ASHRAE - Technical Committee 9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Meeting 14-15 June 2021

Data Center Cooling Resiliency

It is proposed that the overall scope of this TC includes maximizing datacom throughput uptime. A such, it is natural for the TC to concentrate on adequate design, installation, commissioning, and inspection, testing, and maintenance (ITM) issues which are oriented to maximize production uptime. But holistically, maximizing uptime includes minimizing downtime.

Unintended interruption to cooling to the equipment space has occurred in several data centers. The resultant information technology equipment (ITE) downtime can include not only the duration of the cooling outage, but also the time to repair or replace the ITE if it is damaged as a result of the cooling interruption, which can be much longer than the initial interruption.

Planning for such unintended cooling system interruptions can significantly reduce the overall downtime. It is important to have a contingency plan which educates the operators to the hazard and provides procedures implemented before, during, and after the interruption to cooling. For example, temperature trending and associated alarms can be implemented into the HVAC controls to alert operators to developing problems. Just becoming aware of how fast these situations can develops and the potential consequences can be helpful in operators to prepare for these issues.

For reference, such a plan is recommended in section 2.7.7.1 *Equipment Contingency Plan* in the FM Global Data Sheet 5-32 *Data Centers and Related Facilities*:

> 2.7.7.1 Equipment Contingency Plan
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> When a data center utilities and/or support system equipment breakdown results in an unplanned outage to site processes and systems considered key to the continuity of operations, develop and maintain a documented, viable utilities and support system equipment contingency plan (ECP) per Data Sheet 9-0, Asset Integrity. See Appendix C of that data sheet for guidance on the process of developing and maintaining a viable equipment contingency plan. Also refer to sparing, rental, and redundant equipment mitigation strategy guidance in that data sheet
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> Conduct a systematic, strategic assessment of data center utilities and support system equipment. Consider process bottlenecks, single points of failure, unique and long lead time equipment, evaluate equipment integrity, reliability and remaining useful life, fitness for service, and operating history/trends. Evaluate the type and scope of ECP needed to mitigate the equipment specific breakdown exposures
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> The data center ECP includes recovery options and mitigation strategies to respond to and recover from the equipment breakdown exposures, focusing on electrical and cooling equipment. This can include repair, replacement, rental lead time options, used and/or surplus equipment, redundancy, and sparing to minimize the downtime
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> 2.7.7.2 For loss of cooling to data center equipment due to a cooling support system equipment breakdown, the overall objective of the ECP for this scenario is to shut down data processing equipment in an orderly manner upon loss of cooling, or impending loss of cooling, before the

temperature exceeds the facility's or the manufacturer's guidelines, including warranty restrictions (i.e., thermal runaway)

For loss of cooling, the ECP should consider operations, sensors and alarms, and response capabilities of emergency and operating personnel. Include the criticality of the data processing functions and an understanding of the time available to become aware of developing overheating situations, make decisions, and take actions to prevent data processing equipment damage from overheating

2.7.7.3 In addition, evaluate the following elements in the contingency planning process specific to equipment breakdown resulting in loss of cooling to data center processing equipment:

A. Data from the original equipment manufacturer's (OEM) literature for all critical data processing equipment components. Include warranty thresholds, recommended maximum short-term operating temperatures, and automatic equipment shutdown interlocks provided by the OEM due to excess temperatures in all data processing equipment (power supplies, servers, data storage equipment, etc.)

B. Calculations by qualified design professionals involving the nature of the cooling equipment, the room and surroundings, and data processing equipment, to determine the expected room temperature rate of rise on loss of cooling, assuming continued operation of the data processing equipment

C. The probable time to data processing equipment damage due to temperatures exceeding critical thresholds. Include at least the following input: data processing equipment individual heating characteristics, electrical power input to the data processing equipment room, data processing equipment space volume and height, normal data processing equipment space operating temperature, any partial cooling from the cooling equipment connected to standby power

D. Using the information in A through C, develop the following scenarios, at a minimum, in the ECP at several levels of temperature threshold alarms, with the mitigation actions to be taken at each level: 1. Short-term (1 sec), medium-term (1 min), and long-term (1 hr) interruptions of utility power to the entire facility (See 2.7.8 for Service Interruption Planning)

2. Breakdown of a single critical cooling system component, such as chillers, chilled water pumps, condenser water pumps, cooling tower fans, air handler fans (e.g., bearing seize), cooling media control valves (e.g., failing closed), cooling system local and centralized controls, variable speed drives, and electric power (e.g., circuit breakers) for any of the above equipment

3. Additional breakdown scenarios as needed based on a review of the facility's unique design, arrangement, and operation

E. The time necessary to provide sufficient cooling to the data processing equipment space following short-term power loss to the facility, followed by power restoration, to avoid data processing equipment overheating damage. Include at least the following input: time to start standby power generators, cooling equipment connected to the standby power and time to start cooling equipment (e.g., controls, chillers, pumps, cooling towers, CRAH, etc.)

F. Guidance if initial mediation efforts are not successful and the data processing equipment space temperature continues to rise, including interrupting power to the data processing equipment (e.g., main power, emergency power, facility UPS, and equipment based UPS) in accordance with the data processing equipment power isolation plan

2.7.7.4 Implement the loss-of-cooling ECP using the following elements:

A. Training: Provide plan training to facility operations personnel and data processing equipment operations personnel

B. Authority: Designate at least one person per shift to have the authority to implement the ECP including the data processing equipment power isolation plan (Section 2.7.2), if data processing equipment shutdown is needed to prevent damage

C. Operation: Designate personnel on each shift to perform the steps in the loss of cooling equipment contingency plan

D. Practice: 1. Review, test, and validate the loss-of-cooling equipment contingency plan at least annually to confirm efficacy

2. Practice recovering cooling to the data processing equipment, including starting emergency generators, shifting critical equipment operation to backup (N+1) components, restarting HVAC equipment (CRAH, chillers, pumps, cooling towers, controls, etc.)

3. Practice the real-time decision path in identifying situations in which cooling cannot be restored before the data processing equipment incurs critically high temperatures, resulting in the decision to shut down the data processing equipment

4. Practice the actions required to interrupting power to the data processing equipment in accordance with the power isolation plan to ensure the required timeframe is met

2.7.7.5 Review and validate the ECP annually and when there are significant changes on site to manage change and confirm efficacy of the plan.

In concert with these goals, controls should be configured to identify impending overheating events as soon as possible:

2.8.5.1 Controlling HVAC Systems

A. Provide HVAC control systems using a proportional-integral-derivative (PID) algorithm. Program the

controls to provide an alarm if the setpoint error and the historical rate of room temperature change indicate an impending overheating event.

B. Provide alarms to initiate mitigation actions based on several levels of temperature thresholds.

1. High temperature: No more than 2°F or 2°C above the normal setpoint operating temperature of the lower of either (a) the high data processing equipment temperature (as recommended by the OEM) measured at the equipment, or (b) the high space air temperature setpoint per the facility HVAC design.

2. Rate of temperature change: As a result of the study recommended in the loss-of-cooling equipment contingency plan (see 2.7.7.1).

C. Provide audible and visual alarms in the vicinity of the equipment and at a constantly attended location.

D. Provide emergency power to HVAC systems (e.g., fans, CRAHs, chillers, cooling towers) for data processing equipment spaces.

E. Provide battery or an alternative power backup such as capacitors for HVAC controls.