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HOBO® Data Loggers


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Using Data Loggers to Improve Chilled Water Plant Efficiency

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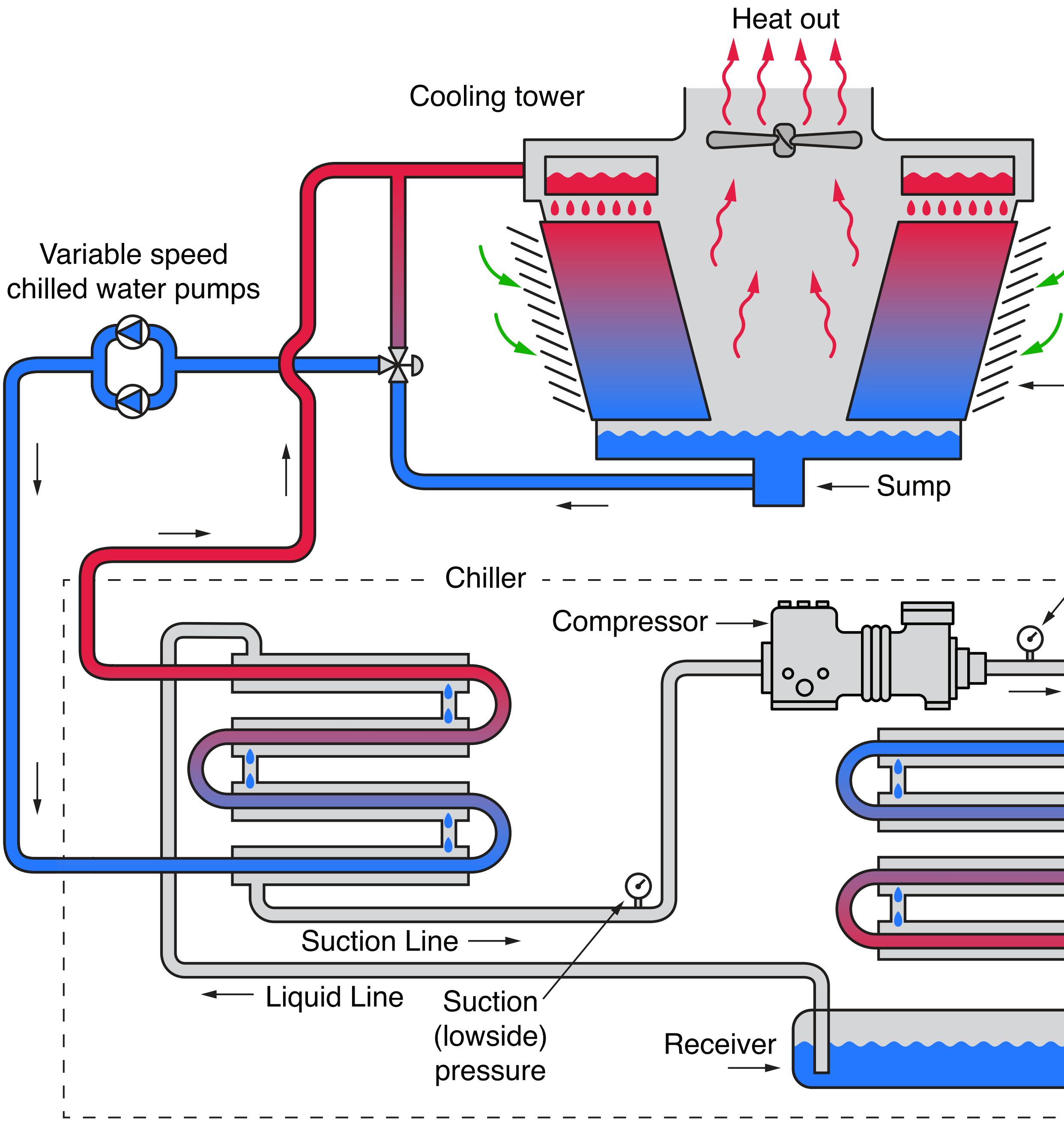
Introduction

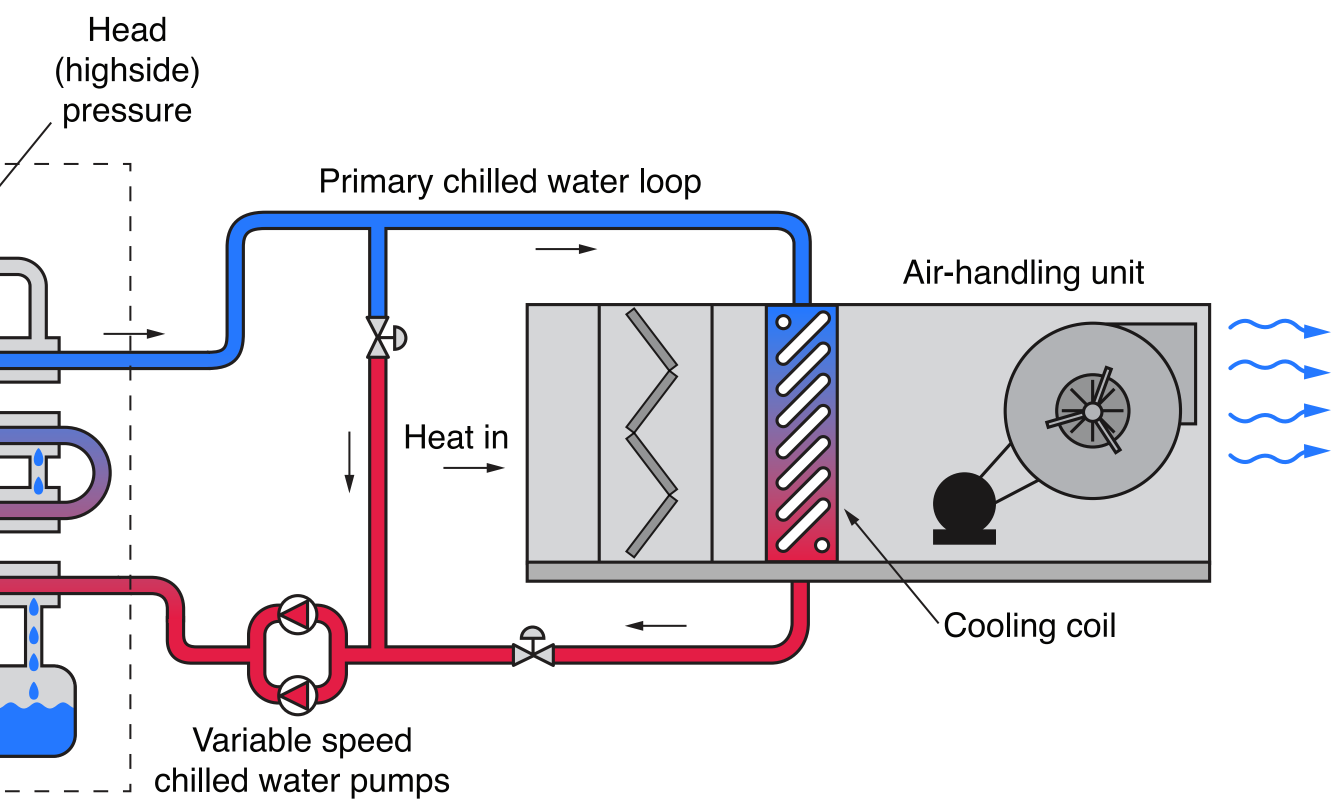
Chilled water plant efficiency refers to the total electrical energy it takes to produce and distribute a ton (12,000 BTU) of cooling. System design, water quality, maintenance routines, cooling tower design, and cooling coil load all affect chiller water plant efficiency and the expense of operating the system.

The focus of this guide is on using data to evaluate the potential positive impacts of controlling chilled water coil differential temperature (ΔT) on overall chilled water plant efficiency.



Chilled water system basics

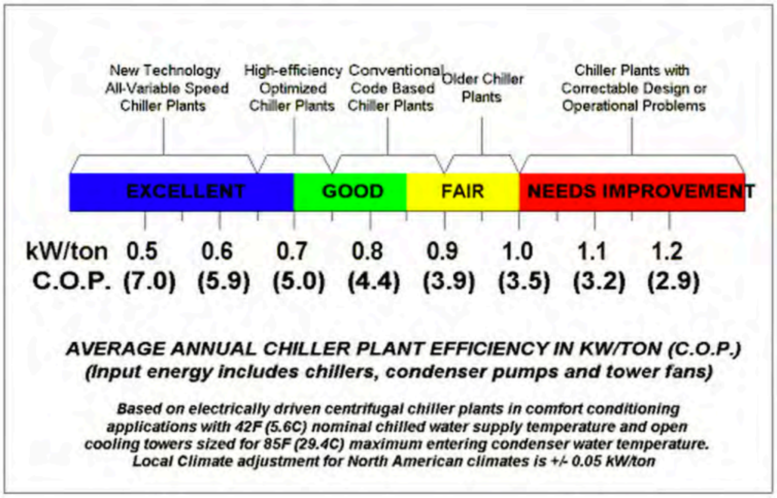
Chilled water pumps circulate chilled water from the chiller to air-handler cooling coils in order to transfer heat from the air stream to water. This water then returns to the evaporator side of the chiller where the heat is passed from the water to a liquid refrigerant. The refrigerant leaves the evaporator as a cold vapor and enters the compressor where it is compressed into a hot vapor. Upon leaving the compressor, the vapor enters the condenser side of the chiller where heat is transferred from the refrigerant to the water side of the condenser where it is circulated to a cooling tower for the last stage of heat rejection via evaporation in the cooling tower.



An important but often overlooked metric of chilled water plant performance is chilled water differential temperature or Delta T, often shown as ΔT.

Using effective metrics to interpret system efficiency

In many cases, chilled water plants are operated entirely to maintain comfort, and effective metrics to assess performance are not deployed. This is despite the fact that the data is often available through the Building Management System, through the use of temporary data loggers, or both. The most common metric of overall system performance is kilowatts per ton of cooling or kW/ton. This would include the power demand of all system components including the chiller(s), chilled water pumps, condenser water pumps, cooling tower fans, sump heaters, filter pumps, etc. Below is a chart showing a comparative range of plant performances.



An important but often overlooked metric of chilled water plant performance is chilled water differential temperature or Delta T, often shown as ΔT. Chilled water plants operate more efficiently when there is a higher differential temperature across the chilled water coils and the system. Coils are often design for 10°, 12°, and sometimes as high as 15°F ΔT.

Negative effects of low differential temperature

When the Delta T in the chilled water system is lower than design, circulating pump energy expense increases and an increase in chiller energy expense can occur. Low system ΔT can also actually lead to the inability to meet the cooling demand. There can be several reasons for low ΔT in chilled water systems and a good place to focus attention is on the chilled water coils which are the loads that drive the system.

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Very often, three-way control valves are found on chilled water coils. When a three-way valve is modulated to anything less than 100% coil position, chilled water supply is bypassing straight to the return and lowering system ΔT.

Over-sized cooling coil control valves are sometimes a problem in chilled water systems. Control valves are manufactured in a range of sizes and flow coefficients. Frequently the desired flow coefficient falls in between valve offerings from the manufacturers. When this is the case, multiple valves can be combined to achieve the desired range ability; however designers often choose a valve that is a little on the larger side "just to be safe," resulting in an oversized control valve with poor control. When valves are oversized, a small amount of valve opening produces a large amount of flow and reduces ΔT across the coil and returns water that is too cold to the system.

Cooling coil selection is another problem that can go unnoticed. Cooling coils should be sized for the same or greater ΔT as the overall plant design ΔT but sometimes are not.

Analyzing chilled water load performance

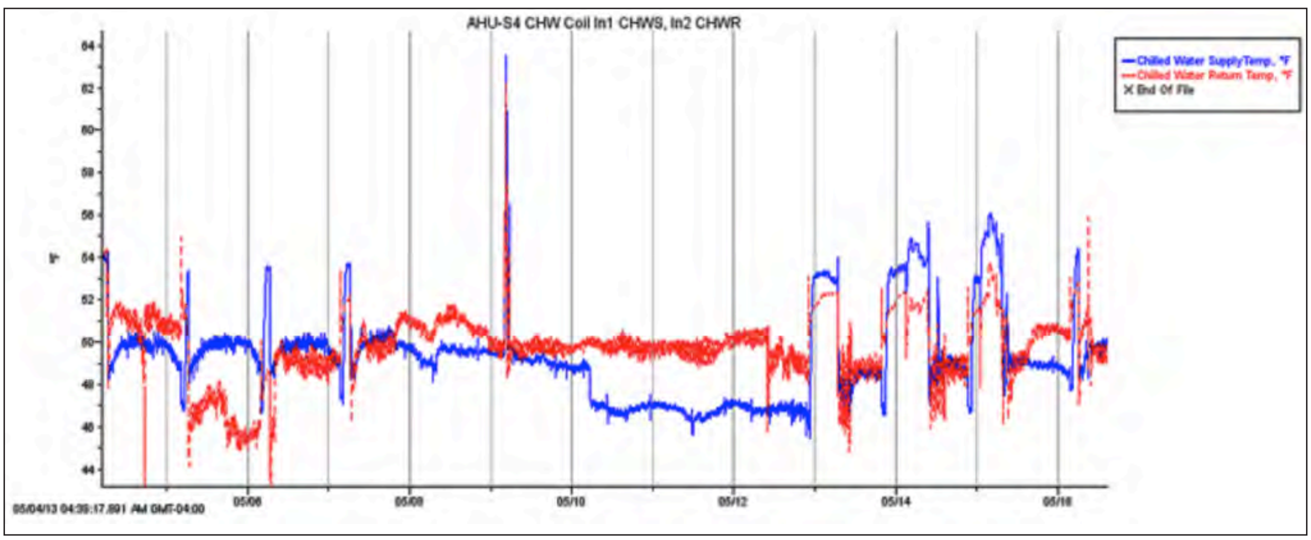
The best way to determine chiller plant and chilled water coil ΔT is to gather and analyze data. This data is often available at the plant level, but is frequently not available at the individual coil level. A great way to collect this missing data is by the use of temporarily deployable data loggers such as Onset HOBO® data loggers. The case study on pages 5-6 describes a real-world deployment and analysis of collected data.

HOBO U12 four-channel data logger

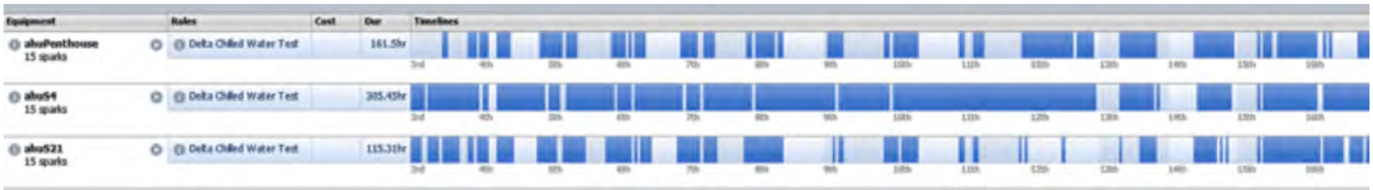
Case study

Control Technologies performed a study of three air handling unit cooling coils to determine the opportunity to produce energy savings by improving the ΔT across the cooling coils. Data was collected using a combination of data from the Building Automation System (BAS) and HOBO U12 four-channel data loggers with TMC20-HD remote temperature sensors with 20-foot cables attached. Sensors were placed on the supply and return sides of the coils and set to collect samples at one-minute intervals for a period of 15 days. On one AHU, there were temperature sensor wells available for use and the sensors were placed in these wells. On the other two AHUs, no wells were available, so the sensors were strapped to the chilled water supply and return copper headers and insulated to get the best reading possible. Data was gathered from the BAS on the supply air temperature, supply air setpoint, and control valve position, also on a one-minute basis.

Once collected, the data can be analyzed using a number of software tools. The easiest and quickest way is to use HOBOware® graphing and analysis software, which is designed for use with the data loggers. Once offloaded, the data can be plotted as shown below.

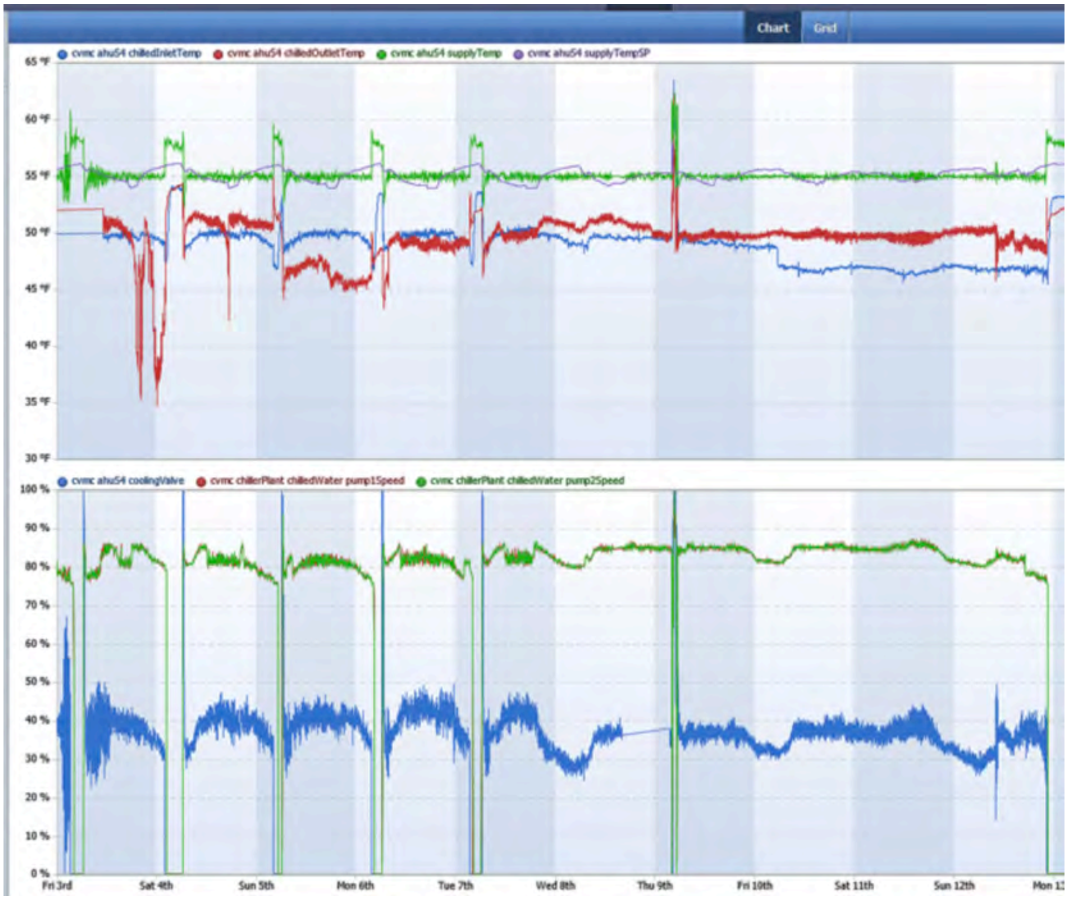


From the chart, it can be seen that throughout the period, the ΔT never approached a typical design condition. This is an indication that more water is being pumped through the chilled water coil than is necessary or beneficial.



The results of the study indicate that during the approximately 15-day period, hundreds of hours existed where the supply air setpoint was satisfied but the ΔT was lower than design. This means more pumping energy was used than needed and that the chilled water plant ΔT was lower than optimal, which in turn meant that chilled water plant efficiency could be improved in this situation.

The following chart combines the HOBO and BAS data and creates a visual representation of all of the variables, including pump speed.



Energy saving potential of managing load-side differential temperature

Improving the ΔT across the cooling coils helps to save energy. If data logging shows that the opportunity exists, this can be accomplished by the addition of chilled water supply and return temperature sensors, and implementing a limiting control loop in the BAS. The loop works by monitoring the coil ΔT and limiting the signal to the cooling control valve to maintain the ΔT setpoint. When the flow is reduced through the coils to maintain the appropriate design ΔT, the differential pressure sensor in the system sees the increased Delta P and slows the pump to maintain its pressure setpoint, thereby reducing the amount of electricity consumed by the pumps. As the overall chilled water system ΔT increases, the chiller efficiency will also increase, saving additional energy and reducing the cost of operating the chiller.

Implementing a solution

Improving chilled water coil ΔT can be done by implementing a second proportional-integral-derivative (PID) loop that gets its sensor data from sensors installed on the chilled water supply and return lines of the individual coil. The supply air sensor and control loop remain the primary control; however, if the coil ΔT drops to a point where it is not beneficial, this second control loop serves to limit the chilled water coil control valve position to keep the coil ΔT at or above the coil's design criteria.

Conclusions & summary

Chilled water system performance and chilled water coil differential temperature is often overlooked in plant operations. By measuring and monitoring chilled water coil ΔT, flow rates can be reduced while still maintaining the discharge air temperature needed to satisfy the cooling and dehumidification demands in the space. Improving ΔT performance at the loads also has the effect of improving overall chilled water system ΔT, which helps to improve chiller efficiency. Using portable data loggers to gather data either for stand-alone use or to marry up with building automation systems helps assess the opportunity for saving energy. Once the data is gathered and analyzed, a strategy to improve chilled water coil ΔT can be implemented if required.

Other informational resources available from Onset:

Facility Manager's Guide to Data Logging

The energy required to operate buildings in the United States is the largest sector of our energy use and represents about 40% of U.S. energy demand. Measuring building performance can help facility staff better manage this energy use. The focus of this best practices guide is on monitoring strategies and techniques that can be utilized by building professionals looking to reduce energy use and optimize performance of their facilities.

Data Logger Basics

In today's data-driven world of satellite uplinks, wireless networks, and the Internet, it is common to hear the terms "data logging" and "data loggers" and not really have a firm grasp of what they are.

Most people have a vague idea that data logging involves electronically collecting information about the status of something in the environment, such as temperature, relative humidity, or energy use. They're right, but that's just a small view of what data logging is.

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.

Addressing Comfort Complaints with Data Loggers

This paper provides facility managers, HVAC contractors, and others with valuable tips on how low-cost data loggers can be used to validate temperature-related comfort complaints.

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.

Monitoring Green Roof Performance with Weather Stations

Data logging weather stations are the ideal tools for documenting green roof performance. A weather station can measure weather parameters such as rainfall, stormwater runoff, temperature, relative humidity, wind speed, solar radiation, and a host of non-weather parameters such as soil moisture on a continuous basis (say every five minutes, hourly, or an interval appropriate to the situation). For the purpose of this discussion, "weather station" may refer to a data logger that measures and stores data from weather sensors. The information a weather station collects can help you make wise choices about designing, tuning, and maintaining a green roof.

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.

Access our full resources library at: www.onsetcomp.com/learning

About Onset

Onset is a leading supplier of data loggers. Our HOBO data logger products are used around the world in a broad range of monitoring applications, from verifying the performance of green buildings and renewable energy systems to agricultural and coastal research.

Based on Cape Cod, Massachusetts, Onset has sold more than 2 million data loggers since the company's founding in 1981.

Contact Us

Our goal is to make your data logging project a success. Our product application specialists are available to discuss your needs and recommend the right solution for your project.

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