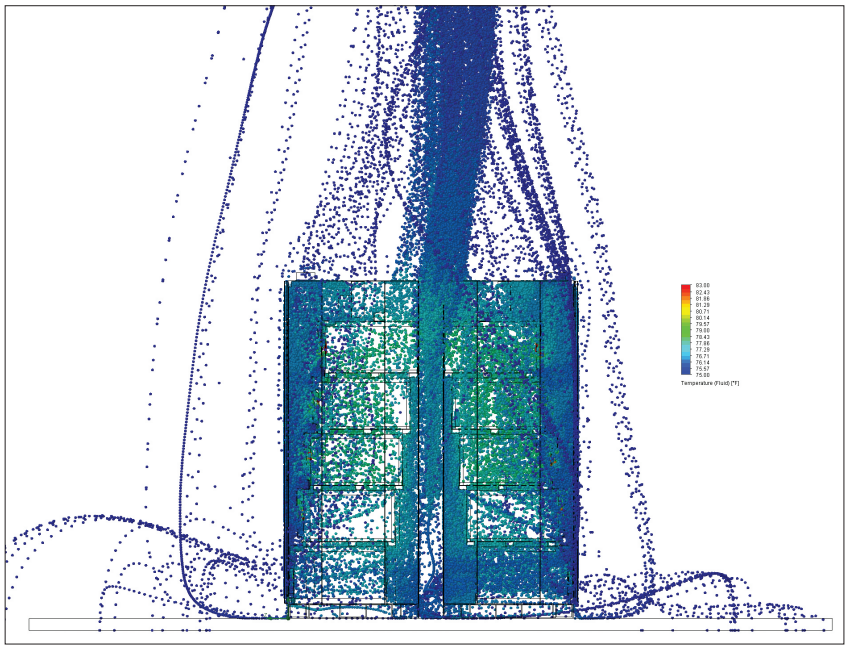
Case Study: Choosing the ideal cabinet solution for optimal product performance and cost savings

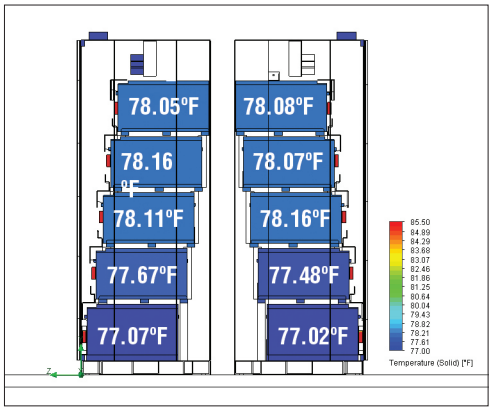
INTRODUCTION

In UPS applications air flow and temperature are two of the most actively discussed topics. One of the major aspects is how air flow or lack thereof directly impacts lead acid battery life for both flooded and Valve Regulated Lead-Acid (VRLA) technologies. Containing batteries in a cabinet with limited / minimal airflow or in a room with positive air pressure that inhibits natural convection will increase temperatures and temperature differentials across the batteries. It is vital to remember that standard lead acid battery design life and ratings are most favorable at 77°F (25°C). As a guideline every 18°F (10°C) increase reduces the life of the battery by half.

East Penn, manufacturer of Deka batteries partnered with C&C Power, a leading manufacturer of DC power products and Stationary Battery Systems to deliver the ideal battery cabinet solution.



These images depict complete modeling of C&C Power UBC "CoolCab" with forced air cooling and Deka front access batteries.



C&C Power and East Penn analyzed, along with customer field testing data, the results across multiple scenarios utilizing various cabinet designs with and without individual battery monitoring systems. For all tests, (monitoring/no monitoring) the final results revealed the optimal environment was a closed door cabinet with a fan induced forced airflow system. The overall measure of success was the lowest battery temperature per system in combination with the lowest temperature delta between the batteries resulting in reduced cooling costs in the battery room and overall cost savings for the end user.

C&C POWER
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PERFORMANCE TESTING SETUP

Extensive simulation testing was conducted using SolidWorks Flow Simulation software. SolidWorks Flow Simulation uses Computational Fluid Dynamics (CFD) to simulate liquid and gas flow in real-world conditions and efficiently analyze the effects of fluid flow, heat transfer and related forces on immersed or surrounding components. The equipment used for the analysis was a custom designed simulation computer at the C&C Power facility.

To promote uniformity, the following guidelines were used for all tests:

- A controlled environment of 75°F (23.8°C) ambient air temperature with batteries and monitors on float
- For all front access battery simulations – Deka HR7500ET batteries using 2.03 BTU's/Hr – per battery
- For all top terminal battery simulations – Deka HR5500 batteries using 1.33 BTU's/Hr – per battery
- All simulations were configured with a 480V battery string
- For all simulations using monitoring – Use of 1 watt per monitor per battery

SIMULATION TEST SET 1 –

Battery Systems without Battery Monitoring

C&C Power UBC "CoolCab"
This is a fully enclosed cabinet design with dual doors. The cabinet is optimized for convection cooling with front access batteries.

C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling
This is a fully enclosed cabinet design with dual doors. The cabinet is optimized for forced air cooling utilizing a fan with front access batteries.

C&C Power UBR Open Battery Rack
This is an open rack design. The rack utilizes natural air flow for convection cooling with front access batteries.

C&C Power UBS Touch Safe Battery Rack
This is a touch safe rack design. The rack utilizes fully perforated front and rear covers for convection cooling with front access batteries.

Typical Fully Enclosed Battery Cabinet
This represents an industry "typical" battery cabinet design utilizing natural air flow for convection cooling with top terminal batteries.

SIMULATION TEST SET 2 –

Battery Systems with Battery Monitoring

Test set 2 was conducted with the same Battery Systems as test set 1 with the addition of jar level battery monitoring devices. The battery monitors used for the simulation contributed 136 BTU/hr of heat to the battery systems. This equates to approximately 1 watt of constant power per module.

PERFORMANCE TESTING RESULTS

Simulation Test Set 1 Results:

Upon comparing the results of each of the test systems in set 1, the solution that proved to provide the best results was the C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling and front access batteries. The C&C UBC "CoolCab" Battery Cabinet utilizes a patented stepped five shelf design. This unique and patented design in combination with an added fan resulted in a maximum battery temperature of 76.37°F (24.65°C) with a battery to battery delta (the difference between the highest and lowest battery temperature in the system) of 0.55°F throughout the entire system.

The highest temperature was measured in the Typical Fully Enclosed Battery Cabinet with natural airflow convection cooling and top terminal batteries. The maximum battery temperature in this system was 79.67°F (26.48°C) with a battery to battery delta of 2.84°F.

The delta between the highest and lowest battery temperatures among the battery systems in test set 1 was 3.8°F. The results validated that the C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling and front access batteries operates up to 5% cooler compared to the Typical Fully Enclosed Battery Cabinet with natural airflow convection cooling and top terminal batteries.

TEST SET 1 DATA

Battery System Type	Battery Type	Battery Temperature In System (F°)			Battery Room Maximum Delta Above Ambient (F°)	Thermostat Set Point (F°)
		Highest	Lowest	Delta		
C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling	Front Access	76.37	75.82	0.55	1.37	75
C&C Power UBR Open Battery Rack	Front Access	78.33	77.22	1.11	3.33	74
C&C Power UBS Touch Safe Battery Rack	Front Access	78.34	77.17	1.17	3.34	74
C&C Power UBC "CoolCab"	Front Access	79.18	77.28	1.9	4.18	73
Typical Full Enclosed Battery Cabinet	Top Terminal	79.67	76.83	2.84	4.67	73

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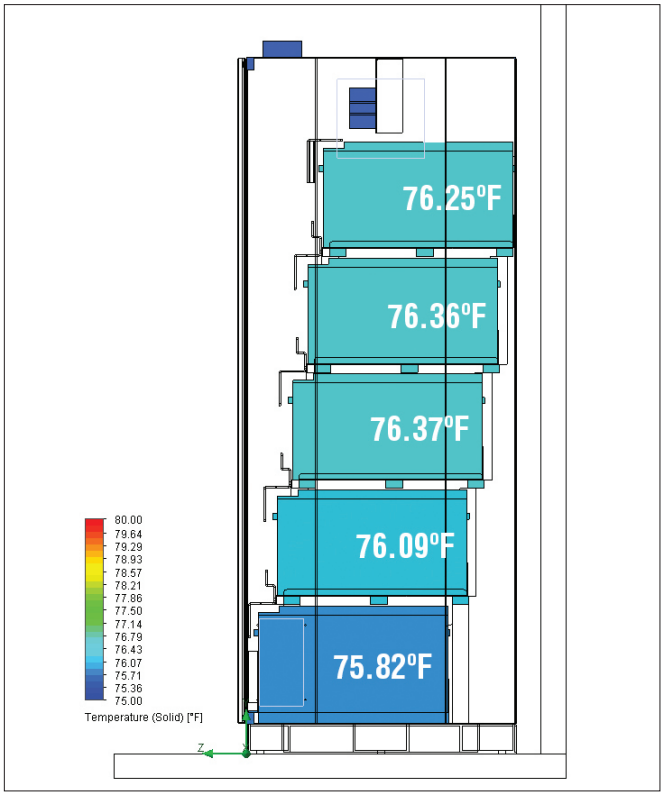
C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling with Front Access Batteries

0.55°F battery to battery delta

1.37° delta over ambient

76.37°F high battery temp

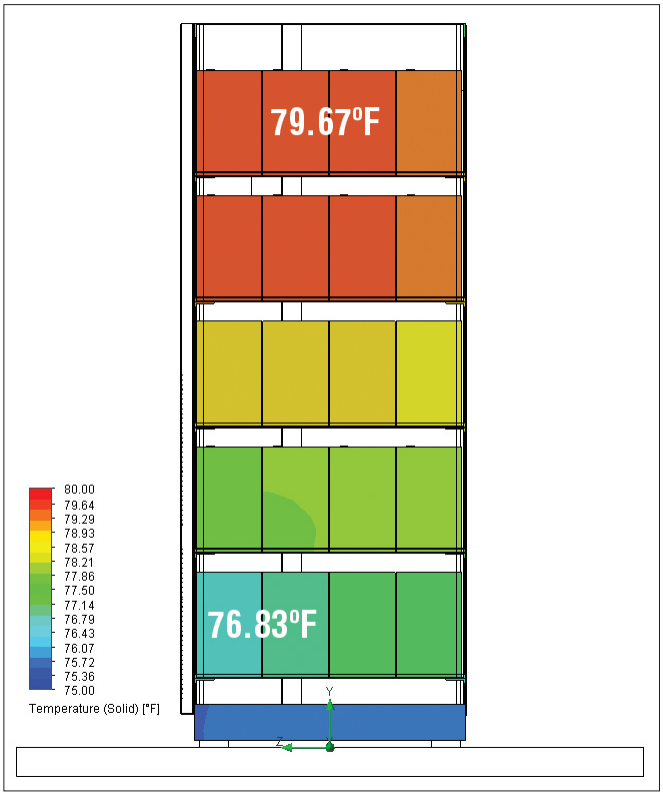


Typical Fully Enclosed Battery Cabinet with Top Terminal Batteries

2.84°F battery to battery delta

4.67° delta over ambient

79.67°F high battery temp



It is vital to remember that standard lead acid battery design life and ratings is most favorable at 77°F (25°C).

SIMULATION TEST SET 2 RESULTS

Using the same testing scenarios as test set 1 with the addition of jar level battery monitors, the best solution was again the C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling and front access batteries. The maximum battery temperature in this system was 78°F (25.5°C) with a battery to battery delta of 0.97°F throughout the entire system.

Again, the system resulting in the highest temperatures was the Typical Fully Enclosed Battery Cabinet with natural airflow convection cooling and top terminal batteries. The maximum battery temperature in this system was 85.34°F (29.63°C) with a 6.6°F battery to battery delta and 10.34°F delta above ambient.

This testing scenario resulted in overall higher battery temperatures and deltas for all systems when compared to Test Set 1. The delta between the highest and lowest battery temperatures among the battery systems in Test Set 2 was 8.3°F. The results show that the C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling and front access batteries operates up to 10% cooler compared to the Typical Fully Enclosed Battery Cabinet with natural airflow convection cooling and top terminal batteries.

TEST SET 2 DATA

Battery System Type	Battery Type	Battery Temperature In System (F°)			Maximum Delta Above Ambient (F°)	Thermostat Set Point (F°)
		Highest	Lowest	Delta		
C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling	Front Access	78	77.03	.097	3	74
C&C Power UBR Open Battery Rack	Front Access	81.08	79.03	2.05	6.08	72
C&C Power UBS Touch Safe Battery Rack	Front Access	81.04	79.02	2.02	6.04	72
C&C Power UBC "CoolCab"	Front Access	83.07	79.14	3.93	8.07	70
Typical Full Enclosed Battery Cabinet	Top Terminal	85.34	78.74	6.6	10.34	68

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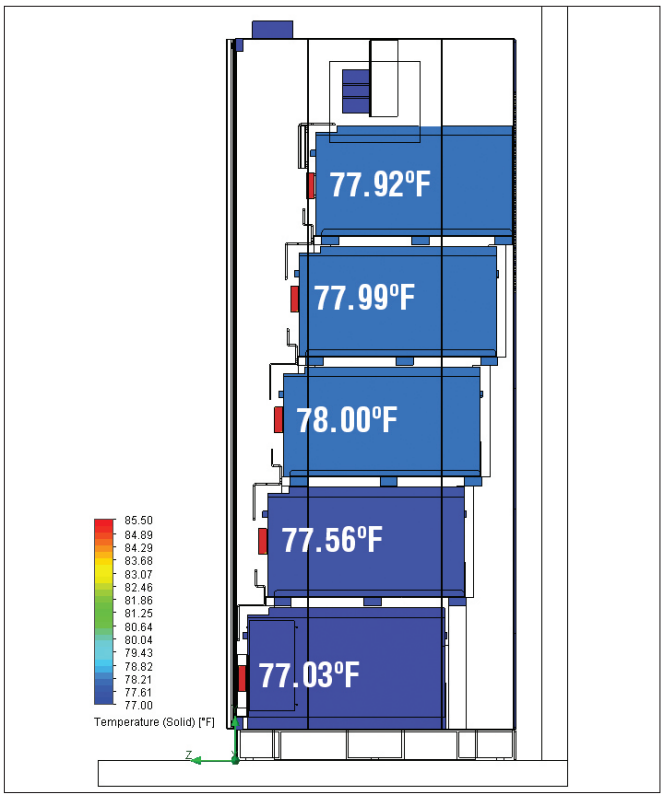
C&C Power UBC "CoolCab" Battery Cabinet with Forced Air Cooling with Front Access Batteries & Jar Level Battery Monitors

0.97°F battery to battery delta

3° delta over ambient

78°F high battery temp

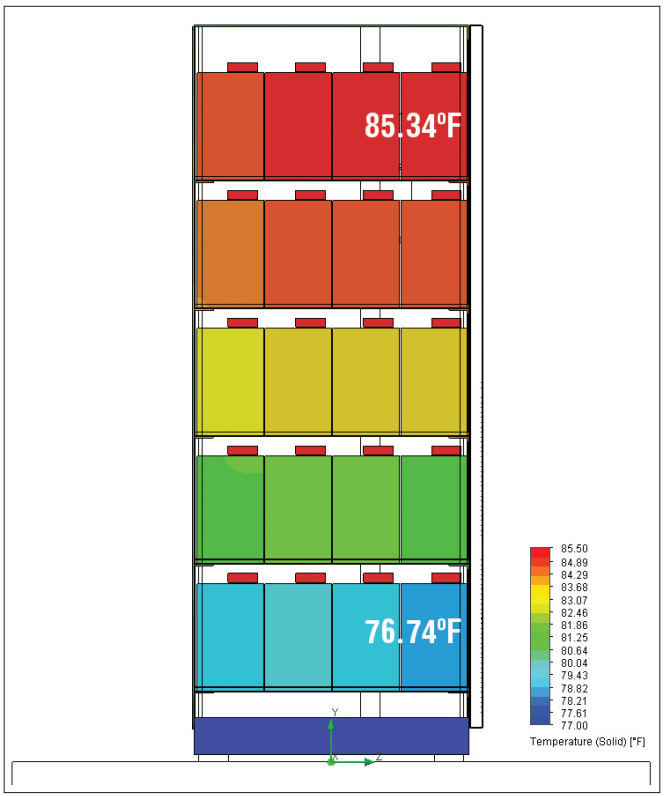


Typical Fully Enclosed Battery Cabinet with Top Terminal Batteries & Jar Level Battery Monitors

6.6°F battery to battery delta

10.34° delta over ambient

85.34°F high battery temp



The airflow directly impacts the batteries temperature above ambient, stratification of battery temperatures within the battery cabinet, and overall battery life.

ARE THERE OTHER FACTORS TO CONSIDER?

Yes. In addition to airflow, battery technology can make a difference. Regardless of the cabinet construction used, some in the industry will undoubtedly point to heat as the weakness of lead acid battery technology and suggest substitutes that have historically performed well in high temperature environments. **However, with the advent of products such as the Deka Fahrenheit, East Penn has created the revolutionary lead acid battery technology that thrives in high temperature applications, lowering energy demands and reducing the overall sites Co_2 footprint. When compared to a standard VRLA lead acid battery the Deka Fahrenheit will last up to 3 times longer in a similar environment.**

SUMMARY OF RESULTS

The study illustrates that cabinet design significantly impacts airflow and how it beneficially correlates to all other critical components of the process. The airflow directly impacts the batteries temperature above ambient, stratification of battery temperatures within the battery cabinet, and overall battery life. By utilizing the most efficient airflow and battery model, significant cost savings can be realized across multiple platforms including battery room cooling and overall battery life and performance. The testing results prove the C&C Power UBC “CoolCab” Battery Cabinet with Forced Air Cooling paired with Deka front access batteries is the ideal industry solution.

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