White Paper

September 2015 WP-23

Impact of Cabinet Color on Data Center Lighting

Key Points:

- Does cabinet color save costs?
- What impact do aisle containment solutions and vertical exhaust ducts (chimneys) have on data center lighting?
- Do these solutions change the lighting impact of white cabinets?

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Overview

The data center industry is experiencing an increase in the number of businesses deploying equipment cabinets in colors other than the traditional black, with white being the most common choice. Typical reasons for this change in color preference are improved aesthetics, work space lighting effectiveness, and cost savings due to decreased lighting requirements. To determine the impact of cabinet color choice on lighting effectiveness and the potential cost savings, Panduit Corporate Research & Development conducted a series of computer simulations.

Black cabinet surfaces absorb a high fraction of the illumination falling on them. By using lighter colors for the cabinets, more illumination is reflected into the room, increasing the overall lighting level. Fewer light fixtures are needed, resulting in a lower continuous lighting power load.

Previous studies have only explored the benefits of white cabinets in the most basic data center configuration (standard open hot aisle/cold aisle). A potentially significant variable that has not been addressed is the use of common data center airflow management methods. Specifically, what impact do aisle containment systems and vertical exhaust ducts (chimneys) have on lighting in the data center, and do these solutions change the impact of white cabinets on data center lighting levels?

Baseline Configuration Model

For this evaluation, we used Autodesk Revit Architecture and MEP software with Lighting Analysts Elum Tools to create a virtual model of a 5,000 square foot (465 m^2) data center with a 12 foot (3.7 m) high ceiling. Nine rows of twenty cabinets each were arranged in an uncontained hot aisle/cold aisle configuration as shown in Figure 1.

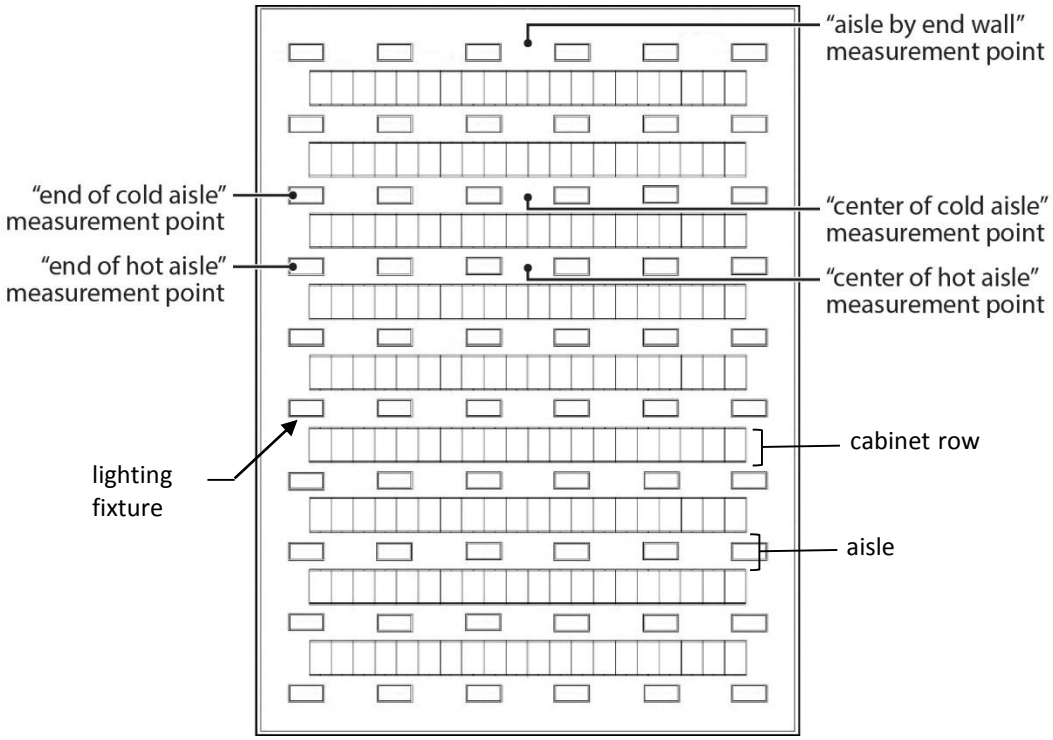

Figure 1. Illuminance Measurement Points for the Baseline Model Scenarios.

All of the aisles between the cabinet rows were 4 feet (120 cm) wide, and the cabinets were 4 feet (120 cm) deep. Light was provided by T8 fluorescent tubes in 2 ft. by 4 ft. (60 cm by 120 cm) fixtures installed in a suspended ceiling in line with the center of each aisle. The room's floor and wall surface reflectance values were set to gray, and the ceiling to white. The measurement points indicated in Figure 1 show where illuminance in the model was measured.

Baseline Configuration Scenarios

Figures 2 and 3 show the baseline hot aisle/cold aisle models with black and white cabinets, respectively. For both scenarios, we measured the simulated light levels, or illuminance, at floor level and at 30 inches (76 cm) above the floor.

Figure 2. Baseline Model of a Data Center with Black Cabinets.

Figure 3. Baseline Model of a Data Center with White Cabinets.

Results of Baseline Configuration Analysis

Figure 4 graphs the illuminance, measured in lux, at each of the points indicated in Figure 1. (*Lux* is the international measure of light intensity on a surface. One lux is equal to one lumen per square meter.) The graph shows that the illuminance is lower in the centers of the hot and cold aisles and along the aisle by the end walls of the data center than it is at the ends of the hot and cold aisles.

The graph also shows that using white cabinets increases the illuminance in all areas measured, with a 56% increase in illuminance in the centers of the hot and cold aisles and a 32% increase in the remaining monitored areas.

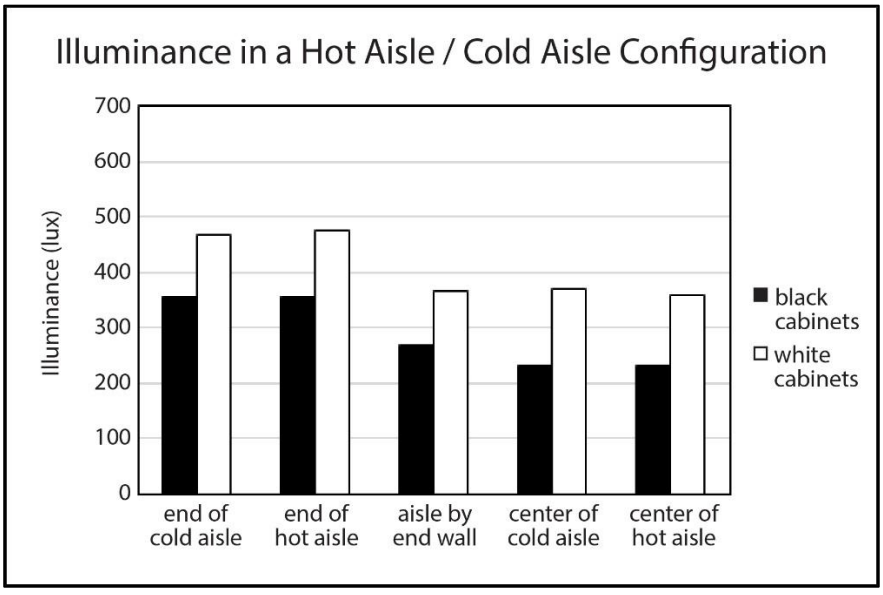

Figure 4. Baseline Model Illuminance.

Cold Aisle Containment Model and Scenarios

The study team created a second set of configurations by adding cold aisle containment to the baseline models, including end-of-aisle doors and a translucent roof for each cold aisle. Figures 5 and 6 show the cold aisle containment models with black and white cabinets, respectively. For each of these scenarios, we measured illuminance at the same measurement points as for the baseline configurations. However, note that the “center of cold aisle” measurement point was within a contained cold aisle.

For information on the benefits of aisle containment solutions, see the Panduit Universal Aisle Containment white paper, *Increased Efficiency with Fewer Deployment Restrictions*.

Figure 5. Model of a Data Center with Black Cabinets and Black Cold Aisle Containment.

Figure 6. Model of a Data Center with White Cabinets and White Cold Aisle Containment.

Cold Aisle Containment Scenario Analysis

Figure 7 graphs the illuminance measured at each measurement point in the cold aisle containment scenario. It shows that with white cabinets and containment there is more illuminance at all the locations measured than there is with black cabinets and containment. The graph also shows that, due to the containment, illuminance is lower in the center of the cold aisle than in the baseline scenarios by 44% to 48%, with both black or white cabinets and containment. However, white cabinets and containment resulted in 48% higher illuminance in the cold aisle than black cabinets and containment.

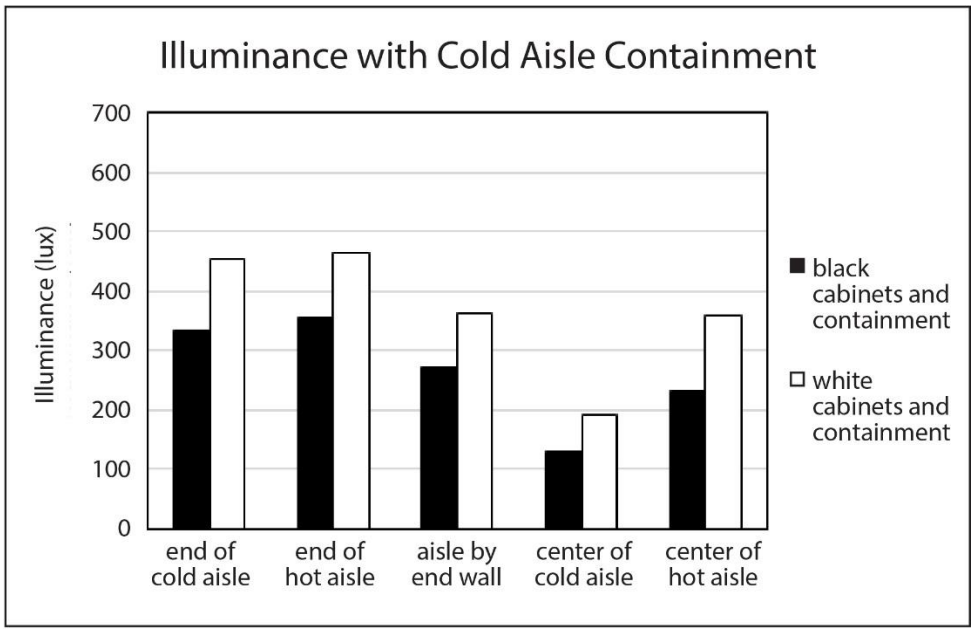

Figure 7. Data Center with Cold Aisle Containment Illuminance.

VED Model and Scenarios

Next, the study team modified the baseline configuration model by adding vertical exhaust ducts (VEDs) on all cabinets. Figures 8 and 9 show the cold aisle containment models with black and white cabinets, respectively. For each of these scenarios, we measured illuminance at the same measurement points as for the baseline configurations.

For information on the energy efficiency benefits of VEDs, see the Panduit white paper, *Deploying a Vertical Exhaust System to Achieve Energy Efficiency and Support Sustainability Goals*.

Figure 8. Model of a Data Center with Black Cabinets and Black VEDs.

Figure 9. Model of a Data Center with White Cabinets and White VEDs.

Results of VED Configuration Analysis

Figure 10 graphs the illuminance measured at each of the measurement points in the VED scenario. Because the VEDs extend from the tops of the cabinets to the ceiling, they effectively prevent the light fixtures over one aisle from providing any illumination to the adjacent aisles. The graph shows that white cabinets and VEDS have a big impact on the illuminance in the hot aisle. Illuminance at the center of the hot aisle is 75% more than the white baseline configuration and 182% more than with black cabinets and VEDs. However, when compared to Figure 4, Figure 10 shows that, at all measurement locations except the hot aisle, the effect of VEDs on illuminance is negligible. White cabinets and VEDs increase illuminance about the same amount as white cabinets alone.

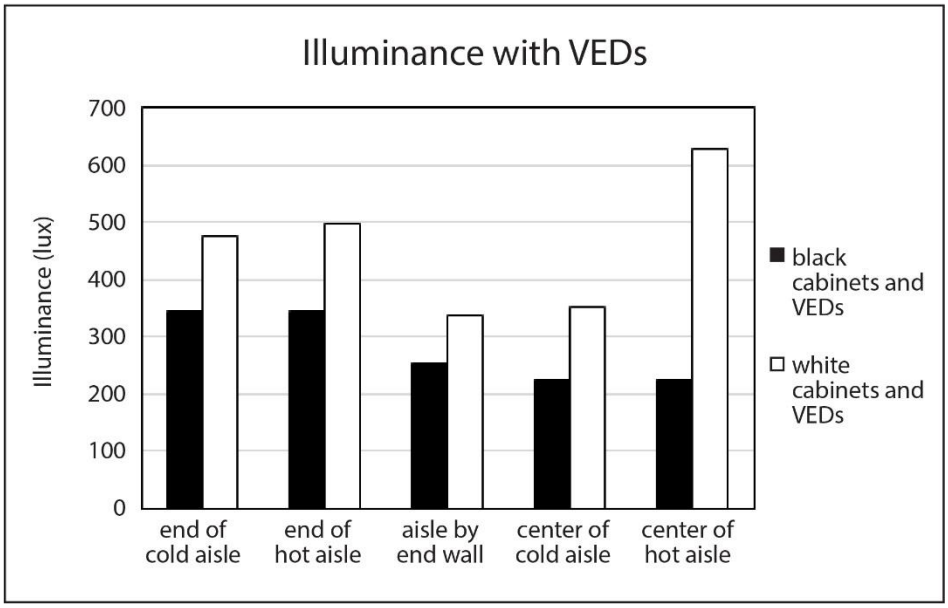

Figure 10. Data Center with VEDs Illuminance.

Summary of Illuminance Measurements

Figure 11 summarizes the increase in illuminance when using white cabinets, containment, and VEDs instead of black. The reduction in illuminance in the cold aisles with cold aisle containment cannot be seen, because the magnitude of the effect is similar regardless of cabinet and containment color. However, the increase in illuminance in the hot aisle with white cabinets and VEDs is obvious.

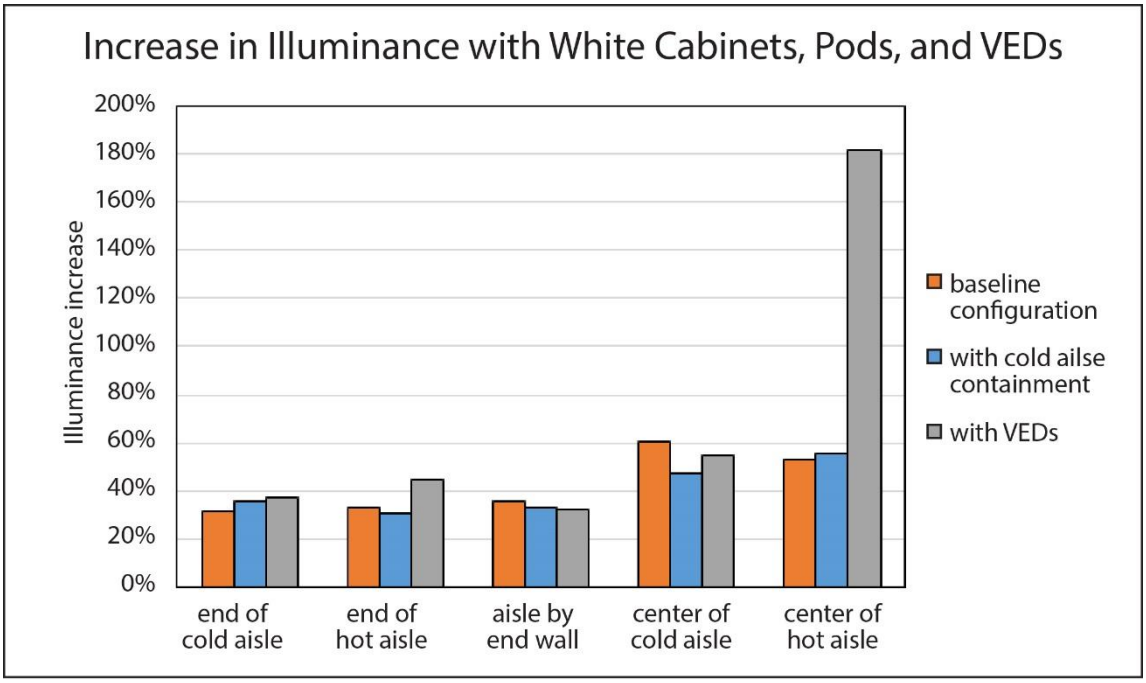

Figure 11. Improvement in Illuminance with White Cabinets, Containment, and VEDs.

Implementation

This study shows that using white cabinets instead of black cabinets increases illuminance, which means that a data center can be lit with fewer light fixtures. However, true optimization of illuminance is more involved than simply uniform reduction in the number of fixtures. Each data center has additional variables, besides those considered in this study, which can affect the results. For instance, the reflectivity of surfaces may be different than the values assumed for this study, the effects of white surfaces may not be uniform throughout the data center, and there may be lighting fixtures that cannot be removed. In the theoretical model, it became apparent that the distribution of light fixtures can be a limiting factor in several ways:

- The number of fixtures can only be adjusted by whole numbers
- The aisle lengths limit the number of fixtures that can be installed
- Fixtures installed too far apart result in uneven light distribution

Cost Benefits

The models and simulations for this study were used to estimate how costs can be reduced in the data center by using white cabinets. *The Lighting Handbook*, published by the Illuminating Engineering Society (IES), recommends illuminance of 100 lux for data centers, but it is more common for such facilities to be lighted to 300 lux. Therefore this study used 300 lux as the target value. In each of the data center configurations, number of lighting fixtures in each cabinet aisle was adjusted until a minimum illuminance of 300 lux was observed. Table 1 lists the savings that were gained from not having to install as many lighting fixtures, and Table 2 lists reductions in operating expenses achieved by reducing the lighting electrical load.

Table 1. Savings from Installing Fewer Lighting Fixtures When Deploying White Cabinets, Containment, and VEDs.

	Baseline Configuration	***Cold Aisle Containment Configuration***	***VED Configuration***
Reduction in number of fixtures	20	20	28
Fixture cost savings†	$5,000	$5,000	$7,000

† Installed cost of $250 per fixture.

Table 2. Energy Cost Reduction with White Cabinets, Containment, and VEDs.

	Baseline Configuration	***Cold Aisle Containment Configuration***	***VED Configuration***
Lighting electrical load with black surfaces	5,120 W	7,168 W	5,120 W
Lighting electrical load with white surfaces	3,840 W	5,376 W	3,328 W
Lighting electrical cost savings	25%	25%	35%

Note: If timers occupancy sensors that turn off lighting when not needed, or more efficient light sources such as LEDs are used, then the potential savings from reducing the number of fixtures are reduced.

Effects on Illuminance in Cabinet Interiors

White cabinets have another benefit over black cabinets. The higher reflectance of a white interior provides more illuminance inside the cabinets, resulting in better working conditions for technicians. However, the question still remains as to whether this is true if the room lighting is reduced.

To find out, one cabinet was modeled with the rear doors open, and illuminance was measured inside the cabinet. This model did not include the effects of a technician standing at the rear door to perform work tasks.

The data shows that if white cabinets are used instead of black cabinets, but the room lighting level is not reduced, then illuminance inside the rear of the cabinet increases by 80%. However, if the room lighting is reduced to take advantage of the white cabinets' higher reflectivity and to save on energy costs, then the illuminance inside the cabinet is only 16% higher. Unless the room is significantly over-illuminated, technicians most likely need additional task lighting to complete work inside either a black cabinet or a white cabinet.

Aesthetic Effects of White Cabinets

The aesthetics of data center cabinet color are extremely subjective. White cabinets make a data center look more contemporary, and they tend to show dirt less than black cabinets. However, in an effort to minimize lighting costs, a data center might have white or near-white walls, floor, and ceiling as well as white cabinets. Too much white in an environment creates a high level of glare and inadequate contrast, which can be hard on the eyes. However, if the space is not often occupied then this may not be a concern.

Conclusions

Here are key takeaways from this study:

- Illuminance varies with the types of containment in a data center
- Outside of the cabinet aisles, white cabinets result in about 25% higher illuminance than black cabinets
- Without containment, white cabinets result in about 50% higher illuminance in the aisles than black cabinets
- With cold aisle containment, illuminance in the cold aisles is reduced by about 45%, regardless of cabinet color. However, illuminance in cold aisles with containment is about 48% higher with white cabinets than with black cabinets
- With white cabinets, VEDs result in an increase in illuminance of about 75% in the hot aisle over no containment

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- With VEDs, white cabinets result in about 180% higher illuminance in the hot aisle over black cabinets
- Using white cabinets results in the same illuminance with fewer light fixtures, saving on installation costs and reduced lighting energy costs by about 25-35%
- Use of white cabinets instead of black cabinets, with the same room lighting in place, can increase illuminance inside the rear of cabinets by about 80%. However, if the room lighting is reduced to take advantage of the white cabinets' higher reflectivity, the increase in illuminance inside the rear of cabinets is reduced to about 15% higher than with black cabinets

Recommendations

Choosing a data center cooling strategy is a higher priority by far than cabinet color, but customers choosing to install aisle containment will need roughly twice the lighting over the contained cold aisles, regardless of the choice of cabinet color. Customers choosing to deploy white cabinets and VEDs should consider reducing the lighting in the hot aisles by half or more.

Reference

IES Lighting Handbook

Acknowledgment

Illumination modeling and simulation for this study were performed by Affiliated Engineers, Inc., of Chicago, IL.

About Panduit

Panduit enables data centers to realize their full potential through an integrated stack of physical and intelligent infrastructure solutions that drive actionable performance gains and efficiencies to reduce operating costs and maximize capacity of power, cooling, space, and connectivity for the greatest ROI. Bridging physical equipment (cabinets, copper and fiber connectivity, and pathways), intelligent solutions (monitored rack PDUs, intelligent patching, and DCIM software), and professional services, Panduit offers the most comprehensive integrated data center portfolios available from one single source vendor. Complemented further by strong technology partnerships, Panduit integrated data center solutions are designed to answer increasing demand for IT services and technologies, while simplifying growing complexity in the data center design.

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