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STANDARDS

Energy Management Subcommittee

SCTE STANDARD

SCTE 253 2019

Cable Technical Facility Climate Optimization, Operational Practice: Understanding Set Point Values, Part 1

NOTICE

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1. Introduction

1.1. Executive Summary

This operational practice is intended to educate individuals working in broadband communications critical facilities on what cooling system set points are and how adjusting set points can impact cooling system operational efficiency. The objective is to provide engineers, technicians and contractors a basic understanding of those impacts so set point adjustments will not be done casually but instead be part of the overall goals to optimize the efficiency of the cooling and heating systems without risk of creating conditions which could cause information and communication technology (ICT) equipment to fail. There are significant implications with respect to the operational efficiency of the facility that can result from changing cooling system set points for the wrong reasons.

A better understanding of cooling system set points will enable people working in critical facilities to avoid actions that may prove detrimental to the facility operation.

1.2. Scope

This document covers the operation of cooling systems and the proper selection of cooling set points for critical facilities in broadband communications systems. The facilities covered are defined as cable operator classes B, C, and D (commonly referred to as hubs and headends) in SCTE 226.

This document provides an explanation of cooling system set points to ensure personnel working in critical facilities understand their operation and how changes in set point settings can result in a positive or negative impact on the ICT equipment. It takes a generic approach and does not explain the detailed operation of cooling systems nor does it delve into the array of cooling system controls as these vary considerably across the different types of cooling systems.

1.3. Benefits

Nearly 30% of the energy demand of the critical facilities included in the scope of this document supports the cooling equipment that provides stable room environment temperatures for the technology in racks to operate. A proper understanding of the impact of temperature set points on equipment efficiency, performance and reliability can be used to optimize energy demand and equipment longevity. Today, many critical facilities are overcooled and/or have multiple cooling with conflicting set points. By following the recommendations in this operational practice, operators should see lower cooling operating expenses, less wear and tear on critical cooling units, and increased reliability of the ICT equipment.

1.4. Intended Audience

Critical facility managers and supervisors along with employees responsible for sites containing critical cooling units would benefit from becoming familiar with this operational practice.

1.5. Areas for Further Investigation or to be Added in Future Versions

Future sections of this document may address more technical details of cooling system operation. Additionally, energy management approaches as they relate to set point values could be added.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

- No normative references are applicable.

2.2. Standards from Other Organizations

- No normative references are applicable.

2.3. Published Materials

- No informative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

- SCTE 184 2015 SCTE Energy Management Operational Practices for Cable Facilities
- SCTE 226 2015 Cable Facility Classification Definitions and Requirements

3.2. Standards from Other Organizations

- No informative references are applicable.

3.3. Published Materials

- ASHRAE TC9.9 2015 Data Center Power Equipment Thermal Guidelines and Best Practices

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
should not	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

ASHRAE	American Society of Heating, Refrigeration and Air conditioning Engineers
BTU	British thermal unit
DP	dew point
ICT	Information and Communications Technology
LCL	lower control limit
LCL_C	lower control limit – cooling
LCL_H	lower control limit – heating
RH	relative humidity
ISBE	International Society of Broadband Experts
SCTE	Society of Cable Telecommunications Engineers
UCL	upper control limit
UCL_C	upper control limit – cooling
UCL_H	upper control limit – heating

5.2. Definitions

dead band	The range of values within which a sensed variable can vary without initiating a change in the controlled process. In the case of cooling, dead band allows the temperature of the space to vary within the predetermined limits before the cooling system responds, thereby reducing the cycling. An appropriate dead band range in relation to the set point prevents unnecessary cycling of the compressor or chilled

	water valve. A dead band is applicable to both temperature and humidity controls. (See Figure 1)
dew point	The temperature at which air reaches water vapor saturation. Dewpoint is constant for a specific amount of water in a specific amount of air while relative humidity (RH) varies with temperature.
equipment inlet air	The air entering the rack mounted ICT equipment.
equipment exhaust air	The air exiting the rack mounted ICT equipment.
relative humidity set point	The RH value that controls the operation of the cooling system.
return air	The air returning to the cooling system.
sensitivity setting	Larger cooling systems can use a combination of dead band and sensitivity setting. In these systems the sensitivity functions the same as the lower and upper control limits.
set point	The desired or target value for an essential variable or process value of a control system. In a critical facility the set point is the desired value (temperature (°F [°C]) or RH percent (RH%) against which the variable that is being controlled is compared.
set point condition	The condition whereby the set point sensor reading is between the upper control limit (UCL) and the lower control limit (LCL).
set point sensors	Set point sensors can be located at or on the cooling system or can be remote, such as on the rack or other locations. If the sensors are on the cooling unit the set point value generally measures the return air stream to the cooling system. For example, a set point of 72 °F (22 °C) means the cooling system is operating to keep the return air at this level. To achieve this, the supply air temperature in most cases is much lower. If the sensors are located on the racks or elsewhere, the cooling system may be controlled based on the value of a specific sensor input or the system can be managed by aggregating multiple sensors. In larger facilities there can be multiple set point sensors creating different control zones, with each unique zone being affected by one or more cooling units.
short cycling	The excessive frequency of starting and stopping of a cooling system.
single stage (fixed capacity) cooling system	These systems are either on and running at 100% capacity or off completely. Also known as fixed-capacity systems, these units run on high speed even if only a small amount of heating or cooling is needed. Generally, this type of system is typical of smaller units or wall packs used in small enclosures with limited heat generated from the ICT equipment.
supply air	The air being supplied by the cooling system.
temperature set point	The temperature value, °F or °C, that controls the operation of the cooling system. See also “set point.”
variable capacity cooling system	Variable-capacity cooling systems can be simple two stage capacity systems based on two separate compressors or a single two stage compressor. Variable capacity systems can also be more complex such as digitally controlled systems that have many discrete steps in capacity. Cooling systems with greater options for responding to the heat being generated in the facility typically cool the facility more efficiently.

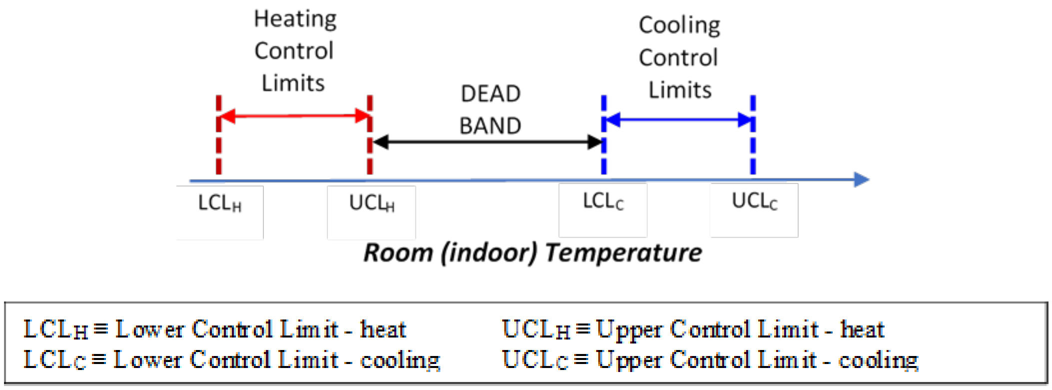

Figure 1 - Dead Band Configuration

6. Set Points and Cooling System Operation

6.1. Set Point Operation

Temperature and RH set points guide the behavior of the cooling system but do not directly specify the condition of the supply air. Set points represent the control limits governing the climate conditions of the room wherever the set point sensors are located. Set point sensors can be located on the cooling unit itself or the sensors can be located on the racks or inside a cold aisle containment area.

A temperature set point of 72 °F (22 °C) requires supply air to be considerably cooler to combat the much warmer air created by the heat of the ICT equipment.

Example

set point = 72 °F (22 °C)   UCLc = "set point +2" = 74 °F   LCLc = "set point -2" = 70 °F

Once the air temperature at the set point sensor reaches the UCLc then the cooling system will activate to remove warmer air from the space and replace that warmer air with cooler air from the cooling unit. This will eventually impact the set point temperature sensor which should result in a steadily declining sensor temperature. Once that temperature sensor reaches the lower control limit the cooling system will respond by reducing the amount of cooling being provided. In a single stage system this is achieved by the cooling system shutting off. (Note that the air circulation fans generally keep running.)

A variable capacity system will modulate its cooling capacity to keep the set point sensor between the LCLc and the UCLc. In addition, the fan speed may decrease to lower the air volume being provided when less cooling is needed.

6.2. Set Point Design Range

No industry standard for temperature or humidity set points exists for headend facilities. ASHRAE has issued guidelines for data centers conditions which are generally applicable to MSO critical facilities. The most recent being the ASHRAE TC9.9 2015 Data Center Power Equipment Thermal Guidelines and Best Practices. It is important to note that the conditions noted in the ASHRAE guidelines are for equipment inlet temperature and humidity measured at close proximity, within 4", of the equipment inlets and not the room ambient temperature.

Air flow conditions within critical facilities vary from site to site, affecting the level of cooling needed to meet the needs of the site. As a result, design conditions should be established for each site ensuring that ICT equipment is not impacted by too high inlet temperatures. In facilities with good air flow management the cooling system set points should be set at a higher limit than a site with poor air flow management conditions. The primary objective is to find the highest set point for cooling system operation without negatively impacting the ICT equipment performance.

The recommended equipment inlet conditions that should be followed include:

- Equipment Inlet Air Temperature Range: 64.4 °F to 80.6 °F (18 °C to 27 °C)
- Equipment Inlet Air RH Range: 20% to 60% RH, non-condensing
- Dew Point (DP): 15.8 °F (-9 °C) to 59 °F (15 °C) DP

6.3. Factors Affecting Supply Air Temperature

The temperature of the supply air from the cooling system is dependent on a number of variables including the type of cooling system, (single stage or variable stage) and the volume of air being provided relative to the ICT load. For example, if the facility uses variable stage cooling systems and has excess cooling capacity relative to the ICT load, the supply air temperature may be only a few degrees lower than the set point temperature since the cooling system can easily accommodate the heat load. On the other hand, if the ICT load is maximizing the capacity of the cooling systems, the cooling system may be operating at 100% resulting in the supply air temperature being substantially below the temperature set point in an effort to achieve the set point condition.

Placement of the set point sensors will impact the temperature of the supply air. If the sensors are located near a higher-level heat source, the cooling system will respond with more cooling to meet the needs of the sensor which in some cases can lead to excess cooling for other areas of the room. On the other hand, if the set point sensors are located directly in the supply air stream then the cooling system will impact the set point sensor very quickly and this can result in “short cycling” of the cooling system, which for fixed capacity systems is very undesirable. Variable capacity systems can modulate quickly to decrease capacity and are less susceptible to short cycling.

6.4. Multiple Cooling System Environments

In a facility with multiple cooling systems, each cooling unit may operate differently even if the set points are common across all units. This is due to variables such as placement of cooling systems to ICT load and air flow patterns in the room. If the set point sensors are located on the cooling system and higher temperature air is returning to this unit, this may cause it to work harder than other units to achieve the set point condition. Conversely, if the placement of perforated tiles is providing excess air flow relative to the ICT load requirement much of that air will bypass the ICT equipment causing the set point sensor on the cooling unit to reflect a lower temperature. In this case, the lower return air temperature would cause the cooling system to operate less.

6.5. Set Point Relationship to Supply Air Temperature

The relationship of supply air temperature to set point temperature is not linear. This means a change in set points will not reflect the same level of change in supply air temperature. For example, if the set point is raised by 4 °F the supply air temperature will not necessarily increase by 4 °F. The change in supply air temperature will vary depending on the ICT load and air flow conditions, ambient room conditions and the type of cooling system being used.

6.6. Relative Humidity Set Points

Relative humidity set points operate in the same way as the temperature set points. If the RH level at the RH set point sensor is outside the established set point condition, humidification or dehumidification mode is activated to achieve the set point condition.

Humidification conditions are further complicated by two factors. First the air flow patterns in a room can result in higher RH air, above the humidity set point, while other units are receiving return air at the desired set point level. In this condition the unit receiving higher humidity air may go into dehumidification mode to reduce the humidity levels. As the RH levels drop, the other units may go into humidification mode to bring the RH level back up to the desired set point condition. A second condition is if the RH calibration of a unit is inaccurate which may cause one unit to be humidifying or dehumidifying in conflicting operation of all other units. This can result in considerable energy waste in a critical facility. Using a wide control range of RH (example 20% to 60%) substantially reduces if not eliminates the possibility for wasting energy via battling humidification – de-humidification from multiple cooling systems.

7. Cooling System Dead Band

7.1. Dead Band

A dead band are defined as “the range of values within which a sensed variable can vary without initiating a change in the controlled process.” A dead band enables the cooling units to be idle without going into the operation change state and avoids cycling between reheat and cooling modes excessively.

7.2. Dead Band Ranges

Equipment intake air temperatures in critical facilities have traditionally been expected to be within a very tight range. The most recent ASHRAE Thermal Guidelines along with changes made by ICT equipment vendors has opened the door to a broader range of inlet temperatures. Traditionally, set points have been set at very low levels, E.g. 68 °F (20 °C) and, in many cases, with a temperature dead band range of zero. Industry research is now supporting a much wider range of temperature conditions to ease the operation of cooling systems. For example, establishing a temperature dead band with a control limit of 4 °F with a set point of 72 ° F (22 °C) allows the return air temperature to range between 70 °F (21 °C) and 74 °F (23 °C) prior to the cooling system responding with a change in operation. This results in the cooling system working less and can result in significant energy savings. Caution must be exercised before changes are made to temperature set points as too high a temperature can cause older equipment to fail. Equipment operating temperature specifications should be referenced. The ICT equipment with the lowest acceptable maximum operating temperature should be the determining factor in establishing set points.

8. Modifying Set Points to Improve Energy Efficiency

8.1. Increases in Temperature Set Points

In an attempt to improve cooling system energy efficiency, considerable research has been done related to optimizing temperature set points. Increasing temperature set points can be effective in reducing cooling system energy use. However, caution must be exercised to ensure these changes do not affect the operation of the ICT equipment. The first step prior to increasing temperature set points is to optimize the air flow in the facility. If rack inlet temperature measurements show a wide variation, for example 10 °F (5 °C) across a room then steps must be taken to optimize air flow. This could consist of reconfiguration of perforated tiles to increase or reduce air flow to certain areas, use of blanking panels to reduce air recirculation or closing under rack openings with grommets. Ideally rack inlet temperature measurements would be within a 5°F (3 °C) range. Assuming the rack inlet temperatures are in the 65°F (18°C) range or less then there is considerable opportunity to change cooling system set points and subsequent raise rack inlet temperatures. Increasing set points should be done very gradually, 1-2° at a time, and rack inlet temperature should be constantly monitored to identify potential hot spots requiring corrective action.

Technical staff should understand the safe operating limits of every piece of equipment in the facility and design the environmental control system to never exceed those limits. The ICT equipment manufacturers recommendation/specifications are the engineer's best tool for determining the "weakest link" in the facility. For cooling, this would be the equipment within the facility that has the lowest maximum operating temperature. For heating this would be the equipment that lists the highest minimum operating temperature.

8.2. Modifying Humidity Set Points

If RH is too high, condensation will appear on the surfaces of the facility (floor, walls, racks) or on the ICT equipment and can have negative effects such as corrosion, mold, and equipment failure. Condensation occurs when the RH approaches 100% and the air comes in contact with any surface that is at a cooler temperature. The cooling system settings should be set to ensure the RH levels are well below 100%.

Alternatively, if RH levels are too low, static electricity build up can cause equipment failure. The use of static dissipative tiles and good grounding discipline can enable safe equipment operation with RH levels as low as 10%.

In the past, RH levels were set at 45% to 50% and were closely monitored especially during seasonal changes. The ASHRAE 2015 Thermal Guidelines have broadened humidity ranges reducing the control required. In many critical facilities, depending on geographical location, humidity controls can be minimized; meaning that not all cooling units need to be operating with a humidity set point condition. In the units that have humidification control functionality, the dead band settings can be broadened to allow the cooling units to float more. RH ranges of 20% – 80% can be quite safe for today's electronic equipment.

Note, when using RH set points the calibration of relative humidity sensors on all cooling units should be consistent; otherwise, operating conflict can occur with one unit humidifying while others are dehumidifying.

9. Temperature Set Point Operation

9.1. Colder Facility Conditions to Assist in Recovery of Thermal Event

Many facilities are operating with low temperature set points, 68 °F to 72 °F (20 °C to 22 °C) resulting in very cold supply air temperature and cold room ambient air temperatures. A common reason for operating facilities at such low temperatures is that the low temperature will provide a longer runway of time to resolve a cooling system failure. Although this appears reasonable it is not the case. An example of how quickly room temperature increase in cases of cooling system failure is explained below based on modeling and simulation conducted at a critical facility.

A typical hub running at 4 kilowatts per server cabinet will experience a thermal shutdown within three minutes during a power outage. Higher density cabinets with 12 kilowatts will shut down in less than two minutes. Instant data loss and lost revenue are the dangers of thermal runaways. If the critical facility is well managed, the benefits of raising the set point outweigh the risks.

Lower temperature set points only provide at most very few extra "minutes" of protection, yet they cost thousands of dollars in wasted electricity consumption each year. Having back up power and redundant or "+1" protection in your cooling system design is smarter, safer and more cost effective.

9.2. Low Temperature Set Points Reduces Cooling Capacity

Efficiency and cooling capacity of a cooling system is negatively impacted with low return air temperature. For example, operating a 10 ton unit with a return air temperature of 85 °F (29 °C) and RH of 35% will have a sensible cooling capacity of 34 kW or 116,000 BTU. The same unit with return air temperature of 72 °F (20 °C) and RH of 50% will have the sensible cooling capacity reduced to 25 kW or 86,300 BTU, representing a cooling capacity reduction of over 25%. This means that by operating at lower temperature set points additional cooling units are required to meet ICT cooling demands. Using the above example for a 100 kW ICT load, operating at the lower set point means at least four cooling systems are required. If temperature set points are set higher, the same facility operating with four cooling units would have additional capacity to handle more ICT load before additional cooling units were required.

9.3. Increased Set Points Reduces Energy Consumption

Studies have been conducted to determine the relationship of increasing temperature set points and energy consumption. Obviously, facility conditions, such as ICT load, building age, square footage, and age of cooling system play a key role in determining the potential for energy savings. However, a general rule of thumb is that each 1 °F increase in temperature set point results in a reduction of 2-4% in cooling energy use. If the cooling capacity in a facility is not optimized to the ICT load requirements, the projected energy savings will not be achieved. To reemphasize; success in increasing temperature set points and achieving energy reductions is dependent on optimizing air flow management and cooling capacity to the ICT load. Without taking the necessary steps to achieve this, attempts to reduce energy use through set point increases may fail. Refer to SCTE 184 for information on how to optimize air flow.

9.4. Managing Set Points in a Mixed System Environments

In the last few years newer cooling systems have been introduced with the option for set points to control supply air temperature. In a mixed system environment with a combination of older units and new units, the basis of control of set points should be on a common variable to avoid conflicting operation.

9.5. Using Rack Based Sensors to Control Cooling System Operation

In large critical facilities a variety of control systems can be used to manage cooling system operation. For example, rack-based temperature inlet sensors communicating with a centralized controller can manage cooling and humidification operation. These systems monitor the inlet air conditions and activate or deactivate cooling system operation as required. This approach generally results in significant energy savings, potentially 30% or more, and can accommodate changes in ICT load very effectively.

10. Conclusion

This operational practice provides foundational information to clarify proper use of set points in cable critical facilities. Having proper set point values should result in higher energy efficiency, utility cost savings, increased reliability of cooling systems and ICT equipment, and lower operational costs of systems over the life of the units.