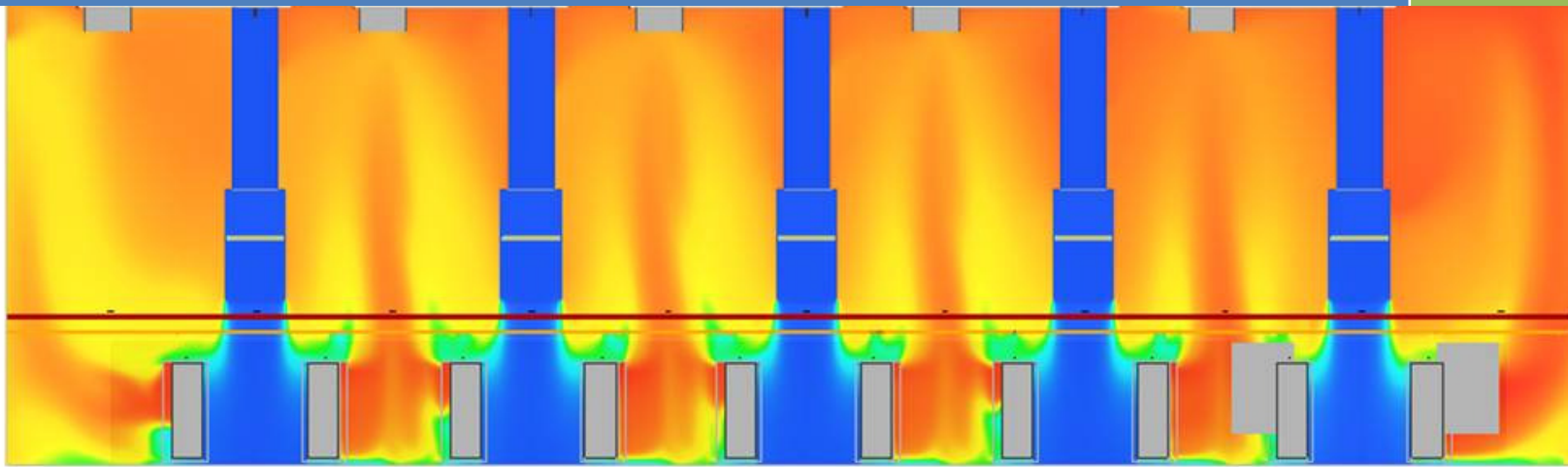


2010

**Hot Aisle/ Cold Aisle
Performance Validation**



The air handling system configuration for this project commissioned by CST was designed to serve a hot aisle/ cold aisle arrangement in a 100,000 data center. Each data center aisle was designed with a low velocity/ static pressure duct header. Each aisle arrangement is served by three air handling units dedicated to each duct header. The air handling unit capacity was designed, from an air flow basis, to be N + 1 configuration.

A commissioning testing Method of Procedure was developed to evaluate the normal operating scenarios with and without end of aisle containment. The normal operation scenario evaluated for this project is provided below.

- Approximately 5kW per cabinet design load
- Including end of row doors
- Constant supply air temperature at 57°F with a process critical temperature condition of 70°F (+/-6°F) at the inlet to server cabinets
- Each AHU running independent to maintain setpoint

In order to validate the hot aisle/ cold aisle design, a mock-up aisle with rack mounted load banks and simulated cold aisle containment was set-up. A testing procedure was developed to validate the capacity of the air handlers to maintain the design cooling load, verify the control and heat distribution and validate the air handler sequence of operations. The primary sequence of operations evaluated included

1. Operations of three (3) air handling units to maintain aisle temperature during loaded conditions of 50%, 75%, 100% and beyond design at 120% with N+1 air handlers in operation
2. Operation of N air handlers during a single faulted air handler condition.
3. Operation of the air handlers with temperature control under return air temperature control mode.
4. Operation of the air handlers with temperature control under a matrix of wireless temperature transmitters located at the upper corners of the server racks.

Temperature sensors were placed at several critical points of interest in order to monitor the temperature distribution and profile during the test. A graphical depiction of the placement of the various temperature placement locations is provided in Figure 1.

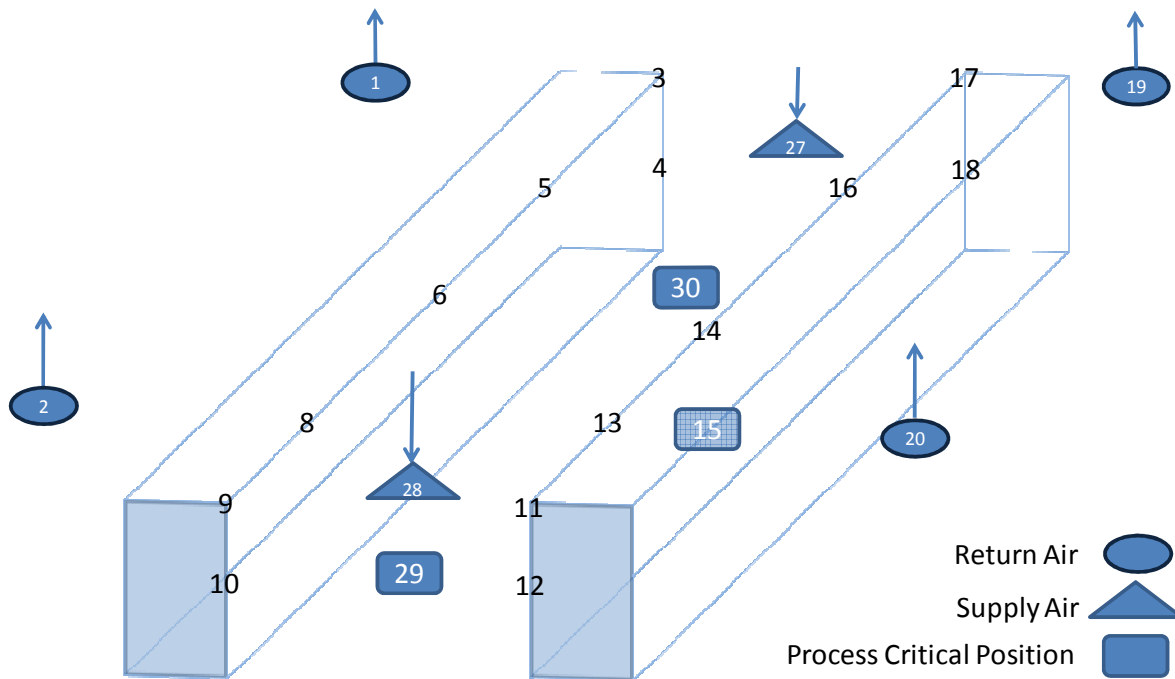


Figure 1 Hot aisle/ cold aisle logger/ sensor distribution plan

The general description of the sensor placements are as follows:

- Supply air temperature is those sensor locations within 5 feet of the discharge from the air diffusers measuring the air intake temperature from the aisle duct diffusers into the cold aisle section of the racks.
- Return air temperature is those sensor locations approximately 10-12 feet above the floor on the hot aisle measuring the air temperature in the hot aisle section of the racks.
- Process critical locations (PCL) are those sensor locations at approximately 4-5 feet above the floor in the cold aisle. The sensor locations are shown as at the edges of the cold aisle racks or at a midpoint location (closer to 2 feet above the floor).
- The “corner” air temperatures are those sensor locations at the upper edge of the rack in the monitoring area where wireless sensors are provided for monitoring temperature conditions within the cold aisle.
- The “edge” air temperatures are those sensor locations at the far edges of the racks near the end of row doors.

The sensor location schedule is shown in Figure 1 are detailed in Table 1.

Table 1 Sensor location schedule

Label	Location	Label	Location
1	Return Air, South East	13	Aisle Midpoint, Corner
2	Return Air, North East	14	Aisle Midpoint, Corner
3	End of Aisle, Corner	15	Aisle Midpoint, PCL
4	End of Aisle, Edge	16	Aisle Midpoint, Corner
5	Aisle Midpoint, Corner	17	End of Aisle, Corner
6	Aisle Midpoint, Corner	18	End of Aisle, Edge
7	Aisle Midpoint, PCL	19	Return Air, North West
8	Aisle Midpoint, Corner	20	Return Air, South West
9	End of Aisle, Corner	21	Supply Air, South
10	End of Aisle, Edge	22	Supply Air, North
11	End of Aisle, Corner	23	Aisle Midpoint, PCL
12	End of Aisle, Edge	24	Aisle Midpoint, PCL

Table 2 below provides a summary of the testing Method of Procedure.

Table 2 Hot aisle/ cold aisle testing MOP

Step	Time	Action
1	7:00 AM	Air handlers set for return air temperature control mode, 78°F
2	7:30 AM	Load banks set to 50% aisle capacity
3	10:30 AM	Load banks set to 80% aisle capacity
4	11:30 AM	Load banks set to 100% aisle capacity
5	12:38 PM	Simulated failure of AHU-2N1
6	1:20 PM	Restore failed AHU-2N1
7	1:35 PM	Simulated failure of AHU-2N3
8	2:10 PM	Restore failed AHU-2N3
9	2:50 PM	Load banks set to 120% aisle capacity
10	4:30 PM	Load banks set to 100% aisle capacity
11	5:00 PM	Air handlers set for aisle temperature control mode, 71°F
12	6:30 PM	Air handlers set for return temperature control mode, 78°F

Observations and Results

1. Temperature of the air at the floor level of the cold aisle remained relatively consistent with the discharge of the air handlers through the air distribution header indicating that the density of the low velocity air descended into the cold aisle effectively for delivery into the equipment racks during control of the air handlers using the air handlers individual return air temperature sensors.
2. The corners of the racks where the matrix of aisle temperature transmitters while under return air temperature control mode at 1 78°F return air temperature setpoint was in the range of 68-71°F, below the desired aisle temperature setpoint of 72°F informing Operations that an increased temperature setpoint of approximately 80°F during return air temperature control mode.
3. During air handler failures the N quantity of running units still delivered the desired temperature conditions in the cold aisle.
4. During air handler failures the N + 1 quantity of running units was able to deliver the desired temperature conditions in the cold aisle at 120% of design load.
5. The control of the system under direct process control of the aisle temperature transmitters was ineffective. The update rate of the wireless transmitters inhibited smooth PID control and resulted in the temperature conditions from running out of the desired conditions and the resultant temperature control process being unstable.

The recommended actions to the client were as follows:

1. Under return air temperature control mode use of an 80°F temperature setpoint will be effective for the desired process control condition at the upper corners of the racks of 72°F.
2. Not to utilize direct aisle temperature control.
3. Utilize return air temperature control with a temperature reset based on aisle temperature readings allowing the process to control on direct measurements of aisle temperature but through a more reliable process control value.

