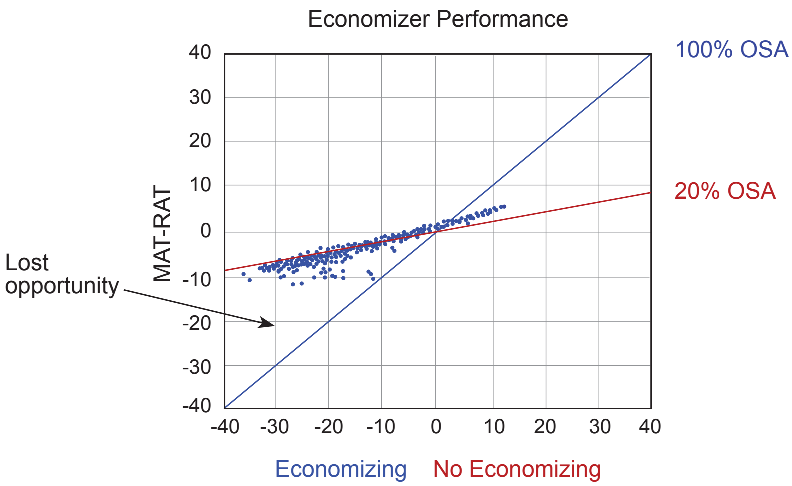
Additionally, economizing action can be integrated with mechanical compressors or non-integrated. Non-integrated economizers switch between economizing action when outside conditions are sufficient to provide 100% of the cooling and switch to mechanical cooling when outside conditions cannot provide 100% cooling capacity. Integrated economizers work by supplementing the mechanical cooling when possible. ASHRAE 90.1 requires the installation of economizers on all new building systems above a particular size based on climate zone. California Title 24 requires integrated economizers on all rooftop units with a greater than 6-ton capacity.

Despite the advantages that economizers offer, studies have shown that 60% to 70% of existing economizers do not work at all or work ineffectively. Failures are typically due to out-of-calibration sensors, failed actuators and/or linkages, and incorrect controller settings.

Evaluating economizer performance requires monitoring temperatures at three points: return air (RAT), outside air (OAT), and mixed air (MAT). Instead of plotting three temperatures as a function of time, plot the mass fraction of outside air as a function of the difference between outside air temperature and return air temperature (OAT - RAT). The outside air fraction (OAF) is calculated as: OAF = (MAT – RAT)/(OAT – RAT).



Onset's external TMC Series temperature sensor



When the economizer is functioning, it should be fully open and using 100% outside air when the outside air temperature is cooler than the return air temperature. This will appear as a line with a slope of 1. When the outside air temperature is warmer than the return air temperature, the economizer will close to the minimum air position of approximately 20%. Deviations from this control strategy indicate problems with temperature or humidity sensors, actuator linkages, leaky dampers, or improper control strategies.

A HOBO U12-013 data logger can be placed in the outdoor air supply to monitor outdoor air temperature and humidity. Adding two external TMC series temperature sensors (as pictured above) in the return air and mixed air stream completes the data collection system.

Where enthalpy-controlled economizers are used, three HOBO MX1101 temperature and humidity data loggers are needed. Converting temperature and relative humidity measurements will require third-party software add-ins for Excel such as ¡Get Psyched! from KW Engineering or PsyFunc from Linric.

With three enthalpy measurements available, the previous outside air fraction equation can be adapted by substituting enthalpy (H) in place of temperature:

OAF = (MAH - RAH) / (OAH – RAH)

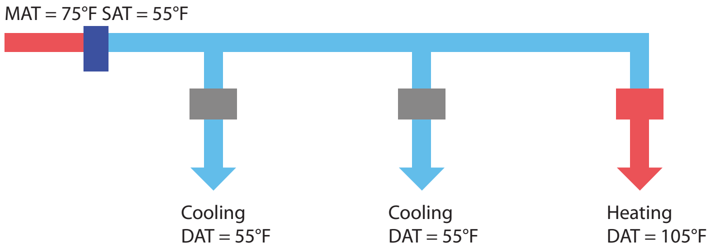
This approach may be necessary in humid climates where outdoor air temperatures may be close to the return air temperature but have a higher enthalpy. Economizing with cool, moist air may not provide much benefit and may in fact increase the mechanical cooling load if an integrated economizer is used.

Data loggers can provide an independent assessment of actual economizer performance, regardless of installed type or intended control strategy.

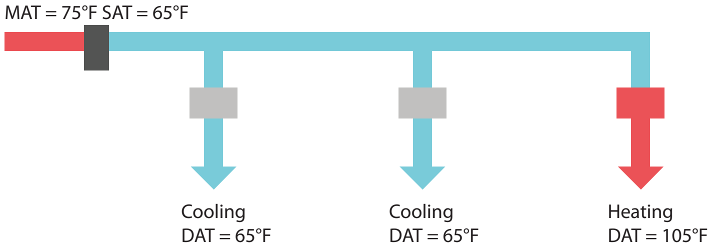
Supply Air Temperature Not Optimized

One of the greatest opportunities for efficiency improvement is optimizing the supply air temperature. Many variable-air volume systems have terminal boxes in perimeter zones that provide heat when needed. Using a single air supply reduces equipment cost but raises operating cost because cool air will need to be reheated. In addition to the extra energy required to heat the air, there is the potential for overcooling a space when the heating system is disabled or a zone has no reheat system.

In the figure below, the mixed air temperature (return + outside air) is cooled to 55°F at the cooling coil. The supply air at 55°F is heated to 105°F before being discharged into the space. Variable air volume (VAV) boxes throttle the airflow to meet the local cooling load, but cannot close completely in order to maintain fresh air delivery. If the heat load in a space is minimal, the discharge air temperature of 55°F may be too low and lead to overcooling.



Raising the supply air temperature to 65°F (for example) reduces the amount of heating energy required at the last zone. In addition, the remaining zones are less likely to be overcooled because the discharge air temperature is higher.



Historically, cooling systems without supply air temperature reset are designed and configured to deliver 55°F air without considering whether this temperature provides optimum performance or comfort. Further, building operators often respond to hot complaints by reducing supply air temperature (where possible) to satisfy one or two zones, but fail to realize the detrimental effect this may have on the balance of the system and occupants.

In addition to the increased heating energy use and discomfort that incorrect supply air temperature can cause, low discharge air temperature may indicate problems elsewhere in the system.

Supply air temperature reset is often implemented in buildings with sophisticated building automation systems, but it is available as an option on many air handlers that serve smaller buildings. Supply air temperature reset can be implemented based on VAV fan speed or outdoor temperature. By concurrently monitoring system supply air temperature (at the air handler), delivered air temperature (at each VAV box or register), space temperature, and outside air temperature, correlations between space temperature and supply air temperature can be identified. Spaces that are often too cold indicate that supply temperature reset would be a good comfort and energy-efficiency opportunity.

In addition to the increased heating energy use and discomfort that incorrect supply air temperature can cause, low discharge air temperature may indicate problems elsewhere in the system. Direct-expansion (DX) cooling systems found in most rooftop units are designed to provide air at 55°F. If the supply temperature is below 55°F, this may indicate restricted airflow or low refrigerant. Many factors can cause insufficient airflow – poor duct design (ducts too small), airflow obstructions within the ducts, clogged filters, or stuck dampers. The entire air supply and return system should be examined to determine the cause of inadequate airflow, beginning with filters and dampers.

If the system has lost refrigerant, the evaporator may function below its intended operating temperature. This can lead to coil icing, which will reduce airflow and further exacerbate the problem and reduce cooling capacity. As more refrigerant is lost, the system will eventually cease to function. If ice is observed on the coils, a technician should identify and repair refrigerant leaks.

For air handlers with chilled water coils, the chilled water control valves may not close all the way or the valve actuator may be broken. This can also lead to lower than intended supply air temperatures.

Types of Data Loggers

With portable data loggers, no one size fits all and there are a range of different types of data logging devices available, including stand-alone data loggers, web-based data logging systems, and wireless sensor networks.

Standalone Data Loggers

Stand-alone data loggers are compact and easy to set up and deploy. You have a choice of low-cost, standa-lone loggers with internal sensors for measurements at the logger location, or multi-channel loggers with external sensors for monitoring at some distance from the logger. All standalone loggers communicate with a PC or Mac via USB.

Web-based Data Logger Systems

Web-based systems enable real-time, remote access to your data via cellular, Wi-Fi, or Ethernet communications. They can be configured with any combination of external smart sensors, and have been designed with an industrial-grade, tamper-proof enclosure. This enables them to be used in indoor HVAC monitoring projects, as well as outdoor projects such as rooftop HVAC system monitoring.

Wireless Sensor Networks

Wireless data nodes are ideal for centralized, on-site monitoring of building performance. By combining data logger and transmitter in one, data nodes transmit high-accuracy, real-time data from dozens of points to a central PC or Mac. This eliminates the need to manually retrieve and offload individual data loggers, saving time and money. Should an obstruction block the wireless flow of data, these MESH networking devices automatically reroute the path to the receiver – all without manual intervention.

Accuracy specifications vary widely among different data loggers, so when shopping around be sure to look for accuracy charts that indicate accuracy over an entire measurement range – not just a single value.

Choosing Data Loggers

Data loggers, of course, are not all the same and with so many choices available today, it can be challenging to know which one is right for your application. Following are some important factors to consider when evaluating data loggers.

Measurement Accuracy

Once you know what parameters you'll be measuring, you need to make sure to choose a data logger that provides the accuracy you need. Accuracy specifications vary widely among different data loggers, so when shopping around be sure to look for accuracy charts that indicate accuracy over an entire measurement range – not just a single value. As a general rule, it's good to look for a data logger that will provide at least twice the accuracy of what your application requires.

Another important factor is data logger resolution, which refers to the number of increments of a value a data logger is capable of reporting. This is important if you plan to deploy a logger for months at a time, or want the logger to record data in 10-second intervals. You should also ask about a logger's response time.

If you're unsure about your application's accuracy and resolution requirements, an experienced supplier should be able to help you determine which product will meet your needs.

Software and Ease of Configuration

All data loggers use software for setup and configuration, but some loggers require more customization than others. User-friendly loggers can be set up and launched by someone with no training in electrical wiring or programming.

Depending on the type of data logger, the user can connect to a PC or mobile device via a USB connection, cellular, Wi-Fi, Ethernet or Bluetooth Low Energy (BLE) technology. The accompanying logger software automatically recognizes the device and asks a series of configuration questions. The user simply chooses a sampling interval and selects an immediate or designated future launch time. There is no wiring or programming involved, even for multi-component weather stations.

Ask about the software that comes with the data logger. Applications are generally Windows and MAC-based, and highly intuitive so the learning curve is minimal. The software should enable you to quickly and easily perform tasks such as setting configuration parameters, designating launch times, and offloading data with point-and-click simplicity. For BLE-enabled monitoring, configuring the loggers and managing data simply requires downloading a free app to your mobile device.

Check the software's graphing and analysis capabilities, including whether you can combine graphs to compare data between sites, or if you can view all of a site's data clearly in a single graph. Depending on the scope and type of data, the manufacturer may also have special application-specific software available.

There are a number of other capabilities to look for. For example, the software should allow you to select a range of data in a graph, and display the maximum, minimum, average, and standard deviation for the measurements in that range. It should also allow you to save data analysis projects for future use.

Finally, since data often need to be passed into other software programs such as spreadsheets or modeling programs, make sure that the logger software allows you to quickly and easily export data. Also be sure that you can print graphs and tables, which is especially important for documentation purposes.

Battery Life

Data loggers are generally extremely low-power devices. However, because they are used in a variety of environmental conditions and sample at different rates, battery life can vary widely. As a general rule of thumb, make sure the data logger you select has a battery life of at least one year.

Most logger manufacturers' software will indicate when the logger's battery power is getting low. You may also want to ask your supplier about whether or not the data logger battery is user-replaceable, as this can eliminate the time and expense of having to ship the logger back to the manufacturer for battery replacement.

Memory

The storage capacity of a data logger can vary widely between models. In general, be sure to buy a logger that provides enough on-board memory to cover the sampling rate and deployment duration you need. If you are unsure of how often you will be able to offload and relaunch your deployed data loggers, it may be best to buy a logger with more memory to prevent any gaps in data.

Cost of Ownership

Today's battery-powered data logging devices are very reasonably priced, and can be a real value if you plan to use them over and over again in multiple applications. It is, however, important to look closely at the total cost of ownership when shopping around. Will the logger need to be periodically calibrated by the manufacturer, and if so, how much will it cost over time? How much does the software cost? How much will you have to spend on cables and structural components for a weather station? Asking these questions will help you understand the true cost of owning the data logger over the long term.

Product Support

Data loggers should be easy to use and not require a great deal of technical assistance. However, as with any high-tech product, there will always be questions.

Seek out a supplier offering a range of product support services. These often start with the initial assessment of your application requirements, and should include telephone and internet-based support resources.

Does a potential supplier have the track record and financial stability to maintain its role as a long-term solutions provider? Be assured that the company will be there to meet your future data logging requirements. Finally, ask the supplier for application notes and other references to gain a sense for how its loggers perform in applications similar to yours.

Resources

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers publishes guidelines and standards that define how comfort and indoor air quality should be assessed.

ASHRAE Standard 55-2004: Thermal Environmental Conditions for Human Occupancy

ASHRAE Standard 62.1-2010: Ventilation for Acceptable Indoor Air Quality

Indoor Air Quality Guide, The: Best Practices for Design, Construction and Commissioning - Summary and Detailed

ASHRAE
1791 Tullie Circle, N.E.
Atlanta, GA 30329
Phone: (404) 636-8400
Web: www.ashrae.org

Microsoft Excel is commonly used to evaluate logger data. Psychrometric functions to calculate wet bulb temperature and enthalpy from dry bulb temperature and relative humidity can be added into Excel using third-party add-in software.

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Other informational resources available from Onset:

Analyzing Air Handling Unit Efficiency with Data Loggers

Operating a heating, ventilation and air conditioning (HVAC) system at optimum efficiency in a commercial setting is complicated, to say the least. There is a very real chance that any number of setpoints, levels, and feedbacks at boilers, chillers, pumps, fans, air delivery components and more can cause costly inefficiencies.

Finding Hidden Energy Waste with Data Loggers: 8 Cost-Saving Opportunities

The first step to reducing building energy costs is identifying energy waste. Statistics on utility bills or name plates on equipment, while useful, are not enough to identify what practices and equipment are contributing to high energy use. Portable data loggers can be used to obtain critical energy use information in a wide range of commercial building types – from manufacturing plants to office buildings.

Monitoring HVAC Performance with Data Loggers

Building operators and managers have the difficult job of providing comfortable working conditions and coaxing aging mechanical equipment to operate at peak performance while minimizing energy costs. If the mechanical equipment is old or has inadequate controls, maintaining comfort at a reasonable cost may prove difficult or impossible. Although energy costs typically represent only 1% of a building's operating expense when occupant salaries are included, they are easily managed expenses. Energy cost savings flow directly to the bottom line as increased profits.

The Energy Professional's Guide to Data Loggers & Building Performance

This 30-page guide, developed in conjunction with Stetz Consulting LLC, details how portable data loggers can be applied in a number of building monitoring applications, such as HVAC systems monitoring, commissioning, Measurement & Verification, and load profiling. The guide offers practical tips and techniques on a range of topics, including data logger installation, monitoring plan development, safety, and data interpretation.

Monitoring Geothermal Heat Pump Performance

This paper discusses how portable data logging technology can be used to measure, record, and document the performance of geothermal heat pumps, and provides specific case study examples of how the technology is being applied in geothermal system monitoring applications.

Optimizing Solar Thermal Performance with Data loggers

This paper discusses how solar thermal systems, with the help of portable data loggers, can be optimized to deliver the financial benefits residential and commercial users hope to achieve through their investments. The paper shows installers and engineers how portable data logging devices can be used to measure performance of solar thermal systems, pinpoint any defects or inefficiencies, and optimize performance for greater return on investment.

Measurement & Verification: Tapping into ARRA Stimulus Funds

This paper provides guidance on identifying potential sources of ARRA stimulus funding for energy performance monitoring projects. It details new programs from the ARRA, explains the growing importance of Measurement Verification (M&V) services, and discusses specific ways ESCOs can apply portable data logging technology to document building energy savings.

Using Data Loggers to Meet LEED® Existing Building Certification Credits

This paper provides information about how data loggers can make it simple to satisfy many LEED Existing Buildings Operations & Maintenance credits. It discusses how the devices can help with the certification process and documenting performance improvements for submission to the U.S. Green Building Council.

Air Compressor Energy Savings: Finding the Low-Hanging Fruit

This paper discusses different ways to measure compressed air system performance and identify savings opportunities. It provides insight into how portable data loggers can be used to monitor compressor power, and references various compressed air upgrade funding programs throughout the United States.

Data Logger Essentials for Building Commissioning

This paper provides building owners, building commissioners, performance contractors, HVAC engineers, and others with valuable tips and advice on effectively using data loggers to analyze building performance.

Evaluating and Applying Data Loggers for Pharmaceutical Monitoring

This paper provides quality assurance managers, regulatory compliance specialists, engineers, and others with valuable tips on evaluating data loggers for pharmaceutical monitoring. It discusses how portable data loggers can be used in a broad range of projects, from analyzing temperatures in an incubation chamber to monitoring packaging and shipping conditions.

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About Onset

Onset is a leading supplier of data logger and monitoring solutions used to measure, record and manage data for improving the environment and preserving the quality of temperature-sensitive products. Based on Cape Cod, Massachusetts, Onset has been designing and manufacturing its products on site since the company's founding in 1981.

Visit Onset on the web at www.onsetcomp.com.

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About the author: Mark Stetz, P.E., CMVP, is principal and owner of Stetz Consulting LLC. His company provides energy-efficiency consulting services, energy audits, measurement & verification, economic analysis, and training. With over 15 years in the energy efficiency field, he has contributed to the IPMVP and FEMP measurement & verification protocols, supported the DOE FEMP performance contracting program, and conducted training workshops worldwide. Additionally, Stetz Consulting is a USGBC Education Provider and EPA Energy Star service provider. Mr. Stetz is a member of AEE, ASHRAE, and the USGBC, and holds registered professional engineer licenses in Colorado and California. For more information, see www.stetzconsulting.com

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