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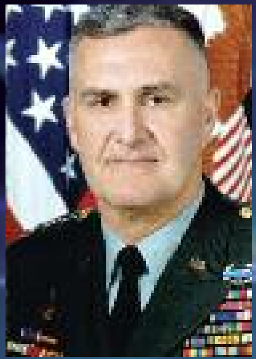
7x24 Exchange International

THE END-TO-END RELIABILITY FORUM

Promises, Promises: Does Your DCIM Solution Deliver?

PUSHING THE ENVELOPE: Expanding Environmental Conditions In The Data Center

Power To The People: Be Proactive When Meeting Power Distribution Needs



General Hugh Shelton
2011 FALL CONFERENCE
KEYNOTE SPEAKER

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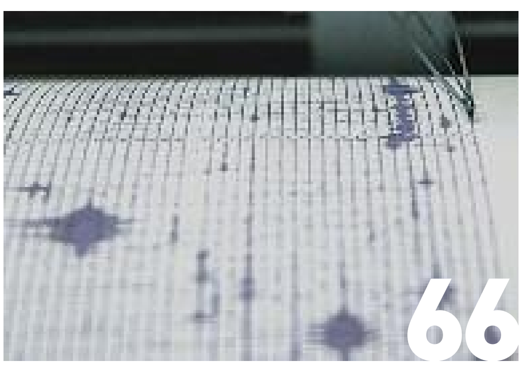
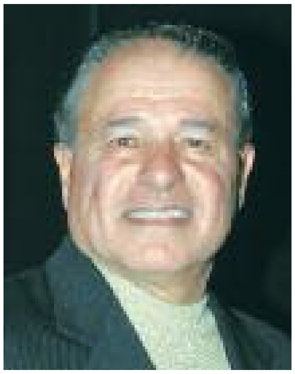


CHAIRMAN'S LETTER



Robert J. Cassiliano

Hope everyone was able to enjoy this summer despite all the catastrophic events!

The hurricanes, floods, fires, and earthquakes of this summer highlight the importance of hardened Mission Critical Facilities. Design and engineering of Mission Critical Facilities must consider these occurrences with regional sensitivity. Resiliency and redundancy are key design components in building a fault tolerant facility. Companies are going to be reviewing the ability of their data centers to be online all the time even during disaster events. This will provide opportunity for Mission Critical professionals to help design, engineer, build, retro fit, and operate high availability environments. Projects for hardening facilities will surely become a priority to assist in minimizing risk to business operation. Companies need to be knowledgeable regarding fault tolerant requirements and be prepared to support clients with creative thinking and expert resources to mitigate risk.

The theme for the 2011 7x24 Exchange Fall Conference being held at the Arizona Biltmore in Phoenix, Arizona November 13 – 16, 2011 is End-to-End Reliability: "Leveraging Innovation". Conference highlights are as follows:

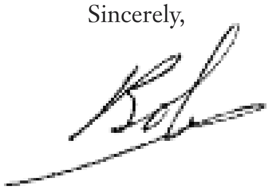
- Conference Keynote: "Leadership That Leaves a Legacy" presented by General Hugh Shelton, The Fourteenth Chairman of the Joint Chiefs of Staff
- Keynotes by MTechnology and AT&T
- ASHRAE Workshop – Greening of Your Data Center
- Presentations by AOL, Deutsche Bank, and Facebook
- Panel Discussion: The Hunt for Talent – with Panelists from Citigroup, Google, and AOL
- Presentations by The Green Grid and the Uptime Institute
- Exchange Tables on Specific Topics at Monday Breakfast and Tuesday Lunch
- An End-User Exchange Forum Luncheon on Monday
- Vendor Knowledge Exchange on Monday Afternoon

Sponsored Event: "An Evening at Corona Ranch"

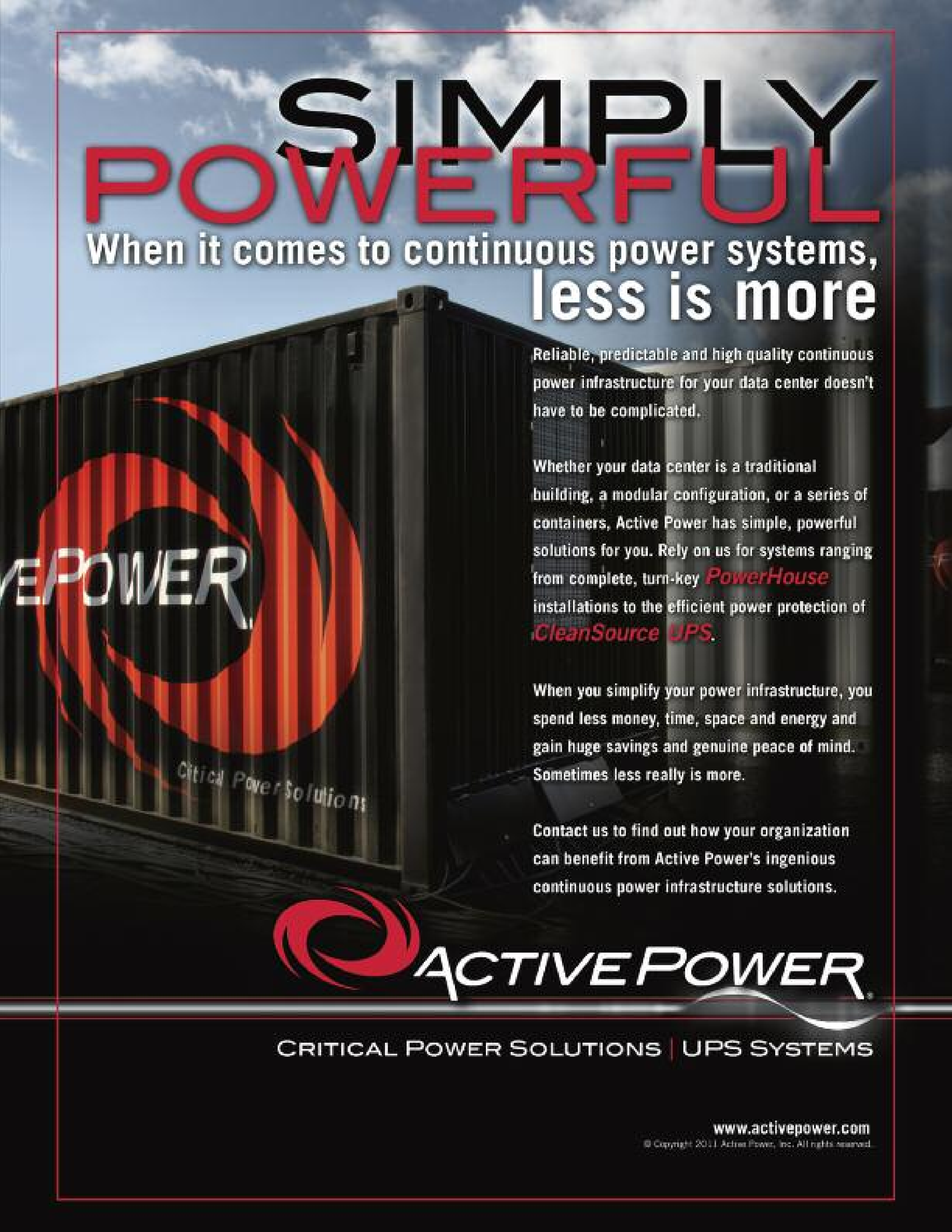
The program content is designed to provide value to conference participants and their companies by focusing on important topics of the day. Energy Efficiency, Cloud Computing, and attracting skilled professionals are highlighted at this year's Fall event.

I look forward to seeing you at our Fall Conference in Phoenix, Arizona!

Sincerely,



7x24 Exchange Chairman, Bob Cassiliano, presents the keynote speaker, Robert F. Kennedy, Jr. with a donation to Riverkeeper, NY's clean water advocate, on his behalf.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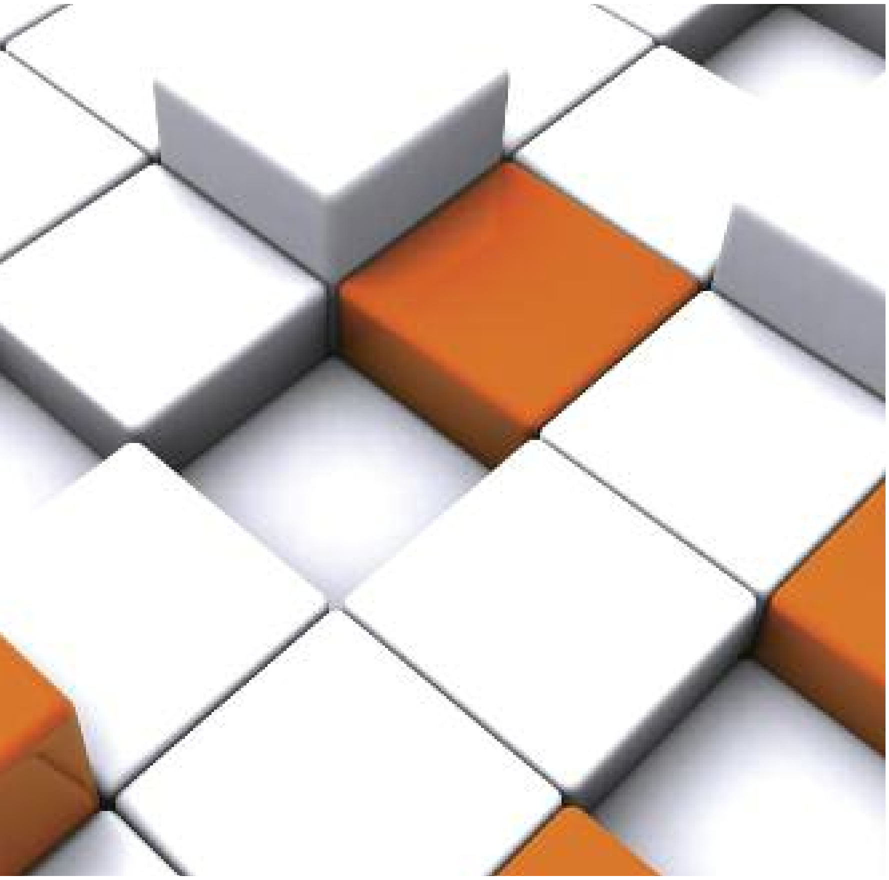

POWER TO THE PEOPLE:

Be Proactive When Meeting Power Distribution Needs

by Dave Mulholland

There's no doubt about it, the data center has become the most valuable asset in today's competitive business environment and this asset continues to expand. As *Digital Realty Trust* has stated, "The average US enterprise company has four data centers in operation, with an average size of over 15,000 square feet (60,000 in total)." Cloud computing is exacerbating the data center development, as *IDC* illustrated, "The market for cloud-computing services and software is expected to grow more than 27% annually over the next five years and reach $73 billion by 2015."

With the sheer volume of data that is stored, companies are constantly seeking new and better methods to maintain, access and retrieve data. But while much attention has focused on developing the right tools to manage and store information, there's one aspect that's been lost in the process – power distribution.

The bottom line: you can have all the servers in place to drive your data center, but all those spinning disks can present unnecessary cost expenditures if you're inefficiently utilizing power to drive these systems. It's important for companies to consider power distribution models...and take a proactive approach to keep costs down and profit margins up.

It's All About the Information

To fully understand the importance of an effective power distribution strategy, it's necessary to take a closer look at what drives the need for more effective management. At the very heart of this focus is the explosion of digital content.

The digital universe is growing at an unprecedented rate. Analyst firm IDC keeps tabs on digital information and how it's impacting the data center. According to the firm's new 2011 report, the volume of information is expected to more than double every two years. This translates to a universe of information growing nearly 50 times by 2020.

"IDC...released its annual survey, which found that the amount of data created and replicated is expected to top 1.8 zettabytes, or 1.8 billion TBs, in 2011, up from just over 1 zettabyte in 2010."

The survey reports this has major implications for anyone who stores and manages information: "The growth of digital data is faster than the

growth in storage capacity to store that data..."

The problem: digital content is putting a strain on the capacity to deliver it. If companies don't have a strategic plan in place, they will encounter a major roadblock – the problem is widespread. A recent *Information Week* article points to just how serious the problem is:

"More than a third...of data center facilities will run out of space, power, or cooling, or all of the above in 2011 or 2012, according to the Uptime Institute which recently surveyed 525 data center operators and owners...Of those that will run out of one or more data center lifelines, 40% plan to build a new data center, 62% plan to consolidate servers, and 29% plan to lease colocation space."

The real issue is companies are working with data centers that are old or cannot handle the growth. For this reason, a proactive development strategy is critical. The article continues:

"A Gartner survey last November found that 47% of representatives from 1,004 large enterprises from eight countries ranked data growth in their top three challenges. This was followed by system performance and scalability at 37%, and network congestion and connectivity architecture at 36%. Sixty-two percent of respondents reported that they will be investing in data archiving or retirement by the end of 2011 to address the data growth challenge."

Data center managers are squarely on the spot as their role has become one of strategic significance. IT is no longer relegated to the back room: They're front and center in strategic planning. IT is a core business unit as the right projects can accomplish a range of goals, such as growing market share, improving cycle time and introducing the right products to market.

"For all this, a CIOs role is crucial, as he shoulders most of the responsibility. He is required to work with heads of other departments to manage projects...that are business driven."

The question now becomes: How can you effectively plan for growth?

Getting the Right Plan in Place

It's now clear that information is driving the need for bigger, faster data centers. But it's not just about building out, it's about having the right strategic plans in place to ensure data is stored and managed efficiently in a cost-effective manner.

It's important to be a proactive thinker, prior to expansion, as it's not just adding more servers, but about choosing the proper servers as well as identifying methods to leverage the technology already in place. That's why companies need to plan before they build. Noted journalist and analyst Frank Ohlhorst says the solution is not what it used to be. Budget constraints are forcing companies to get creative.

"In the past, when large budgets, venture capital investments and growing revenues reigned supreme, solving data center overutilization problems was a simple matter of building a bigger and better data center. With today's economic downturn, that solution just won't fly. IT execs must perform due diligence before proposing a solution for an over-utilized data center, and that requires a long, hard look at the problem and all available options. With data centers, there are many paths to consider."

But it goes beyond having the right technology. Equally important is strategic planning for power usage and distribution. All the strategies in the world mean nothing unless you plan for the expanded use of power that's required to handle the new data center requirements.

Powering Up

With the continued growth of information and the corresponding expansion of the data center, it stands to reason this ups the demand for power. Recently, the Environmental Protection Agency (EPA) released a report on energy efficiency in the data center.

According to the report, power consumption more than doubled in a little more than 5 years, from 2000 to 2006. This number was expected to double yet again by 2011. This translates into big numbers and even bigger costs. The EPA estimated that the federal government alone could conceivably spend $740 million just for data center electricity in 2011. What was once a competitive advantage has now become a liability.

And it's not just about costs associated with expansion. It's the dramatic rise in the cost of power over recent years. Recently, the US Energy Information Administration took a hard look at energy prices. The Administration estimates pricing averages 11.6 cents per kWh in 2010 – which is a growth over the cost of 11.5 cents in 2009. This number is expected to hit 11.9 cents per kWh in 2011.

This growth has gotten the attention of the CFO as increased costs are impacting the bottom line. Electronics Cooling points out that power and cooling is even costing more than the IT equipment it supports.

"Historically, the cost of energy and the cost of the data center power and cooling infrastructure have not been on the radar for most Chief Financial Officers and Chief Information Officers and have not been considered in TCO models...This was a reasonable

assumption during the 90s, when server power and energy costs were substantially lower. However…power density has been increasing at an alarming rate."

Thus, an effective power and cooling strategy is the key to success. CIOs must keep a mindful eye on the power they're using, while planning for the future.

Taking a Proactive Approach

Far too often, companies take a reactive approach to power distribution. They're flying blind with the amount of power they need to drive their systems. In this scenario, it's a matter of trying, failing and revisiting before they get the right combination. This drives costs up and can lead to failures in the IT infrastructure. According to Electric Light and Power, approximately 92% of all outages result from poor planning on their power distribution system:

"An unscheduled power outage costs the average large industrial customers approximately $40,000, increasing to $75,000 for a four-hour outage. The Electric Power Research Institute estimates annual outage costs to society amount to $119 billion."

Companies must know their power paradigm before getting in too deep. They must turn their attention to auditing the data center's current power distribution systems.

A proper audit allows for both IT and facilities managers to evaluate the data center's power path leading to current servers, the efficiency of existing transformers and even a Kilowatt-per-cabinet analysis of existing server rooms. The audit empowers companies to optimize current power distribution and help the systems management team plan ahead for denser server loads.

It's important to work with a strategic vendor that understands power distribution specifically for data centers. Rather than writing a spec and having electrical contractors react, you need to know the current scenario before jumping in. This also means the facility and IT manager can no longer operate in silos. They both must be involved in the power and capacity decisions.

So the audit is crucial, but what will it tell you? There are many factors involved in a proper audit. You need to know the number of racks you'll need, as well as the kilowatts per rack. You need to consider both overhead or raised floor configurations.

Determining the Right Approach

Traditional thought dictates that traditional, raised floor configuration was the only choice for a mission-critical data center in an existing or retrofitted property. But the time it takes to build out or retrofit a raised floor model takes years. In addition, if a company is renting its data center space, the raised floor model makes it difficult to relocate when new space is needed.

But there are power distribution solutions available that allow facilities managers to circumvent that raised floor plan without sacrificing performance – modular, overhead bus lines. These are as easy to install as an overhead lighting fixture system and do not require further preparation of the concrete floor. On the other hand, for a facilities manager who needs to expand or develop a new data center site, a better option would be a containerized data center that can be housed indoors or outdoors with self-contained power and cooling options.

But design is not the only success factor. It's important to have a full monitoring system in place as well. System improvements simply cannot be made without taking the right DCiE and PUE energy and power usage effectiveness measurements. These measurements enable companies to deal with higher energy costs, the need for increased data center capacity, and the increase in energy usage.

An effective Branch Circuit Monitoring System brings the ability to monitor down to the server branch and circuit breaker level. It provides real-time load currents and voltages. The correct calculations will focus on total power on the panel level (KW, KVA, KVAR, PF and load percentage) – as well as the branch level. The right system will also provide warning and alarms alerting customers to their adjustable current, and whether a customer is over voltage or under voltage.

Harnessing the Power

It's not just about buying and building anymore when it comes to today's data centers. Information explosion is driving the build-out of larger, energy consuming data centers. Effective power management has taken center stage in this discussion, and the right strategy could save a company millions.

Companies must take a highly proactive approach to power planning. They need to have an accurate assessment of current usage and what it will take to plan for the future. In today's world, planning is everything, and you need to partner with a vendor that could help you power the data center without breaking the bank – Power to the People!

Dave Mulholland is Vice President of Marketing, Service for Power Distribution, Inc. (PDI). He can be reached at dmulholland@pdicorp.com


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HOW SHOULD I GROW MY DATA CENTER?

by Christopher M. Johnston, PE

Knowledgeable data center owners and operators have learned, to their regret, over many years that building too much or too little data center critical IT load capacity (simply called capacity in this article) at one time often causes major problems. This article examines the typical problems encountered, proposes a strategy for rational growth, and illustrates an example of how to implement the strategy.

When too much capacity is added at one time, three undesirable things inevitably happen:

- The Owner makes a larger Capital Investment (CAPEX) than is necessary, wasting limited funds to build capacity that will not be needed for many years. The Owner cannot make a suitable Return on Investment (ROI) until the overbuilt capacity can be put to beneficial use. For example, if the Owner's ROI criterion is five years payback, then it makes no financial sense to build capacity that will first be used more than five years in the future.
- The data center operates inefficiently because only a small part of the installed capacity is used, driving up the Operating Expense (OPEX), Total Cost of Ownership (TCO), and PUE. Data centers are typically designed to operate most efficiently at full capacity, and the efficiency drops off dramatically at partial load. For example, a typical low voltage, double conversion, static UPS system operates at 77% efficiency while at 10% load, and 92% efficiency while at 50% load or greater. A Dynamic Rotary UPS (DRUPS) has essentially constant losses, so a DRUPS that is 96% efficient at full load will be 71% efficient at 10% load. A facility PUE forecasted to be 1.5 at full load will deteriorate to 1.8 or more when operated at half load.
- The data center is more difficult for technicians to operate at low load. Water-cooled centrifugal water chillers have difficulty operating with a low percentage load and frequently surge and even drop off line. UPS battery service life often shortens if the UPS system is operated at low load. Variable speed motor drives become cranky and less reliable. Generator sets smoke and foul the engine exhaust system with unburned carbon, which is called wet stacking.

Conversely, when too little capacity is added at one time, at least three undesirable things can happen:

- The cost per kW for added capacity is greater for small increases than for large increases. The economies of scale and reduced costs expected when adding 2mW of capacity don't hold true when only 600kW of capacity is added.
- Getting the electrical and cooling capacity increases to line up in a simple, logical manner becomes a problem. If UPS capacity is added in 600kW increments, then the corresponding cooling load increments are about 200 tons. If the chillers are 1000 tons each, then another chiller, cooling tower, chilled water pump and condenser pump might be needed for a 200kW UPS capacity increase, or adding 200kW cooling capacity increments might require less efficient systems (such as air-cooled chillers) than more efficient technology with larger increments (such as high efficiency water-cooled centrifugal chillers).
- The risk to the operating IT load increases every time capacity is added to the data center. The more often we add capacity, the more risk we incur. Regardless of every effort to eliminate human error through elaborate planning and Methods of Procedure, we court disaster every time we add capacity in a live data center. This risk is particularly acute when capacity must be added to a UPS system that is already carrying critical IT load. Don't forget that the UPS system must be taken off line to add the additional module and to perform testing and commissioning.

So, how should we establish a rational strategy for planning load growth in both capacity and frequency? While details vary with different projects and different owners, there are four major components to the strategy:
(1) forecast load growth, (2) determine Day 1 capacity, (3) determine the timing of future capacity additions, and (4) master plan the ultimate facility.

The first step is to prepare a forecast of capacity needed over the operating life of the facility. Begin with the initial load when the data center opens (Day 1) and end 15 or 20 years in the future. Those preparing the forecast shouldn't worry that it won't be perfect (unless you have a better crystal ball than mine), but it will be the best initial effort. The forecast should be kept up-to-date during the life of the facility so it serves a guide for timing capacity additions and updating the strategy. For example, if the next capacity addition is required when the critical IT load reaches 3mW, and the updated forecast is that the load will reach 3mW in two years, then the capacity addition project should be begun far enough in advance so it is tested and commissioned 2–3 months before the capacity is needed.

When the data center opens on Day 1, you should have enough capacity for the first four or five years of operation. This preparation will permit the technical staff to become very familiar with the facility and all operations and maintenance modes before the first capacity addition is made. Adding capacity when the data center is new and the operations staff is not well-versed and comfortable in all operating and maintenance modes is a recipe for disaster. It's far better to build enough capacity for four to five years so all of the inevitable bugs will be revealed and resolved before adding capacity in a live data center.

You should plan for phased capacity additions at intervals of more than two years. This approach is sometimes called the "modular" concept of data center design. Additions at two year intervals or less keeps the data center in a state of constant construction and commissioning, thus increasing the risk to the operating critical IT load. Hard experience has taught that poorly planned construction causes more outages than routine operation in a live data center.

Master planning the facility for all phased capacity additions can prevent future problems by (1) identifying risks to the operating critical IT load, and then (2) establishing strategies to mitigate the risks. In a perfect world, each capacity addition would be free standing and not connect to any existing systems. In the real world, such a strategy produces very costly and inefficient designs. Expanding the capacity of existing systems is often more expedient, such as adding a 1000 ton chiller to an existing 3000 ton central plant rather than building a new central plant with two 1000 ton chillers. Master planning should identify how the addition will be connected and should provide proper valves, circuit breakers, and connections points to facilitate the addition at minimal risk. And while you're doing it, don't forget to provide some additional space for future infrastructure upgrades.

Here's an example of how this strategy was implemented in the conceptual design of a large data center.

1 The Owner's IT team prepared a critical load growth forecast showing 3mW of critical load at Day 1 initial operation, increasing to 10mW in the fourth year, and 40mW in the 15th year. The forecast was produced with some trepidation but was necessary for not only this effort, but also for use in Total Cost of Ownership (TCO) calculations used to assess alternatives.

2 Using the forecast, the team determined that the initial capacity would be 10mW, adequate to meet the forecast through the fourth year.

3 Again using the forecast, it seemed logical to design and construct the facility in four phases of 10mW each. Each phase will be built in a separate building on the same site, with Phase 1 adjacent to Phase 2, and Phase 3 adjacent to Phase 4. At the same time that Phase 1 is completed, the building shell for Phase 2 will also be completed. When Phase 2 is completed, the building shell for Phase 3 will be completed. This procedure will continue for Phases 3 and 4. A similar design could be easily done for a multi-story data center, except that the entire core and shell would be constructed as part of Phase 1.

4 As an example of what's done during master planning, an electrical utility substation will be installed on the site with 40mVA of initial capacity and capable of expansion to 80mVA capacity without affecting the operating critical load. Spare circuit breakers will be provided in the switchgear and cables will be run out to manholes for extension to future phases without having to work inside energized electrical switchgear. All of the utilities and spaces are planned in a similar manner. It's not essential to plan down to the wall switch and receptacle level, but it is essential to plan major systems so you don't find a fatal flaw in the original plan as you begin design for Phase 2.

In this article we have examined at a high level the problems encountered in adding capacity, proposed a strategy for rational growth, and illustrated an example of how to implement the strategy. We hope that this technique will assist the industry in determining when and how to add data center capacity.

Christopher M. Johnston, PE is Critical Facilities Chief Engineer for Syska Hennessy Group. He can be reached at cjohnston@syska.com

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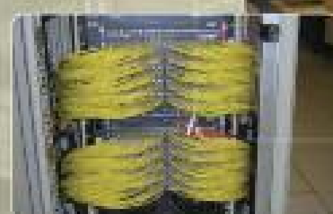

By Michael Dauffenbach

MAXIMIZING THE RELIABILITY OF STANDBY POWER USED IN MISSION-CRITICAL APPLICATIONS

Identifying equipment, systems design and maintenance procedures that contribute to dependable Emergency Power Systems

Mankato, MN – While standby power system reliability is a concern for any facility, it is especially important for mission-critical applications such as hospitals, data centers, telecommunications, government, municipal water and water treatment. Additionally, there are numerous organizations that rely on standby power systems for business continuity and to reduce exposure to monetary loss resulting from a utility outage.

To maximize reliability, facility managers need to understand and consider the critical factors that go into specifying, installing and maintaining a standby power system. These factors can be grouped into five categories:

1. Generator set design and manufacturing quality
2. Generator set sizing and power system design
3. Commissioning and operator training
4. Maintenance and periodic testing
5. Code compliance

While no mechanical system can be expected to perform with 100 percent reliability over time, modern diesel and spark-ignited standby power systems come very close to this ideal – provided they are properly designed and maintained. In fact, power system component failure is a fairly rare event, whereas the vast majority of problems result from human error or neglect. This paper will examine the factors that contribute to power system reliability and suggest ways to maintain it at the highest possible level.

What is "reliability"?

Before discussing ways to ensure better power system reliability, it is important to define the term. The Institute of Electrical and Electronics Engineers' (IEEE) Reliability Society defines reliability this way:

Reliability is a design engineering discipline which applies scientific knowledge to assure a product will perform its intended function for the required duration within a given environment. This includes designing in the ability to maintain, test, and support the product throughout its total life cycle. Reliability is best described as product performance over time.

To a great extent, reliability can be designed into generator sets, transfer switches, switchgear and control systems to increase the likelihood that they function as intended. Of course, the other part of the definition relates to maintenance, testing and support – all human activities that must be carried out as part of an overall plan to maximize reliability.

Another way to look at reliability is to consider it from an economic point of view. In general, to get the highest reliability, facilities will incur greater

costs for redundant equipment, advanced system design and more frequent maintenance.

For organizations that face life-safety risks or severe financial losses if their standby power system fails, it is often prudent to invest more to attain the highest possible measure of reliability. For example, this often means designing for N+1 redundancy in utility feeds, generator sets and UPS systems as recommended in the Uptime Institute's Tier IV design topology. While this redundant system design approach comes at a higher first-cost, power reliability and availability improve. N+1 redundancy also enables periodic equipment maintenance to be carried out without affecting the availability of the standby power system.

Actual measured availability of power systems in mission-critical data center applications ranged from 99.67 percent to more than 99.99 percent in a 2006 study by the Uptime Institute. At the higher end of the availability were systems with N+1 redundancy. However, the Uptime Institute noted in its study that actual availability was below the vaunted "Five Nines" (99.999 percent) sought by many mission-critical applications.

However, this higher cost must be weighed against the cost of power interruptions that disrupt manufacturing or business. Industry studies have found that the cost of downtime for a major corporation can range up to $6.5 million per hour. For certain businesses, it is clear that the additional investment in a more reliable power system will be a wise decision. In addition to financial considerations, the ability to maintain electric power to systems whose loss may impact human safety, such as ventilation systems, elevators and stairwell lighting, is also critical.

Each organization has to determine the level of reliability it can afford, or, conversely, the amount of risk it can tolerate. And, while spending more money for redundancy to eliminate single points of failure generally increases reliability, it also increases complexity, which at some point may, itself, threaten reliability. After determining what level of reliability may be acceptable and affordable, an organization must turn to the selection of equipment and suppliers.

1. Generator set design

Engines – Diesel engines are some of the most reliable prime movers ever designed and are the most popular choice for standby power applications. For optimum reliability, look for engines that are designed specifically for power generation applications and not simply adapted from off-road heavy-equipment applications. Engines specifically designed to power generator sets have been optimized to start and assume full load in 10 seconds or less and run at a constant rpm (1,500 rpm or 1,800 rpm). Because they operate at a constant speed, generator set engines also have different turbochargers than typical off-road or on-road engines, have different combustion parameters and need to meet different emissions levels.

For the highest reliability, look for generator sets with engines that have some measure of reserve horsepower capacity at the alternator's nameplate kW rating and a low brake mean effective pressure (BMEP). ISO 8528-5 identifies larger engine displacement and lower BMEP as key factors in a generator set's ability to accept load without an undue drop in output voltage and frequency. Engine manufacturers vary in their approach to this issue. Therefore, when one-step load-acceptance is called for in mission-critical applications, select a manufacturer that can provide a generator-drive engine with the highest displacement and lowest BMEP relative to nameplate kW rating.

New engine manufacturing quality standards practiced by some companies have helped increase the mean time between failures (MTBF) on engine components by a significant factor. Manufacturing improvements have included significantly higher machining tolerances, better metallurgy, sophisticated quality control systems (ISO 9001: 2008) and improved inspection and testing. In addition, the best modern engines are computer-controlled – which not only improves performance, economy and reliability, but also limits the possibility that an operator may inadvertently alter the engine's performance characteristics. Each of these incremental design and manufacturing steps taken by several leading engine companies helps to assure power system operators that mechanical failure of the prime mover will be a very unlikely event.

Alternators – As a major component in the standby power system, the ability of the alternator to supply its rated kVA and resist damage from transients is crucial to the reliability of any power system. While most major manufacturers utilize standard alternator protection schemes, more recent microprocessor-based controls take transient protection to a higher level. These introduce the feature of programmability into protective devices for over-current protection. For example, with modern molded-case circuit breakers (MCCB), the system designer can set the devices to activate very near the protection limits for the alternator. Older analog fault-protection methods had a lot of gray area, meaning that the protection points had to be quite conservative, leading to more fault occurrences than really necessary. The reliability of older thermal-magnetic breakers depended on the amount of regular exercise they received.

The type of alternator selected depends not only on the size of the electrical load it must supply, but also the types of loads. Factors to consider when specifying alternators for the most reliable power systems include temperature rise, fault tolerance and reactance issues, especially with large, nonlinear loads such as UPS systems and large motors.

2. Generator set sizing and system design

Appropriately sizing a generator set

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System design

Design considerations such as N+1 generator set redundancy, transfer switch selection, controls and ambient conditions play an enormous role in maximizing reliability.

- **N+1 system design** – The Uptime Institute has developed a Tier Classification of I – IV to describe the design topology of standby power systems used in mission-critical data center applications. Tier I topology (see Figure 1) represents a power system design with no redundancy – typical of most commercial standby power installations. In practice, according to the Uptime Institute, this design scheme results in approximately 99.67 percent availability annually.

Figure 2 shows a Tier IV topology that is recommended for mission-critical data center applications with the greatest need for power availability. With N+1 redundancy in utility feeds, standby generators and UPS systems, such a system is expected to deliver annual availability of approximately 99.99 percent. A standby system with multiple generator sets (either paralleled or segregated by loads) improves reliability because the scheme increases the likelihood that at least most of the generator sets will start and run as intended. In a paralleled N+1 system design, typically all generator sets start when there is an interruption in utility service. With proper configuration of the switchgear, the "extra" generator set will shut down after a time if all the other generator sets start and run normally.

- **Transfer switches** – The selection of the transfer switch depends on the types of loads on the system. Choosing the right mode of operation (open, closed or programmed) for the application can go a long way to minimize the stress of load acceptance on the generator set. This is especially true in facilities with large motor loads or large nonlinear loads such as a UPS system, motors with variable-speed control or other electronic loads.

- **Control systems** – Controls have been among the fastest-evolving power system components. Both analog systems and microprocessor-based digital systems offer high reliability, and both continue to be manufactured and used, depending on the application. There is a good argument that the monitoring capability of digital systems enhances reliability of the total system by helping to identify issues before they become problems.

Power systems that feature the flexibility inherent in open-protocol control systems and software ensure better compatibility and system integration – which leads to increased reliability. While certain proprietary control protocols may exhibit acceptable reliability as a stand-alone system, the likelihood of failure increases as these systems are interfaced with components from other manufacturers or software from

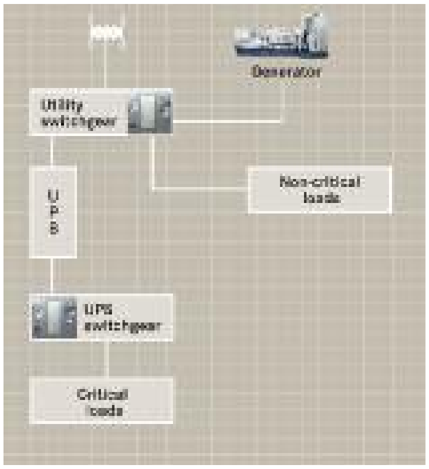

Figure 1. A typical Tier I design topology for a standby power system serving a few critical loads. Such a system has been shown to exhibit about 99.67% annual availability.

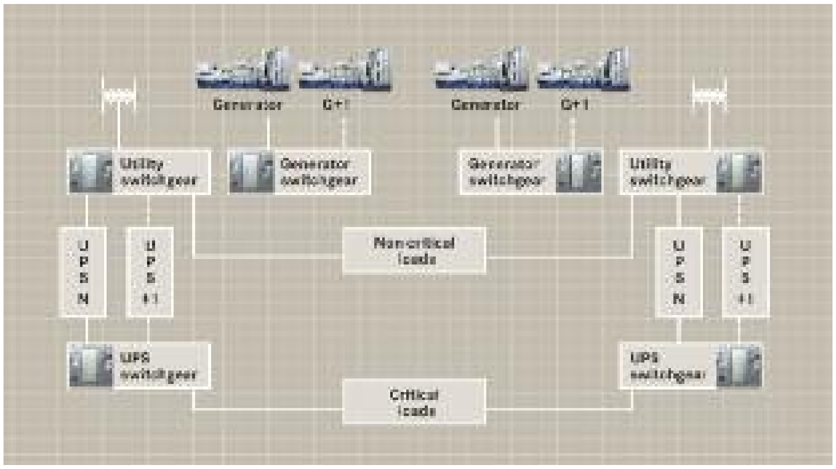

Figure 2. A standby power system with Tier IV design topology and full N+1 redundancy in utility supply, UPS systems and generator sets. This design has been shown to exhibit upwards of 99.99% annual availability.


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third-party suppliers. Proprietary control systems also complicate testing and maintenance if there are compatibility issues between components and subsystems.

- **Ambient conditions** – The operating environment must be taken into consideration when designing and installing a standby power system. Power systems in coastal regions are likely to need more frequent maintenance and inspection due to salt air. In areas of the earthquake-prone western United States, power systems used for mission-critical applications need to be designed and built to meet the seismic standards of the International Building Code (IBC). Similarly, site altitude and temperatures are important factors in system specification and design that may affect generator set rating.

3. Commissioning and operator training

Proper commissioning is essential to the startup of a standby power system and ultimately is essential for the system's reliability, regardless of its size, type or industry. As power systems become more complex, the commissioning process becomes even more important to confirm that the entire system functions as designed.

The purpose of commissioning is to verify that all components in the power system are functioning as designed in the event of a power outage. In fact, it is during commissioning that most design or installation flaws are uncovered. The generator set must start and accept load, and all alarm functions need to be tested and verified. If the system does not function as required, then remedial measures need to be taken. Following a commissioning protocol such as ASHRAE 0-2005 and the manufacturer's guidelines will ensure that the commissioning process will be implemented in a coordinated manner.

The commissioning process is also an educational opportunity for system operators and maintenance personnel, and it sets a baseline for future operational analysis. Making a video of the initial training session is one way to help new personnel quickly adapt to the established operating and maintenance routine.

Proper training of operating personnel is essential for a reliable standby power system since human error or neglect is responsible for the majority of power system failures. Personnel training begins during the commissioning process and should cover system operation, record-keeping and periodic maintenance. Operators must be familiar with all the power system components, alarm conditions, operation and maintenance procedures. Special attention should be given to critical subsystems such as fuel storage and delivery, starting batteries, engine coolant heaters, and air flow in and out of the generator building or enclosure. Frequent retraining is also necessary, along with making sure that personnel maintain an operational history of the power system. Consult your generator set manufacturer about factory training opportunities available to customers.

4. Maintenance and testing

Once a power system has been properly designed and commissioned, the most important factor in its long-term reliability is regular maintenance and system exercise. Some organizations undertake the maintenance themselves, while others opt for maintenance services direct from the generator set manufacturer or its distributor. See Figure 3.

Preventive maintenance of generator sets should include the following operations:

- Inspections
- Oil changes
- Cooling system service
- Fuel system service
- Testing starting batteries
- Regular engine exercise under load

It is important to establish a maintenance schedule that is based on the specific power application and the severity of the environment. For example, if the generator set is located in an extremely cold or hot climate, or is exposed to salt air, the generator set's manufacturer can help develop appropriate measures to deal with these special needs.

Like regular maintenance, periodic testing is required by code in mission-critical applications. It is best to exercise a generator set under the actual facility load it will be expected to supply in emergency conditions. When operated with the actual building load, the entire power system is tested – including the automatic transfer switches and switchgear.

Operating a generator set under no-load conditions can adversely affect its long-term reliability if the generator cannot get up to an exhaust temperature of approximately 650 degrees F before the test is over. It is very important that both the engine and generator reach this minimum operating temperature in order to drive off any accumulated moisture that may have condensed in the system. Under heavy load, diesel engines come up to operating temperature in a matter of minutes,

Figure 3. Regular exercise and maintenance of the complete power system are very important factors in high reliability.

whereas, without load, they may not reach operating temperature even after prolonged operation.

Most manufacturers recommend that generator sets be exercised periodically, loaded to at least 30 percent of rated capacity. If it is not practical to test with the actual facility load, permanent load banks should be considered in the initial power system design, or a maintenance contract should be considered with a service professional that can bring in a portable load bank to properly load the genset during the exercise period.

At least once a year, all facilities should exercise the power system under the actual facility load and full-emergency conditions to verify that the system will start, run and accept the rated load. Running for up to several hours under these conditions helps to test all the system components. (It should be noted that total operating time for testing may be limited by local authorities for the purpose of reducing exhaust emissions released into the air.)

Besides verifying that the generator set will start and run, periodic exercise has the benefit of heating up diesel fuel and eliminating accumulated condensation in the fuel tank. Since clogged fuel filters and fuel contamination are among the leading causes of power system malfunctions, the cycling and refreshing of fuel is an important step in ensuring overall system reliability.

5. Code compliance

There are a number of industry and governmental codes that address standby generator set and power system reliability issues. Some affect the manufacture of power systems, and some affect their installation, maintenance and operation. Compliance with all the appropriate codes will increase reliability. Codes addressing or impacting power system reliability have been established by the following organizations:

- **NFPA (National Fire Protection Association)** – Section 110 addresses the standards for performance for a standby power system and recommends monthly maintenance and periodic testing.
- **IEEE (Institute of Electrical and Electronics Engineers)** – Defines reliability and addresses protocols for improving it through analysis and testing.
- **NEC (National Electrical Code)** – Also known as NFPA 70, the NEC has become the de facto standard set of electrical requirements throughout North America. NEC Section 700 sets standards for commissioning of generator sets and sets operational parameters.
- **JCAHO (Joint Commission on Accreditation of Healthcare Organizations)** – Recommends minimum standards for standby power systems for healthcare organizations, including record-keeping, maintenance and periodic testing under load conditions to ensure reliability.
- **UL (Underwriters Laboratories, Inc.)** – A national testing and rating organization. Compliance with the organization's UL 2200 code is designed to ensure that standby power systems are safe. UL 1008 is a rating for automatic transfer switches that verifies the switch will operate reliably for at least 3,000 operations – a number that is not likely to be exceeded for many years.
- **IBC (International Building Code)** – Sets seismic standards for generator sets installed in geographic areas prone to earthquakes to ensure reliable operation after a seismic event.
- **ISO (International Organization for Standardization)** – This organization's ISO 9000 family of standards helps power system manufacturers develop quality control systems. ISO 8528 sets standards for load acceptance and transient response.
- **EPA (U.S. Environmental Protection Agency)** – Sets standards for emissions from many sources, including emissions from standby power systems.
- **Local air quality codes** – Recent air quality laws enacted in the South Coast region of California are restricting some generator sets to running a maximum of 30 minutes per month. This practice may affect the long-term reliability of standby power systems by reducing the frequency of power system testing and possibly damaging generator sets by not allowing them to reach minimum operating temperature. Where local codes discourage proper generator set exercise due to air quality concerns, consult your generator set's manufacturer for recommended exercise procedures.

Conclusion

Standby generator sets are very reliable machines with normal availability in excess of 98 percent on an annual basis. However, the generator set is only one component in a standby power system, and reliability needs to be considered in terms of the total system design.

In addition, close coordination between the facility manager and all the power system equipment and building automation system (BAS) suppliers during design, installation and commissioning is vital for maximizing reliability. This coordination is necessary to identify potential failure modes and develop solutions before problems occur. By considering these factors along with the generator set manufacturer's recommendations, managers of mission-critical facilities can be assured of the highest possible reliability of their standby power systems.

Michael Dauffenbach is Factory Training/Power Gen Specialist for MTU Onsite Energy. He can be reached at Mike.Dauffenbach@mtu-online.com

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LEVERAGING INNOVATION TO MEET MARKET DEMANDS

By Ian McClarty

Innovation has always been a driving force within the technology industry, and data centers are no exception. However, it is interesting how innovative concepts have helped shape the IT and data center landscape, and how they continue to do so.

Many traditional data centers were often times created and constructed with immediate need in mind. Companies needed to secure their data, and colocation facilities were developed to help them address their requirements. While this worked very well for the immediate needs of 10 to 15 years ago, some things were not carefully planned to be viable for the long-term. Fast forward a decade or so, and we began to see a shortage of available colocation space, along with other power constraints as technology continued to evolve and consume more and more power. In today's high-density colocation environment, it is not unusual to have server racks consuming 200+ watts per square foot.

This recent increase in new and innovative supportive technologies and infrastructure has many facilities scrambling to meet market demands. Instead of scurrying to simply meet client requests, data centers can effectively and efficiently leverage their design and infrastructure to successfully support clients not only today but for the long haul.

The question becomes, then, how has innovation allowed the industry to keep up with demand, and what innovative methodologies and processes are now taking center stage to help ensure everyone's needs continue to be met?

Security

Heightened security and compliance measures utilized by data centers ensure client's vital information is kept private and safe at all times. However, how safe is safe and how do clients know that their data is truly protected? It's one thing to have security staff onsite, but the compliance standards the industry has seen develop assist in creating peace-of-mind for clients. Perhaps they are not the first thing people think of regarding data center or technological innovation, but SAS 70, PCI DSS, and SSAE 16 in the near future, help address many data center security market demands. While the SAS 70 standards have been around for quite some time, their application to data center facilities is commonly seen as a benchmark of sorts for security. This, in turn, has created an environment that allows facility operators to address the demands of today's increasingly data-driven world, and continue to do so moving forward. The SSAE 16 standards will effectively replace SAS 70 in the next few months, helping ensure U.S. service organization reporting standards mirror and comply with the international standard – ISAE 3402.

PCI DSS is a much more recent example of an innovative concept applied to service providers, including data centers. Again, through the assessment of a facility's security features by qualified auditors, a data center is able to present a suitable solution to anyone that takes online payments. Here we see how the rise of e-commerce created a market need, and how a new concept, the PCI DSS standards, helped address it. These are just two examples of keen security certifications that were developed and applied to our industry. There will no doubt continue to be others in the days ahead and the IT solutions provider or data center that sets itself up to achieve them will continue to be successful.

Infrastructure

Infrastructural support is a key component of any data center and an important aspect to potential clients. Additionally, this area has been and will continue to be a driving force when it comes to innovation. The power, cooling and network systems a data center leverages help to set it apart and distinguish it from competitors. Not to mention, the systems in place today can help address the changing market needs of tomorrow.

A facility that is predicated upon state-of-the-art infrastructural designs will find itself in an advantageous position. For instance, supporting infrastructure that embraces modular design concepts enable a data center facility to not only address today's needs, but scale and expand as necessary to meet future requirements. Leading infrastructure providers are well aware of this and have been developing systems and equipment in a manner to help capitalize on the ever-growing and ever-changing market demands. Whether it is a modular chiller plant, a medium voltage UPS system, or something else entirely, innovations made at the manufacturer level shape how a data center is able to be designed and successfully grow with evolving technology requirements.

Another area that infrastructural innovation has helped shape markets is overall data center efficiency. With green initiatives filtering into the industry landscape, power usage effectiveness (PUE) and energy efficiencies are increasingly critical to

success. State-of-the-art power and cooling designs only get you so far. The supportive technology has to be in place first, or the design will be meaningless. Fortunately, there is no shortage of innovation within data center infrastructure systems.

Cloud

There is maybe no technology concept today more talked about than cloud computing. With this increasing interest, more and more businesses are looking into learning and investing in the unique product. Subsequently, many data centers are re-examining current technologies to prepare for the future and address market demands. However, instead of redesigning an entire system, which could require significant additional capital investments, data centers can leverage existing techniques, provided they considered future needs during the design process.

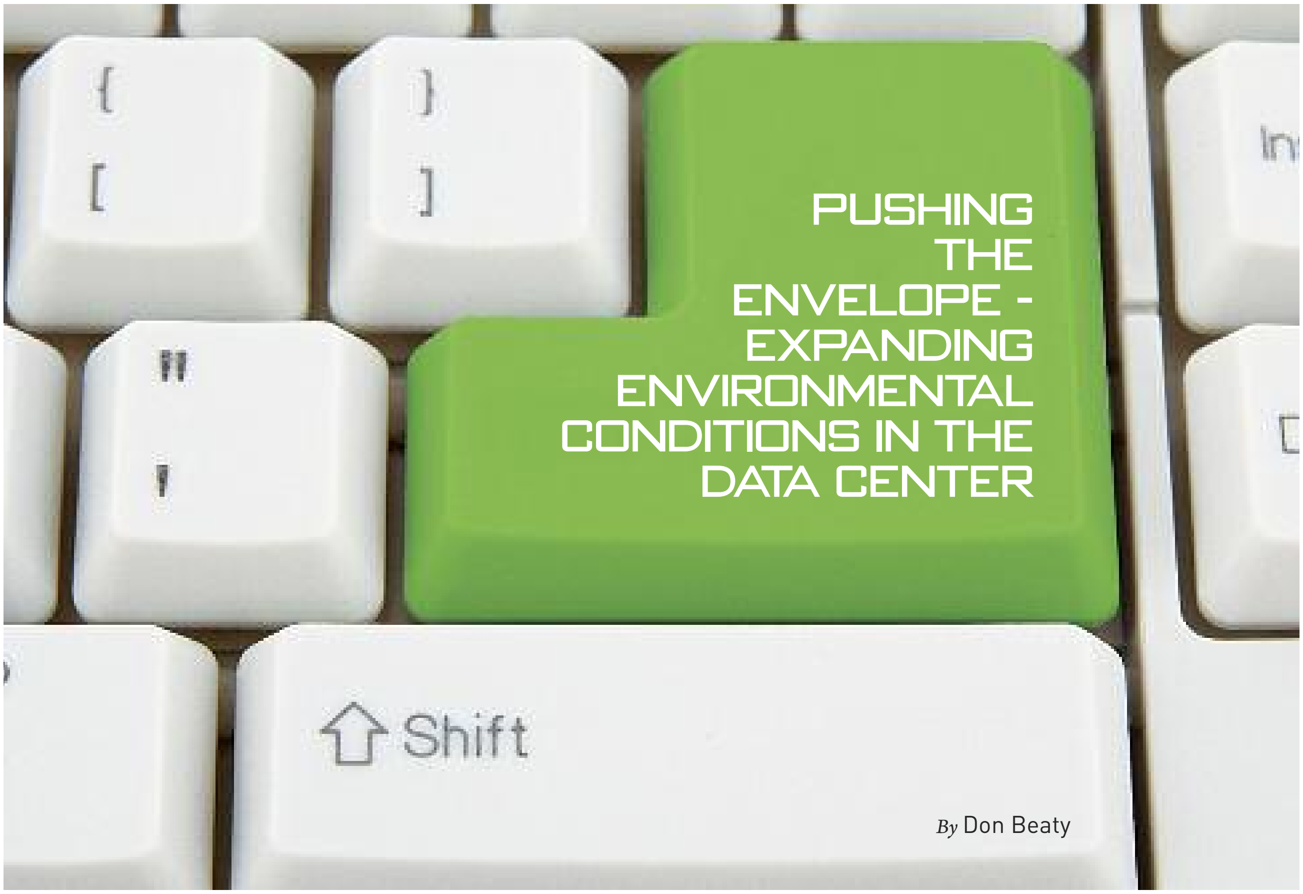
Power and cooling needs for a cloud server are going to be different than those of a colocation solution, and the underlying support systems of a data center need to account for that. Case in point, a cloud server may only be powered on for short periods of time, whereas a more traditional server requires a more continuous power supply.

Although cloud may be a relatively new topic, data centers can leverage current infrastructure, design and security arrangements to fit the needs cloud computing requires, provided the innovation within those systems allows for it.

The Road Ahead

Meeting the current and ever-changing demands of clients and their businesses is an ongoing process. However, with the right approach and mindset, they can be successfully addressed. Fresh innovations and new systems are constantly being developed within the technology and data center infrastructure space, helping ensure solutions meet requirements. A few of these innovations have been highlighted here, and who knows what the future will bring? One thing is certain, a data center that is open to or set up to accommodate these innovations will continue to grow and adjust as necessary to provide optimal IT solutions.

Ian McClarty is the president of Phoenix NAP. He can be reached at ian@phoenixnap.com



PUSHING THE ENVELOPE - EXPANDING ENVIRONMENTAL CONDITIONS IN THE DATA CENTER

By Don Beaty

Opening Comments

The industry is continuing to adapt to a changing landscape of efficiency mandates making energy consumption one of the primary considerations. Previously, reliability considerations dominated the design of mission critical spaces with energy consumption being a secondary concern. The operational environmental envelope within the data center (temperatures and humidity) can have a significant impact on energy consumption. ASHRAE has continued to adapt along with the industry by periodically expanding their thermal environmental envelope guidelines. The following data points illustrate how periodic expansions of recommended temperatures have evolved:

- ASHRAE 2004 – 68 °F to 77 °F
- ASHRAE 2008 – 64.4 °F to 80.6 °F

Beginning in 2004, ASHRAE published both Recommended and Allowable Ranges for IT equipment thermal envelopes. The industry's long term experience with reliability dominating decisions regarding cooling resulted in very few installations and operators implementing the Allowable Range even though it created significant opportunities for both capital cost and energy cost savings.

Another influence observed for not operating within the Allowable Range was a lack of industry validated failure rate data which could identify the potential consequences of operating within this envelope. In May 2011, ASHRAE published a Whitepaper that provides this failure rate data, information the industry has been seeking for years. This Whitepaper provides groundbreaking information that can radically change how we think about server cooling.

In order to responsibly pursue and apply these opportunities for CapEx and OpEx savings, the following basics need to be understood:

- Where are the temperatures measured?
- What are the differences in the Data Center Environmental Equipment Classes?
- What is an Environmental Envelope and why not a simple range?

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- What are the definitions of Recommended and Allowable Envelopes?

In 2004, ASHRAE established that temperatures for compliance with the guidelines were to be measured at the air inlet to the IT equipment. Figure 1 shows the measurement points at both the server and rack level. Measurement at the server level shows conformance with the manufacturer's requirements and measurement at the rack or even row level is for systemic purposes such as facility health.

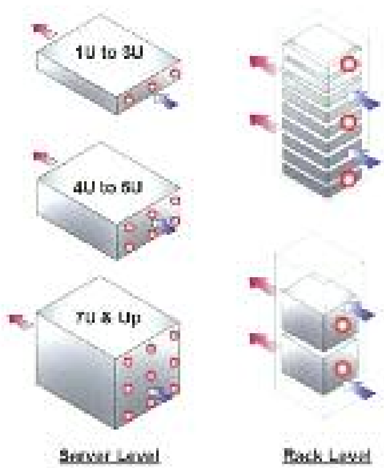


Figure 1 – ASHRAE Thermal Guidelines Measurement and Monitoring Points

Recommended Envelope:

The purpose of the Recommended Envelope is to provide guidance to data center operators on maintaining high reliability while simultaneously operating their data centers in the most energy efficient manner. The Recommended Envelope is based on IT OEM's expert knowledge of server power consumption, reliability, and performance vs. ambient temp.

Allowable Envelope:

The Allowable Envelope represent parameters that IT manufacturers use to test their equipment in order to verify that functionality within those environmental boundaries.

There are many different uses and requirements for both IT equipment and data centers. To address these differences, ASHRAE established Environmental Equipment Classes. In 2004, the categories were defined as Classes 1 to 4. In 2011, the data center Classes were modified to be defined as Classes A1 to A4. These Classes vary the environmental requirements with A1 being the most stringent and A4 the least stringent. Figure 2 provides an overview of the amended 2011 Classes as well as a comparison with the 2008 Classes.

Figure 3 provides the environmental specifications for each of the classes including both Recommended and Allowable. The specifications include parameters for dry bulb temperature, % relative humidity, dew point and rate of rise limits. There are variations as to whether % relative humidity, dew point, or both is listed. The intent was to expand the environmental envelope and to most effectively define a given environmental condition.

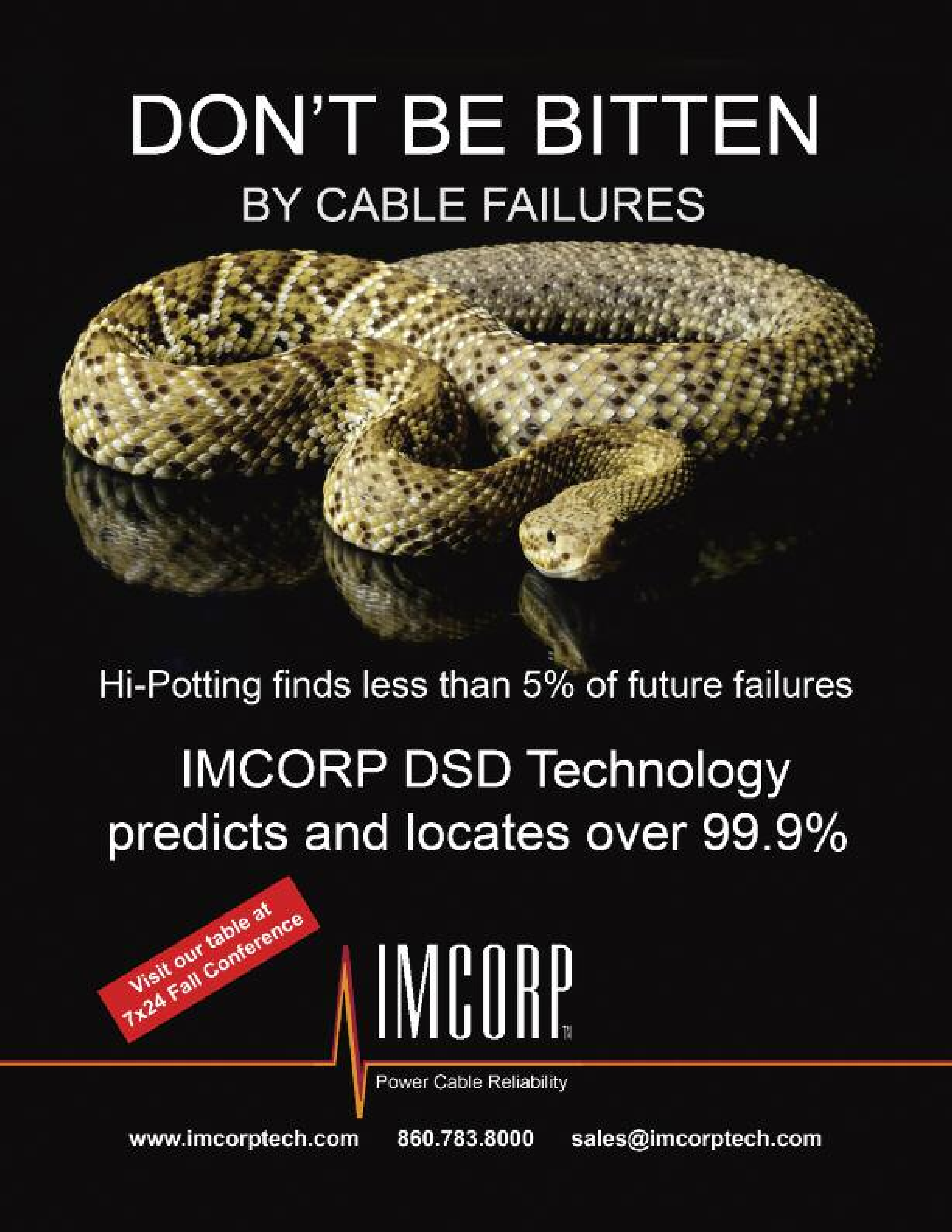
Explaining psychrometrics is not within the scope of this article but some overall psychrometric characteristics are important to mention. Reliable IT equipment performance is dependent on both temperature and humidity and the most effective way to visualize this relationship is with a psychrometric chart (Figure 4).

The example chart includes dry bulb temperature, wet bulb temperature,

ASHRAE Table 3. 2011 and 2008 Thermal Guideline Comparisons (modified)

2011 Classes	2008 Classes	Applications	IT Equipment					Environmental Control	
			Server Enterprise	Server Volume	Storage Products	Personal Computers	Workstations	Tightly Controlled	Some Control
A	B	C	D	E	F	G	H	I	J
A1	**1**	**Datacenter**	X		X			X	
A2	**2**	**Datacenter**		X	X	X	X		X
A3	**N/A**	**Datacenter**		X	X	X	X		X
A4	**N/A**	**Datacenter**		X	X	X	X		X

Figure 2 – ASHRAE Table 3: 2011 and 2008 Thermal Guideline Comparisons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ASHRAE Table 4. 2011 Thermal Guidelines - Fahrenheit (modified)

Data Center Classes	Equipment Environmental Specifications							
	Dry-Bulb Temperature		Humidity Range, non-Condensing				Maximum	
	Low °F	High °F	Low		High		Dew Point	Rate of Change(°F/hr)
Recommended								
A1 to A4	64.4	80.6	41.9°F DP		60% RH	59°F DP		
Allowable								
A1	59	89.6		20% RH	80% RH		62.6	9/36
A2	50	95		20% RH	80% RH		69.8	9/36
A3	41	104	10.4°F	8% RH	85% RH		75.2	9/36
A4	41	113	10.4°F	8% RH	90% RH		75.2	9/36

Note: Recommended applies to all A classes; evaluate ITE metrics in this paper for conditions outside this range.

Figure 3 – ASHRAE Table 4: 2011 ASHRAE Thermal Guidelines provides environmental specifications for equipment

dew point temperature, and % relative humidity conditions. By plotting any two of these conditions, the remaining conditions are determined. There is an environmental envelope shown in Figure 4 for the Recommended Range as well as for the Allowable Ranges for all Data Center Classes.

The word "Allowable" in Allowable Range really says it all. Implementing the Allowable Range permits data centers to achieve significant reductions in CapEx and OpEx based on the expanded range of environmental values. This would be an easy decision if there was no concern for the reduction of server life or server reliability by doing so.

Though it is anti-intuitive, there are actually situations where operating in the Allowable Range does not reduce server life and server reliability and may in fact, actually improve these characteristics.

The fundamental basis for this statement is that server life and reliability are largely dependent on their individual operating conditions. While this may seem obvious, what is not so obvious is how much impact the variation in conditions and their cumulative impact can have.

This situation is loosely analogous for any equipment that may be exposed to an extreme condition for a short time period versus a long time period. Ultimately, the comparison of these operational modes can yield a significant difference in life and reliability. This description can be expanded to encompass two conditions:

- Extreme optimum conditions
- Extreme harmful conditions

Consider the following three scenarios. The initial reaction might be that Scenario 1 is the best from a life and reliability perspective. However, there is at least some temptation to consider Scenario 3 as being the best from a life cycle and reliability perspective.

- Scenario 1 – 100% of lifetime at constant "average conditions"
- Scenario 2 – 90% of lifetime at an "extreme harmful condition"
- Scenario 3 – 90% of lifetime at an "extreme optimum condition"

The ASHRAE Whitepaper demonstrates, with some supporting statistical data supplied by manufacturers, that volume server hardware failure rate decrease with a reduction in temperature. On the surface, this supports the historical notion that "colder is better" with respect to overall data center operating temperatures.

In general, colder being better is

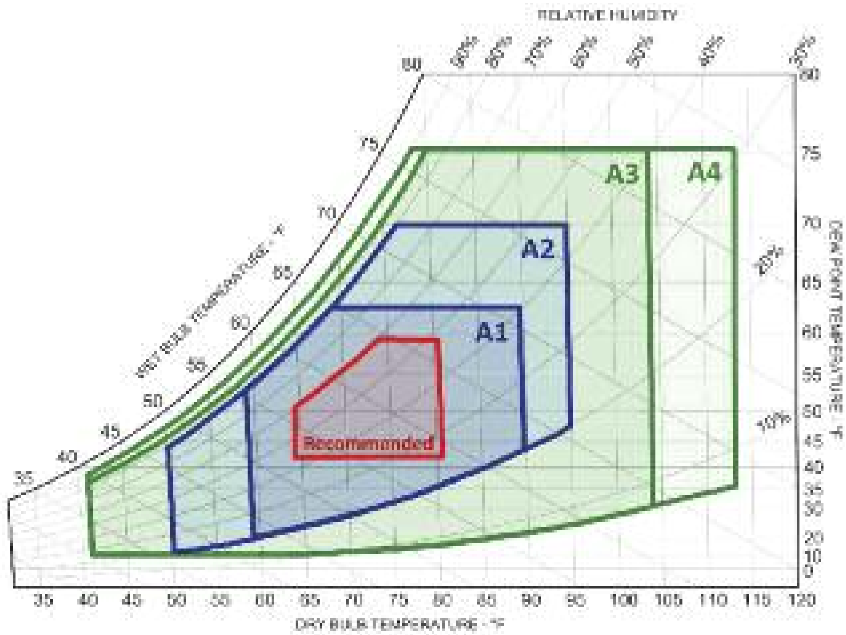


Figure 4 – ASHRAE psychrometric chart shows how the environmental classes have expanded

true from a failure perspective as long as a non-condensing environmental conditions are maintained (above the dew point). However, using compressorized cooling (traditional cooling equipment) to produce a colder environment may needlessly consume energy which can negatively impact both CapEx and OpEx.

As an alternative to relying solely on compressorized cooling, an economizer system may be used to supplement and in some cases entirely replace the necessity for mechanical cooling. A simplified definition of an Economizer Systems is one that takes advantage of the climate outside being able to be used directly or indirectly provide cooling without the use of compressorized equipment. The ASHRAE Allowable Range for classes A1 to A4 enables an expand number of hours per year that the climate outside can meet the allowable conditions for proper IT equipment functionality.

Assume a data center is currently operating with a constant server air inlet temperature of 70°F. Depressing the air inlet to lower temperatures using compressorized cooling may decrease that equipment's efficiency and subsequently increase OpEx costs. However, if the outdoor temperature is less than say 65 °F for a large number of hours per year, the opportunity exists to operate at server air inlet temperatures below 70 °F. This lower operating temperature provides better server conditions from a life cycle and reliability perspective.

Figure 5 shows the temperature impact on the failure rates of volume server hardware. It is important to note that these failure rates were assembled by ASHRAE TC 9.9's IT OEM subcommittee which included many IT OEMs. The data is derived directly from IT OEMs and provides valuable historical perspective on real-world reliability.

Servers themselves are used for many purposes. These can include highly critical applications to ones with minimal criticality or even time sensitivity. The almost limitless variation in applications means there are different operational strategies amongst data center operations. This variation results in no single baseline applying to all applications.

To resolve this variation in operating profiles, ASHRAE created a relative baseline. That baseline assumes a constant 68 °F operating temperature. This condition is labeled as an "X Factor" of 1. Where the temperature impact on volume server hardware failure rate is lower than the baseline, the "X Factor" is less than 1. Conversely, where the temperature impact on volume server hardware failure rate is greater than the baseline, the "X Factor" is more than 1.

It is important to note that the "X Factor" is relative. For example, if a facility operating at a constant 68 °F has 5 server failures / year, if the "X Factor" was 0.8, then the expected failure rate would be 0.8 x 5 server failures = 4 server failures / year. Conversely, if a facility operating at a constant 68 °F has 5 server failures / year, if the "X Factor" was 1.4, then the expected failure rate would be 1.4 x 5 server failures = 7 server failures / year.

Significant opportunities exist for maintaining a server failure rate equal to or less than that created when using traditional

ASHRAE Table C-1. (modified)

Temperature Impact on Volume Server Hardware Failure Rate

Dry Bulb Temp (°F)	Failure Rate X-Factor		
	Lower Bound	Average Bound	Upper Bound
A	B	C	D
59.0	0.72	0.72	0.72
63.5	0.80	0.87	0.95
68.0	0.88	1.00	1.14
72.5	0.96	1.13	1.31
77.0	1.04	1.24	1.43
81.5	1.12	1.34	1.54
86.0	1.19	1.42	1.63
90.5	1.27	1.49	1.69
95.0	1.35	1.55	1.74
99.5	1.43	1.61	1.78
104.0	1.51	1.66	1.81
108.5	1.58	1.71	1.83
113.0	1.67	1.76	1.84

Note: Relative Hardware Failure Rate X-Factor For Volume Servers As A Function Of Continuous Operation

Figure 5 – ASHRAE Table C-1 Temperature impact on volume server hardware failure rate

ASHRAE Table 7 (modified)

Time-At-Temperature Weighted Failure Rate Calculation For It Equipment In Chicago

Location	% Bin Hours and Associated X Factors for Chicago at Various Temperature Bins								Net X-Factor
	59 - 68 °F		68 - 77 °F		77 - 86 °F		86 - 95 °F		
	% of Hours	X Factor	% of Hours	X Factor	% of Hours	X Factor	% of Hours	X Factor	
Chicago	67.80%	0.865	17.20%	1.13	10.60%	1.335	4.60%	1.482	0.99

Figure 6 – ASHRAE Table 7 Time at temperature weighted failure rate calculation for IT equipment in Chicago

compressorized environment is illustrated in Figure 6. The table shows a time at temperature weighted failure rate calculation for IT equipment, using Chicago bin data. This calculation shows that even with temperature excursions into the Allowable range during summer extremes in Chicago, the aggregate effect of using a compressorless cooling system in this location yields less failures.

This is an eye opening development. Returning again to the previous three Scenarios, the Chicago example is actually a demonstration of Scenario 3.

- Scenario 3 – lifetime where 90% of the time is "extreme optimum condition"

In conclusion, the data center industry is currently in a highly adaptive mode with many fundamental precepts of design and operation experiencing significant changes. How we think about providing cooling and subsequently cooling system reliability needs to be reevaluated in light of evolving industry data and mandates for greater efficiency.. Embracing a much broader view of potential solutions may result in significant CapEx and OpEx savings with no compromise in reliability and perhaps potentially yielding a net increase.

Don Beaty is President of DLB Associates. He can be reached at dbeaty@dlbassociates.com

CLOUD COMPUTING AND DISASTER RECOVERY

By Yan Ness

Why DR?

It's about Business Process Assurance

Disaster Recovery investment is essentially an insurance policy that critical business processes continues at an acceptable service level after a variety of disaster scenarios. If the business processes do not work under the designed-for disaster scenarios, the DR investment is wasted and the enterprise is put at risk.

So a good DR plan starts with an explanation of the business processes it is intended to protect and under what scenarios. This also helps your business leaders know what is at stake as you present DR costs and benefits.

Business Process *is* Software

In today's workplace, most critical processes of any scale are automated by software. Whether you have 5 employees and use QuickBooks or 50,000 and use SAP it's likely your business cannot operate properly without the invoicing, accounts receivable, payroll or payables supported by that software. The manual processes such as entering paper invoices or printing paper checks need to continue as well. But without the software and the data, there's little or no ability to do so. No longer is there a file cabinet with the paper records to fall back on.

Knowing the business processes at stake allows you to identify which software applications need to be protected, and to what degree.

Software needs Hardware

All software applications run on a collection of power strips, network cables, switches, routers, servers, storage devices, load balancers and security appliances. Today's stack is complicated and can involve many devices and configurations all of which must be in synch to operate properly. To properly design a stack requires understanding all its layers, from the power strip at the bottom to the application at the top.

Since you know what software to protect (based on the processes you're protecting) you can identify which hardware to protect and you'll know exactly why you're protecting that hardware. The cost of redundant hardware and data replication often exceed the perceived value, measured by dollars or processes protected, of a warm DR site.

The threats to your hardware, and hence the scenarios under which you want DR, can be described as a spectrum of damage from minimal to incapacitated.

Failure Spectrum

What's a Disaster?

Instead of defining an exhaustive list of

hypothetical disaster scenarios at the risk of missing one, we use the failure spectrum to identify levels of failure. The failure levels are cause-agnostic within a stack, but they help us identify how we are (or are not) covered against that degree of failure.

At the lowest level of the failure spectrum, a failed power supply in a server or failed disk drive in an array might occur. Any application running on a single server with a single power supply and no backup is certainly exposed to a catastrophic level of failure result in the case of a power supply failure. A more severe degree of failure would include a catastrophic failure to an entire server (CPU, RAM, melt down etc).

At the highest level of the failure spectrum are things such as a building fire that destroys the stack and all its surroundings. Any production environment without proper offsite backup could experience a complete loss of critical processes and data records. A well designed DR plan must protect the company against failures at this end of the spectrum.

Failures at the lower end of the spectrum are more common than those at the top, but can be just as catastrophic. So it makes sense to invest in the lower ends of the spectrum first. And this is where cloud computing really helps DR.

Cloud and DR

All Clouds are Not equal

Well-designed clouds should isolate the virtual server from the hardware. This means that if the host hardware has a catastrophic failure, the virtual server should still be able to run, albeit with a small delay. This is what it means to isolate the virtual server from the hardware host. But most cloud offerings don't isolate your virtual server from the host it runs on. In many cloud computing offerings, a single host failure causes all virtual servers on that host to fail. In other words, there is no hardware isolation. To use Cloud Computing to improve your chances of surviving a disaster, you must have hardware isolation.

Hardware isolation is achieved by building a cloud that has N+1 (or 2N) hosts and uses virtualization technology that will automatically fail over a server from one host to another.

DR from the Clouds

Once your environment is in a private cloud, the Disaster Recovery infrastructure becomes much less expensive and less complex.

First, you are well protected against a catastrophic server failure, assuming you have hardware isolation in an N+1 server environment. Since this is more common than more serious damages higher up the failure spectrum, this alone can drastically decrease a company's risk of IT failure. In fact, a 2010 study by the Aberdeen Group showed that cloud users experienced more improvement in decreasing downtime events over the past year, decreasing 9 percent, while non-cloud users decreased only 4.7 percent. Moreover, the impact of downtime was also decreased. The average length of downtime per disaster recovery event was 8 hours for non-cloud users, and 2.1 hours by cloud users (nearly four times faster).

But the bigger benefits of cloud computing come at the point of executing the disaster recovery infrastructure. Just compare the cost and complexity of a DR plan for 25 physical servers with 8 network switches versus a private cloud with 3 hosts, 2 network switches and 1 SAN (RAID and redundant controllers).

Moving the 25 physical servers to an N+1 private cloud first protects against more common failures such as hardware or server failure. But virtualizing your servers also essentially converts your server hardware to software. Each server becomes represented by a file that you can copy and move around. So to DR a server, you merely have to copy a file. It's a lot easier – and cheaper - to replicate a file than hardware. Better yet, it makes your server hardware agnostic, so you no longer have to maintain exact duplicate hardware stacks and all of the consequent software patches. You have the option of using a minimal resource footprint for your DR stack, knowing that if it has to become production, dropping in an extra server or storage will seamlessly increase its capacity.

A private cloud with a few hosts and a SAN can use tools like SAN to SAN replication, Site Recovery Manager by VMWare, VEEAM by VEEAMSoft, or any number of available products to replicate the servers as files. Ideally, the virtual servers will go to a 2nd offsite location in a way such that they can be started quickly in the event of a disaster.

The morale of the story is, wait until you've moved your environment to a private cloud before implementing a 2nd offsite Disaster Recovery infrastructure. You'll find it much

simpler and cost effective.

We eat our own dog food

We used to have a suite of about 20 physical servers at each data center for our own corporate infrastructure. We have databases, monitoring, management, web, content and numerous other servers that manage and deliver our services. It's critical that the business processes and application those servers support are operating normally at all times.

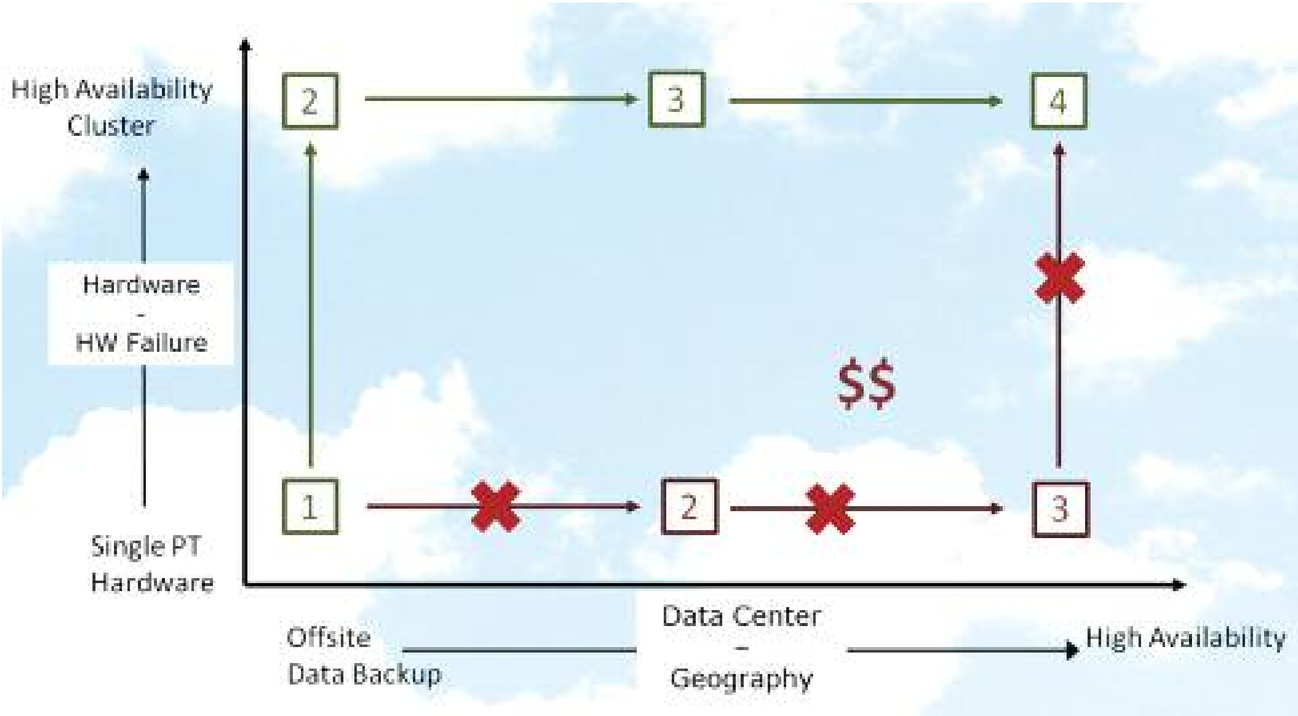
We used to use a complicated, offsite backup process for the 20 physical servers that would move the data to another site. We had spare servers and a long, cumbersome, step-by-step process for restoring data and applications in the case of a disaster. As we added more physical servers (we got up to 28), we had to expand that pool of available hardware at the same rate – and maintain all of it.

We migrated 27 of the 28 physical servers to a Private Cloud with 3 hosts and a SAN. It has capacity for about another 20 servers. We put a second Private Cloud at another data center. We use VEEAM to backup each host to the second private cloud at the other data center. We have a 2 hour RPO and 2 hour RTP for all 27 servers. We test it a few times a year, and the failover is reliable and fast. Sometimes we use it to fail over just a few servers that make up a single application. Every time we add a new virtual server to our private cloud, it automatically comes with DR coverage. Now our incremental cost to have warm DR for every new server is slight. Our protection against disasters is significantly improved just by our move to the cloud.

Summary

We've seen companies spend a significant amount of money for a DR site with redundant hardware and data replication to protect against production hardware failures. This is a very expensive way to protect against hardware failure. Save everyone time and money by first migrating to an N+1 (or 2N) cloud. Then, at minimum, always invest in offsite backup. That way, when you get asked "When will we be back up?", you can at least answer "The good news is 'not never'. The bad news is, I'm not sure when." The most cost-effective thing you can do to increase the protection of your business processes is to move the applications that support them to an N+1 (or 2N) private cloud. This provides significant protection against whole server failures without the cost of moving production from one data center to another and greatly simplifies the upgrade in resiliency from "Not Never" to "within 4 hours."

When the time comes to implement a warm DR site, you'll find that starting from the N+1 private cloud gives your company a huge head start.



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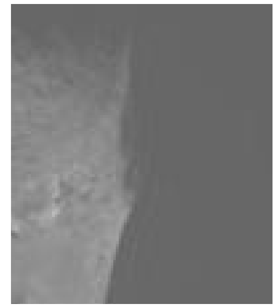


IMPACTS on Data Centers from the new ASHRAE 90.1-2010 Energy Standard

by Dennis Julian, PE, ATD, DCEP
Wayne Drooks, PE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) goal for the 2010 edition was to reduce energy costs by 30% compared to the 2004 version. Capital costs and return on investment (ROI) were not considered during the process.

Previous editions of this standard have been interpreted to exclude data center equipment from the energy efficiency requirements since they were considered to be process loads. The new 2010 version specifically includes data centers and introduces additional specific requirements on total system efficiencies and individual equipment efficiencies. Many features routinely incorporated into other project types are now required to be provided in data centers.

These new requirements will improve data center efficiencies and result in operational savings. But they will also most likely increase the initial cost of the systems. System designs will change as a result of these requirements but those changes will need to be carefully designed so as to not reduce the reliability and availability of the data center operations.

ANSI/ASHRAE/IES Standard 90.1-2010 is a consensus document. It represents a best practices approach to energy efficient systems. It is not a code or a specific requirement until it is adopted as such by the Authority Having Jurisdiction (AHJ). This can be at the local state or federal level. This is commonly done through the adoption of energy codes such as the International Energy Conservation Code (IECC). The present IECC-2009 is based on the ASHRAE 90.1-2007 standard. The IECC-2012 code is presently being revised and will incorporate many provisions of the ASHRAE 90.1-2010 standard. As this energy code is adopted by various AHJs, the requirements for data centers will become enforceable.

Other standards that may eventually adopt the new version are certification programs for energy efficiency and sustainability such as LEED. The current draft for the updated LEED 2012 includes a mandatory requirement to comply with ASHRAE 90.1-2010.

There are multiple sections of the standard that may impact the data center. This article will review these in general and more specifically some of the electrical and mechanical systems most affected.

Architectural – Building Envelope

There have been changes and additions to this section that will minimally affect the data center. The envelope requirements always applied to the buildings where data centers were located. One of the changes includes a mandatory requirement for a continuous air barrier for all buildings. This requirement is beneficial to the operation of the data center. Other changes will affect

support spaces such as offices but will not be of consequence to the data center itself.

Lighting

The allowable lighting watts per square foot have been reduced for interior and exterior spaces and the control requirements have been expanded.

Exterior spaces have been broken out into five zones. The zones are based on the areas surrounding the data center and vary from rural undeveloped areas to major metropolitan areas. The exterior lighting power allowances vary based on the zone where the facility is located.

This could be an area of concern for providing adequate security lighting in rural and less developed areas. Lighting fixture types will need to be selected based on lumens per watt and may increase the use of advanced lamps and technology including LED fixtures.

Interior lighting power levels have been reduced from 10-18% depending on the classification of the data center areas. Designs will need to ensure that adequate lighting levels are maintained with these reduced power levels.

Transformers including PDUs

Minimum energy efficiency requirements for transformers 600V and below have been added to the standard. Transformers need to comply with the provisions of the Energy Policy Act of 2005. Efficiencies are to be measured per the testing requirements of NEMA TP-1 2002. Essentially the testing emphasizes efficiencies at part load (approximately) 35% since that is a typical loading for general use transformers. This also tends to be true in data centers with redundant transformers (PDUs). Efficiencies as measured by NEMA TP-1-2002 are generally required to be over 98% as indicated in the standard.

THREE-PHASE TRANSFORMER EFFICIENCY

kVA	Efficiency	kVA	Efficiency
15	97.0	225	98.5
30	97.5	300	98.6
45	97.7	500	98.7
75	98.0	750	98.8
112.5	98.2	1000	98.9
150	98.3		

Source: Table 4-2 of National Electrical Manufacturers Association (NEMA®) Standard TP-1-2002, 'Guide for Determining the Energy Efficiency for Distribution Transformers'.

EPACT 2005 federal law is not identical to the NEMA Standard TP-1. A major difference is that the federal energy efficiency mandate does not exclude K-factor rated transformers or harmonic mitigating transformers, which NEMA TP-1 does exclude from its scope. The federal law also does not specifically exclude retrofit or replacement transformers from its scope, as NEMA TP-1 does.

NEMA TP-1 certified transformers are typically more expensive than non-certified units.

Heating, Ventilating and Air Conditioning (HVAC) Systems

Most equipment efficiencies have been increased from the previous standard and economizers are required in more climates. Many of these requirements applied to other project types but are now specifically required in data centers.

Piping

Variable flow piping systems. The standard requires piping systems to be variable flow. Constant flow piping systems are not allowed. Variable pumping systems controlled by differential pressure and exceeding 10 hp, shall have the sensor located at the most remote heat exchanger or at the location requiring the greatest differential pressure. The maximum pressure set point shall not exceed 110% of the required differential pressure to achieve design flow. Where DDC controls are used the differential set point shall be reset downward based on valve positions until one valve is nearly wide open. Exceptions are provided for systems that include no more than three valves and where the minimum flow is less than that required by equipment manufacturers, such as chillers, where total pump system power is 75 hp or less.

This requirement will require the monitoring of all the chilled water valves by the DDC system and a control sequence to calculate the required differential pressure in the system based on the position of all the chilled water valves.

Piping shall be insulated per Table 6.8.3B except where the design operating temperatures range between 60F and 105F or where heat gain or loss will not increase energy usage.

It is common to not insulate dry cooler piping which could range from 40F to 110F. This may lead to increased costs for insulation.

The standard has developed a minimum pipe size requirement. It is a general requirement based on standard weight steel piping. The minimum pipe sizes do not apply to piping that is not in the critical circuit at design conditions for more than 30% of the operating hours.

Therefore, piping that experiences higher flows during maintenance or abnormal conditions is not required to be sized based on the standard.

The table includes the piping sizing requirement from the standard and some typical industry values that have been developed based on comparison of initial cost, pumping energy, noise generation and system erosion due to fluid velocity. As can be seen from the chart there is not a lot of difference in the smaller sizes but as pipe increases to 6 inch or larger the differences can be substantial.

ASHRAE 90.1-2010			**Clear Water**		**Glycol and Water Mix**	
Nominal Pipe Size (inches)	Variable Flow System (gpm)	Maximum velocity (fps)	Industry Design Flow for water(gpm)	Typical Industry Design velocity for water(fps)	Typical Industry Design Flow for glycol(gpm)	Typical Industry Design velocity for glycol(fps)
2 1/2	68	4.56	40-65	2.7-4.4	30-50	2.0-3.4
3	110	4.77	65-115	2.8-5.0	50-90	2.2-3.9
4	210	5.29	115-240	2.9-6.1	90-190	2.3-4.8
5	250	4.01	240-440	3.9-7.1	190-340	3.1-5.5
6	440	4.89	440-700	4.9-7.8	340-550	3.8-6.1
8	700	4.49	700-1450	4.5-9.3	550-1100	3.5-7.1
10	1000	4.07	1450-2400	5.9-9.8	1100-2000	4.5-8.1
12	1500	4.26	2400-3500	6.9-10.0	2000-3200	5.7-9.2
Pipes over 12 inches		5.0		8.3-12.8		7.3-11.2

The pipe sizing in the standard should lead to a reduction in pipe friction losses and therefore reduced pressure requirements (head) for the pump thereby reducing operating costs. The larger pipe sizes will result in increased costs for piping, valves, supports and installation.

Maximum flow rates are based on variable flow piping systems operating over 4400 hours per year.

Controls

System controls shall not permit reheat or simultaneous heating and cooling for humidity control. This is a common occurrence in computer room system designs that will no longer be permitted.

If the new ASHRAE TC9.9 temperature and humidity requirements are followed this should have minor effect on computer room design and operation. It could be a concern on tightly controlled humidity levels and in rooms with high humidity and low internal heat loads leading to overcooling.

Additional more sophisticated controls may be required to prevent this condition.

Equipment

One of the mandatory provisions is minimum equipment efficiencies. In addition to the previous tables for equipment efficiencies, Table 6.8.1K has been added that lists minimum efficiencies for Air Conditioners and Condensing Units Serving Computer Rooms.

Equipment efficiencies must be verified through a certification program or the equipment manufacturer shall install a permanent label stating that the equipment complies with the requirements of Standard 90.1.

CRAH units cannot be single speed constant volume. Per the standard, air handling and fan coil units with chilled water cooling coils and supply fans 5 hp or greater shall have two speed or variable speed motors. As of January 2012 this requirement also includes units with direct expansion cooling and a cooling capacity of 110,000 Btu/h (9.1 tons).

Economizers

Each cooling system that has a fan shall include either an air or water side economizer. Climate zones are the same as the IECC 2006 standard. Exceptions are listed for the following:

a. **Exception a: Individual fan-cooling units for the following (from Table 6.5.1B):**

1. No economizer requirement for data centers in climate zones 1a, 1b, 2a, 3a, 4a (essentially southeast US and mid-Atlantic areas)

2. Cooling systems under 135,000 Btu/h (11.25 tons) in zones 2b, 5a, 6a, 7 and 8 (essentially the Northeast, eastern side of the Midwest and Alaska and some southern areas of Texas and New Mexico)

3. Cooling systems under 65,000 Btu/h (5.4 tons) in zones (essentially the West coast and the western side of the Mid-west).

b. **Exception c: Spaces humidified to satisfy process needs, but it is stated that this exception does not include computer rooms.**

c. **Exception j: Systems primarily serving computer rooms where:**

1. The total design cooling load of all computer rooms in the building is less than 250 tons and the building is not served by a centralized chilled water plant, or

2. The room total design cooling load is less than 50 tons and the building is served by a centralized chilled water plant, or

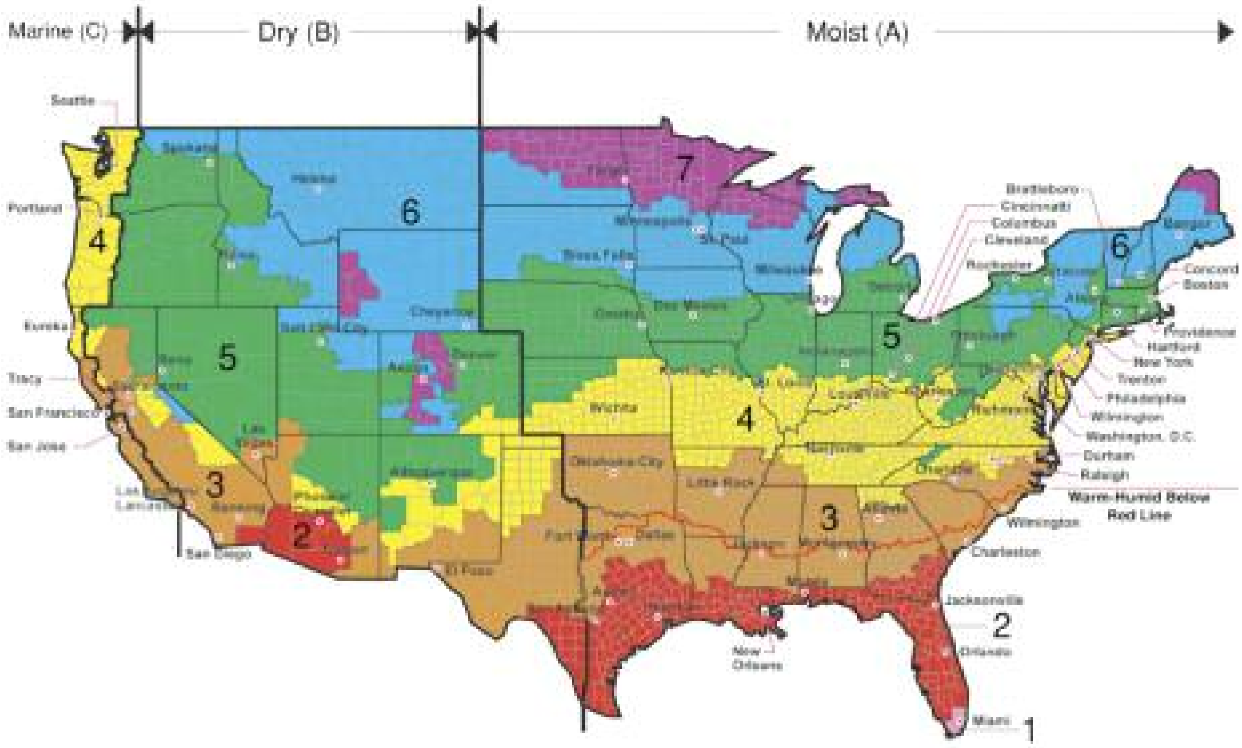
3. The local water authority does not allow cooling towers, or

4. Less than 50 tons of computer room capacity is being added to an existing building.

d. **Exception k: Dedicated systems for computer rooms where a minimum of 75% of the design load serves:**

1. Those spaces classified as an essential facility.

CLIMATE ZONES



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

2. Those spaces having a mechanical cooling design of Tier IV as defined by ANSI/TIA-942.

3. Those spaces classified under NFPA 70 (NEC) Article 708 – Critical Operations Power Systems (COPS).

4. Those spaces where core clearing and settlement services are performed such that their failure to settle pending financial transactions could present systemic risk as described in "The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System, April 7, 2003".

Using exception k to eliminate the need for economizers could impose a host of additional requirements for mechanical and electrical systems to comply with the definition of Tier IV, essential facility or a COPS facility including structural and architectural considerations for robustness, survivability after an event and compartmentalization.

Water economizers: system shall be capable of cooling supply air by indirect evaporation and providing up to 100% of the expected system cooling load at outdoor air temperatures of 50F dry bulb / 45F wet bulb and below. Exceptions:

1. Evaporative water economizers for systems primarily serving computer rooms: 40F dry bulb / 35F wet bulb.

2. Dry cooler economizers for systems primarily serving computer rooms: 35F dry bulb.

3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50F dry bulb / 45F wet bulb and where 100% of the expected system cooling at 45F dry bulb / 40F wet bulb is met with evaporative water economizers.

Pressure drops for the economizer system are restricted to reduce additional load on the pumps during non-economizer system operation.

Integrated economizer controls are required to allow partial cooling even when additional cooling is required to meet the load.

This requires series installed economizers in lieu of the more common parallel economizers.

Many water cooled chiller systems have been installed with plate and frame heat exchangers that are designed and operated as a chiller replacement when the outdoor ambient conditions are appropriate. This implies the heat exchanger is installed in parallel with the chillers and the water is typically bypassed around the chiller. Therefore, the heat exchanger is an all or nothing operation.

This standard will require the heat exchanger to be in series with the chiller at all times so it can provide partial cooling.

Humidification

Systems with hydronic cooling and humidification systems designed to maintain a minimum dew point of 35F shall use a water side economizer if an economizer is required.

Fan System Power Limitation

Fan cooling systems exceeding 5 hp must be variable speed and the motor size must not exceed the next larger standard size greater than the brake horsepower (bhp). The bhp must be identified on the design documents for verification by the AHJ.

System Commissioning

The standard requires that HVAC control systems be tested to ensure that controls are calibrated, adjusted and are working properly. For projects larger than 50,000 sf of conditioned space, detailed instructions for commissioning the HVAC systems shall be provided by the designer in the plans and specifications.

Energy Cost Budget Alternative

Section 11 of the standard outlines the requirements to evaluate compliance of the proposed design with the prescriptive requirements of the standard. There are still some mandatory requirements that need to be met. Once these are satisfied, alternative designs can be evaluated to show compliance with the standard.

Conclusion

Following ASHRAE 90.1-2010 will provide additional energy savings during operation. It may also lead to higher initial costs for equipment installation and structure. Designers will need to be creative in incorporating these energy saving features while keeping initial costs under control and maintaining the required level of reliability and availability of the data center.

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Is Your Data Center Experiencing Growing Pains?

Unprecedented growth is causing big problems

The increasing power density of server racks has created a crisis at many data centers. They're running out of protected power from uninterruptible power supply systems. They're running out of computer room floor space too. Moreover, many IT operations have been given a mandate to cut energy costs and improve operating efficiencies, to help their facilities achieve LEED® (Leadership in Energy and Environmental Design) Certification.

S&C can help

S&C's PureWave UPS™ System provides *total power protection* . . . not just for your servers but for critical air conditioning and mechanical systems as well. And the PureWave UPS System will help you attain your efficiency and energy-saving goals.

PureWave UPS System Ratings

System Rating		Voltage
kVA	kW	
313 to 2600	250 to 2000	208 to 600
2500 to 20 000	2000 to 16 000	4160 to 25 000

Medium-voltage PureWave UPS System

The PureWave UPS System is ideal for high-density data centers. It will let you meet Tier III or Tier IV electrical requirements as well as Class A or Class B cooling requirements. Only the PureWave UPS System can be installed outdoors without modification, saving valuable interior floor space and reducing cooling loads.

Contact us and we'll show you how the PureWave UPS System can provide uninterruptible power for your data center at the lowest installed cost.

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Promises, Promises: **Does Your DCIM Solution Deliver?**

by Fred Dirla

Data Center Infrastructure Management (DCIM):

It's one of the hottest buzzwords for data center operators today. In 2010, a report by the **Gartner Group** predicted a 60 percent market penetration of DCIM by 2014. In the report, **"DCIM: Going Beyond IT,"** analyst David J. Cappuccio explores the importance of DCIM for dealing with rising energy costs and inefficient power usage in the data center. The report indicates data center managers cannot reduce costs unless they have real-time data center software to provide an accurate view of current resources consumed.

Simply put: DCIM software is a powerful monitoring solution effectively integrating information from a broad set of tools that have traditionally been held within IT or Facilities management "silos." In addition, DCIM solutions are instrumental in reducing the time-to-deploy new servers by up to 50 percent, extending the life of a data center by up to five years, as well as helping to attain a power usage effectiveness of 2.0 or less. And to cap it off, with regards to extracting information from often disparate systems, DCIM gives the data center team a "single lens" through which they can monitor capacity planning, risk management, power utilization and overall efficiency of the data center.

A number of established data center software players have aligned themselves with this designation. However, not all DCIM solutions are created equal. Data center operators looking to deploy DCIM must conduct proper due diligence before investing – it's a key step to ensuring the solution fits specific needs, now and in the future.

Investing in DCIM Software - Best Practices

Before investing, the first step is to define the challenge. Managing data center environmental performance is not just about wires, black box devices, monitoring hardware, or the vast array of specialty devices being pitched as cure-alls. It's about managing all of the data such as:

- IT assets and system
- Space utilization
- MEP system resiliency and performance
- Energy, financial and environmental

Unless there's access to all the aforementioned data in a holistic format – the data center's performance picture is incomplete. Why? Because the data is often stranded across multiple proprietary systems. Identifying what data is available and where the gaps are is needed to establish an optimal performance management process.

Ideally, the best DCIM tool should provide centralized monitoring, management, and intelligent capacity planning of a data center's critical systems. Furthermore, the platform must conduct real-time monitoring and management across IT and Facility infrastructures to maximize data center ROI.

Basic features and requirements DCIM

tools must have are:

- **Identifying Primary User(s)** – determine the number of users the tool needs to serve. Is it in the hundreds, thousands or millions? Make sure the tool can handle the load.

- **Establish a Clear Outcome** – identify focus areas i.e. environmental performance, energy management, efficient IT equipment deployment, capacity management.

- **Power Cooling Information** – a constantly moving target, data collection and analysis of power cooling information can pose significant challenges. Take a small operation of about 1000 servers, with each server having two plugs to monitor. Add in rack-level temperature monitoring plus the ability to monitor core power and cooling infrastructures – the whole set-up could easily reach 3000 measurement points. With points changing constantly, it might be necessary to measure and store a value for each data point at a frequency of once per minute. That's over 1.5 billion measurements per year!

- **Information Accessibility** – a major hurdle for most solution providers. DCIM must function as a true browser-based application that allows full access to anyone on the network. While many claim to offer true DCIM, they either force users to install client software on each desktop or make them log into the application through a browser, which means limited functionality.

- **Scalability** – the application must allow room for growth as the organization expands. The ideal solution should make adding new data center facilities to the system a simple matter of adding to the existing application. This will provide visibility into all data centers in the portfolio in a clear and consistent manner regardless of scale or design.

However, to go beyond just the basics, add these DCIM elements to your checklist:

- **Fully Browser-Based and Secure** – This offers a powerful, real-time data collection and database engine that allows data center teams to manage IT assets while supporting the infrastructure to maximize resource utilization and energy efficiency. Most importantly, the tool must meet the most stringent data security, application resiliency, and bandwidth requirements of corporate IT networks, while being vendor neutral – allowing seamless integration with virtually any operations systems and hardware running in the data center.

- **Able to Handle Unlimited Users** – Scalability is good, but unlimited users are better. The interface must provide rapid and intuitive access to all data as needed – from managing hundreds to hundreds of thousands of circuits. It should also provide information down to the individual circuit to prevent overload, while tracking energy usage by the rack, row, or cabinet – providing simple PUE calculations for specific systems.

- **Holistic Data Views** – A centralized "Single Pane View" throughout various monitoring and control systems, installed at a single facility or throughout an entire corporate portfolio is a "must have."

- **Real-Time Reporting Tools** – These tools are needed for delivering alerts prior to a catastrophic event as well as enabling pro-active planning for growth and expansion with up-to-the-minute information. In addition, the tools should provide a Load Simulator to analyze load impact before cabinet equipment is added. From global reports, right down to information on individual circuits, information must be delivered in easy-to-read graphical depictions.

- **Fully Compliant** – DCIM solutions need all proposed levels of monitoring according to DOE legislation. A real-time data collection engine helps data center operators manage IT assets and the supporting infrastructure, to maximize resource utilization and ensure energy efficiency. An intuitive front-end needs to provide immediate access to vast amounts of real-time data for informed decision-making.

- **Easily Deployed** – A flexible DCIM tool enables new assets to be added with little or no external program requirement. This includes: power utilization efficiency such as PUE, DCiE, RCI and facility load; profile-based analysis, defining a definitive start point to understand a "green strategy" endpoint; and energy savings tracking with documented results.

- **Out-Of-The-Box Functionality** – Finally, a good DCIM tool offers user-friendly capabilities to create custom screens and reports. The selected DCIM software must leverage business intelligence to ensure raw data is transformed into actionable intelligence. This should include the ability to graph data and trend it over time.

As energy prices continue to skyrocket and data centers become increasingly complex, managers are scrambling to find new ways to bring costs and efficiencies under control. DCIM promises to be the panacea for all that ails the data center. But beware: Not all DCIM tools are created equal. It's important to define objectives ahead of time and ensure the tool offers the best of the best in DCIM, including: a unified view, real-time reporting, full compliance, and ease of deployment. Only by doing your homework, can you realize the true benefits of DCIM.

Fred Dirla is CEO of FieldView Solutions. He can be reached at fdirla@fieldviewsolutions.com

HOT AISLE/COLD AISLE SYSTEMS DRIVING CHANGES TO FIRE PROTECTION

By Lee Kaiser, PE

Fire protection installations in Data Centers/Telecommunications rooms are being challenged by computing density increases and the push for PUE improvements. High cooling loads and reducing cooling energy cost is driving data center managers to change the physical structure of their rooms. Hot Aisle and Cold Aisle (HACA) containment systems in the various flavors they come in are very efficient at improving cooling efficiency and can often have short payback timeframes. Many data centers have had systems retrofitted as well as systems designed for new installations. It is obvious that they are here to stay and for good reason.

HACA containment systems affect fire suppression and detection in many ways. They can make fires more difficult to detect and the obstructions they create can make them more difficult to control or extinguish. If you have employed HACA strategies in your data center, but have not made adjustments for the fire protection of the room, you most likely have a problem and it may be bigger than you think.

This article attempts to describe how HACA systems will affect conventional approaches to fire protection in the data center/telecom environment and considerations you should make when designing a room with HACA systems. The truth is the fire protection community has not kept up with the pace of change in technology rooms. Often code development follows behind changes in technology. However, the good news is that experts within the fire protection industry are taking aim at this challenge today in order to develop guidance for the changing data center.

THE MISSION CRITICAL FIRE RISK

The perception of risk to your facility can often be diminished by false reasoning in two ways. First is the notion that fires in data centers don't happen. Companies are often silent about fires in their IT facilities, in hopes of maintaining a positive brand image. In addition many fires that do occur in these buildings are successfully controlled or extinguished by fixed fire suppression systems and are thus hardly newsworthy. These facts make it very difficult to monitor fire activity in data centers; yet we know they occur. Fire protection service firms respond several times a year to re-arm suppression systems that discharged because of a fire. In the interest of client confidentiality these service providers do not share information about fires.

The second deception in judging fire risk often occurs to data center managers who are investigating HACA systems to employ in their facility. Manufacturers of containment systems are aware that the fire protection community has concerns with the effects on fire detection and suppression, so the containment system literature often makes assurances that their system will work with existing fire protection systems. Some of these claims are misleading and are made from a simple understanding of how fire suppression systems work, rather than being based upon solid fire science, experience and testing.

CONTAINMENT SYSTEMS AS NEW BARRIERS IN THE DATA CENTER

When you start to break down the concepts employed by the various types of containment systems they are essentially barriers or new partitions within the space. These barriers serve to direct the cooling airflow to where it is needed most at the face of the computer server.


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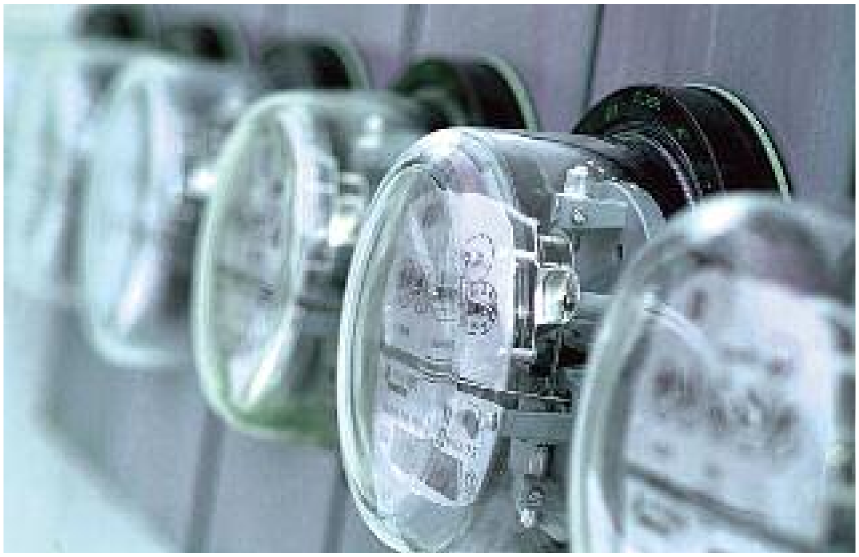

Many people assume that if a barrier added as part of a containment system is transparent, it will not affect the fire protection in the room. However, these barriers create three conditions that change the approach needed for fire protection in a medium to high density data center:

1. The airflow pattern changes and disrupts the normal development of the smoke plume.

2. The airflow velocity in the room increases within the contained aisle and can be a challenge for conventional means of smoke detection.

3. The barriers act as obstructions to sprinkler spray patterns and clean agent suppression nozzles.

When thought of as barriers, the need for a professional analysis of the room's fire detection and suppression system becomes well warranted.

CHALLENGES FOR DETECTION

The National Fire Alarm and Signaling Code (NFPA 72) gives guidance to engineers on the spacing of smoke detectors in rooms with different air change rates. The fire alarm code only provides data for smoke detector spacing in rooms up to 60 air changes per hour (ACH); this equates to data centers loaded to roughly 5 kW per rack. According to the Intel Corporation, HACA containment systems start being used in data centers with densities of near 12 kW per rack and higher. With cooling airflows sufficient for typical HACA cooling loads, air change rates within the contained aisles range from 500 to 1000 ACH and higher. These high rates mean high velocities and will challenge ceiling mounted spot smoke detectors due to the velocity of the air and dilution of smoke.

It has been common for fire protection engineers to specify air sampling smoke detection (ASSD) in rooms exceeding 60 ACH because of their increased sensitivity to smoke. Because of higher velocities experienced within contained aisles it makes even more sense to utilize ASSD. Engineers should consider installing ASSD sample pipes/ports arranged to sample the hot return/exhaust openings in the contained aisle. This would be done the same manner as is commonly applied to traditional CRAC unit return air grilles.

Data center designers would do well to take notes on best practices of semiconductor manufacturing clean rooms where ASSD is often employed. Clean rooms have similar challenges of high velocities, turbulent air flows, and directional routing of air. There is an easy translation to data centers where air sampling detectors should be installed at the return air inlet to air handling units and somewhere immediately downstream of the hot side of the server at the ceiling level.

Despite the fact that more research is needed on how to detect fires in high airflow environments, many professionals believe that the detection techniques needed are already available to the industry.

CHALLENGES FOR SUPPRESSION

Whether the barriers that form the HACA containment system are applied horizontally, vertically or both, they can affect sprinkler pattern development and clean agent dispersion. NFPA 13: Standard for the Installation of Sprinkler Systems is very explicit in how to apply fire sprinklers to overcome obstructions in the protected space. These rules should be applied to sprinklers where HACA barriers are applied. Many of these containment systems have provisions for "automatic" removal when a fire occurs; usually by means of a fusible link. For removal to work the fire has to grow to a point where it can melt the link(s). If the link that removes the barrier is not placed perfectly over where the fire starts, the fire will need to grow larger to build heat in the location of the link. This also applies to systems that require fusing of multiple links for barrier removal. Be wary of containment systems that require a large fire to remove the barrier before the fire sprinkler system is given the opportunity to activate.

Plastic drop out panels, used most often in cold aisle containment

systems, are another type of barrier that "automatically" removes. These panels are UL listed and melt around 135°F so that the sprinklers above the panels can operate. Data center managers should know that the listing requires use of standard response sprinklers above the panel that operate at a higher temperature near 155°F. Typically this sprinkler type is not installed in data centers; usually quick response sprinklers which fuse at 135°F are used. The temperature difference is important and could lead to issues with sprinklers operating before the necessary panels have dropped out. Installing quick response sprinklers inside the contained aisle may be a good way to avoid this issue.

In facilities utilizing clean agent fire extinguishing systems, containment barriers must be removed prior to agent release. Containment systems which rely upon fusible action for removal are a problem because of the large fire size needed to obtain the action. Clean agent systems in data centers most often activate upon detection of smoke, not heat; and are designed to extinguish small developing fires. The problem of barrier removal can be overcome by adding extra clean agent nozzles within the contained aisle.

Clean agent nozzles have several of the same obstruction distance requirements as sprinklers. In HACA retrofits a qualified fire protection firm should be consulted to ensure the required extinguishing concentration can be obtained given the new barriers installed in the space.

It is a valid assumption that clean agents will disperse to spaces which are not in line-of-sight of the agent nozzle, such as the ability to reach the inside of server cabinets. The high airflows associated with containment systems challenges our current assumption and more research must be done on this topic.

NEW FIRE PROTECTION RESEARCH INTO HACA ENVIRONMENTS

The movement to use HACA in mission critical environments has not gone unnoticed by the fire protection community. Recently there has been a significant emphasis on this issue by the National Fire Protection Association (NFPA) and their research division, The Fire Protection Research Foundation (FPRF). In March 2011, the FPRF held their Suppression, Detection and Signaling Technical Working Conference and took a day for industry experts to focus on the issue at a meeting "Fire Protection Challenges in Telecommunications and Information Centers." In April the NFPA 75 and 76 Technical Committees, which address IT and telecommunications rooms, held a joint meeting to continue the conversation from March. New research papers on the topic of fire protection in data centers were presented in June at the 2011 NFPA conference.

Most recently a new research project is being considered by the FPRF to study smoke detection design in high airflow environments. This is certainly exciting for the fire protection community and will hopefully provide clarity to the issues surrounding HACA containment systems.

While more research is needed into these new challenges from all interested groups, one thing is for certain; hot aisle/cold aisle containment systems have the attention of data center managers, designers, and fire protection professionals. All are working to ensure a reliable means exists to detect and suppress fires in these environments. If you have added HACA to your data center and not had a qualified professional evaluate your fire protection system, you could be risking higher losses than what your business can tolerate.

Lee Kaiser, PE is the Engineering Manager for Orr Protection Systems. He can be reached at lkaiser@orrprotection.com

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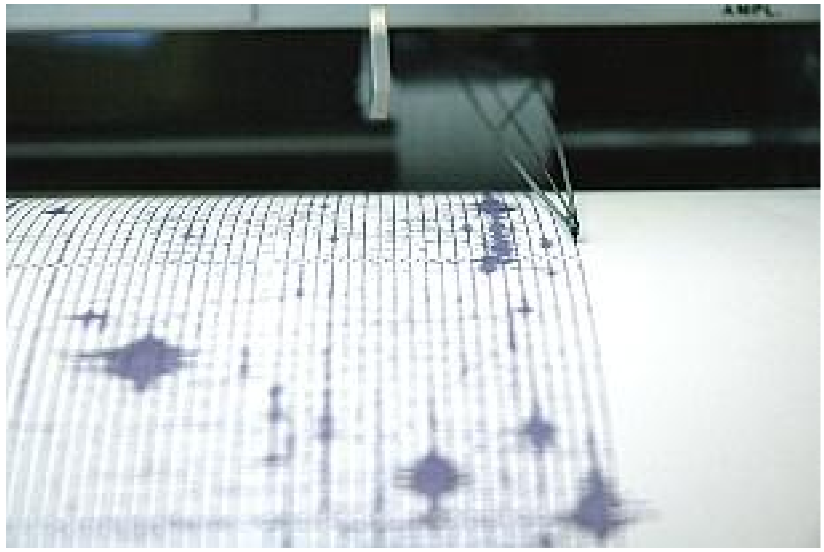
By Dwight Wells



Understanding provisions in the latest edition of the International Building Code is critical for specifying emergency standby power systems that will continue to operate after events such as an earthquake or a hurricane.

HOW THE IBC SEISMIC AND WIND-LOADING STANDARDS APPLY TO EMERGENCY STANDBY POWER SYSTEMS

The International Building Code (IBC) is a comprehensive set of building standards that was first proposed in 1997 by the International Code Council (ICC) and adopted in 2000. The IBC sought to harmonize the many national, state and local codes that govern the design of structures in an effort to eliminate duplicative or conflicting standards and, therefore, make compliance more uniform.

The IBC has been updated on a three-year cycle; the latest version is IBC-2009. Currently, all 50 states and the District of Columbia have adopted version IBC-2000, IBC-2003, IBC-2006 or IBC-2009 as their de facto building code.

While the main focus of the IBC is structural integrity and fire prevention, certain provisions govern the certification and installation of emergency standby power systems used in locations that are seismically active or are subject to high wind loading of up to 150 mph. Depending on the classification of the structure and type of occupancy, seismically certified emergency standby power systems are required in order to ensure power after a catastrophic event, such as an earthquake or wind event.

The primary needs for electrical power after such an event is for the continuing operation of essential

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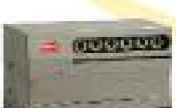

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40% Savings estimate is derived from actual performance test results of (1) Stulz-ATS CWE-LR vs. (1) Liebert model FH740C, at 16,500 cfm, against 0.3" of external static pressure.

facilities to support the community and various life-safety systems that support building egress. Where power systems are required for continued operation of the facility, the standby generator set and supporting components must be sized to operate all other critical components in the building such as: air handling units, air conditioning, cabinet heaters, air distribution boxes, boilers, furnaces, chillers, cooling towers, water heaters and other similar mechanical, electrical or plumbing equipment required to keep the building functional. Where life-safety is of concern, the emergency standby power would be required to operate emergency lighting, elevators, ventilating systems, communication systems, alarms, fire pumps and other systems involved in protecting life-safety. At a minimum, IBC certification and installation details are required in seismically active locations for the following essential facilities that are classified as Occupancy Category IV in Table 1:

- Hospitals with surgical or emergency treatment facilities
- Fire, rescue, ambulance and police stations
- Designated public storm shelters
- Emergency response centers
- Power-generating stations and public utilities
- Structures with toxic or hazardous substances
- Aviation control towers and air traffic control centers
- Facilities involved in critical national defense functions
- Water storage facilities required for fire suppression

Additionally, an emergency power system that continues to operate following a seismic event plays a positive role in business continuity, allowing the proper shutdown of manufacturing processes or the preservation of computer data – both of which help reduce financial risk.

OCCUPANCY CATEGORY	OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities
II	Buildings and other structures except those listed in Occupancy Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300 • Buildings and other structures containing elementary school or day-care facilities with an occupant load greater than 250 • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500 • Group 1-2 occupancies with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities • Group 1-3 occupancies • Any other occupancy with an occupant load greater than 5,000 • Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Occupancy Category IV • Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released
IV	Buildings and other structures designed as essential facilities, including but not limited to: • Group 1-2 occupants having surgery or emergency treatment facilities • Fire, rescue, ambulance and police stations, and emergency vehicle garages • Designated earthquake, hurricane or other emergency shelters • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response • Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures • Structures containing highly toxic materials as defined by Section 307 where quantity of the material exceeds the maximum allowable quantities of Table 307.1 (2) • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions • Water storage facilities and pump structures required to maintain water pressure for fire suppression

Table 1

Deciding when to specify a seismic power system

Not every area of the U.S. or type of structure is required to have a seismically certified emergency power system. According to the IBC, a seismically certified emergency power system is only required in locations and structures that meet certain criteria. Figure 1 shows the areas in the country that are seismically active and where seismic design must be considered. The criteria include importance factor (Ip), building occupancy category, site soil class and spectral response acceleration.

- Importance Factor – The IBC uses an importance factor (Ip) to designate whether an emergency standby power system is a critical or non-critical component. A non-critical component has an Ip of 1.0, but a critical component has an Ip of 1.5 when any of the following conditions apply:

  1. The emergency standby power system is required to operate after an earthquake for life-safety purposes (such as egress lighting, sprinkler systems, fire protection systems, smoke evacuation, etc.).

  2. The structure contains hazardous materials.

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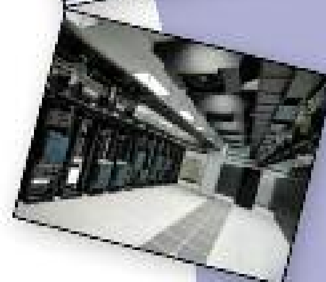

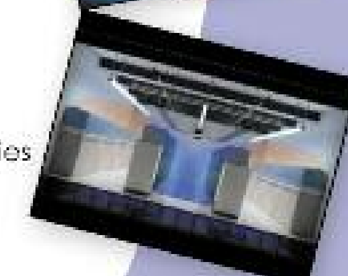


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3. The emergency standby power system is located in an Occupancy Category IV structure and is needed for the continued operation of the facility or its failure could impair the continued operation of the facility.

- Occupancy Category – Table 1 shows the occupancy categories of buildings and other structures as listed in the IBC-2003, 2006 and 2009. Categories I through III do not require a seismically certified emergency power system unless they are located in a seismically active area with short-period response acceleration greater than 0.33g and the equipment is given an Ip = 1.5 because of number points 1 or 2 above. See Table 2. However, all Category IV structures require such a system when the importance factor is 1.5 (i.e., essential) and SDS is more than 0.167g.

SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD RESPONSE ACCELERATIONS

VALUE OF S_{DS}	OCCUPANCY CATEGORY I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g < S_{DS} < 0.33g$	B	B	C
$0.33g < S_{DS} < 0.50g$	C	C	D
$0.50g < S_{DS}$	D	D	D

Table 2

- Site Classification – In any seismically active zone, the potential for structural damage is influenced by the soil type. The least structural damage can be expected on solid rock (Site Class A), while the most structural damage can be expected on loose, liquefiable soils (Site Class F). See Table 3.

- Short-Period Response Acceleration – This is a number (SDS) derived from the expected ground movement forces (measured in g = acceleration due to gravity) in seismically active locations as defined by the United States Geological Survey (USGS). The value also accounts for the soil type of the location. Refer to Figure 1

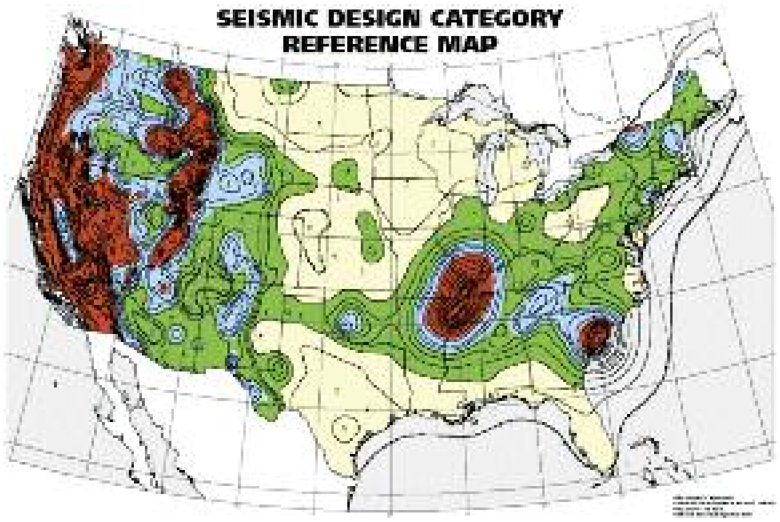


Figure 1. Map is based on SDS values assuming Soil Site Class D. Areas is green, brown and blue represent areas of the United States affected by the seismic requirements of the IBC Codes. (Map compliments of The VMC Group)

as a reference map of the contiguous United States. The higher the SDS value the more severe are the seismic forces acting upon a structure and its contents. This number is then used in conjunction with an Occupancy Category (I – IV) to determine a Seismic Design Category (A through F). Buildings with Seismic Design Categories C – F have requirements for seismically qualified components when the component Ip = 1.5.

SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME
A	Hard rock
B	Rock
C	Very dense soil and rock
D	Stiff soil profile
E	Soft soil profile
E	Any profile with more than 10 feet of soil with: 1. Plasticity index > 20 2. Moisture content > 40% 3. Un-drained shear strength < 500 psf
F	Any profile containing soils with: 1. Liquefiable soils; quick and highly sensitive clays; collapsible, weakly cemented soils 2. Peats and/or highly organic clays 3. Very high plasticity clays 4. Very thick soft/medium stiff clays

Table 3

The following three critical parameters are the basis for determining whether a seismically certified emergency power system is required:

- An SDS of 0.167g or greater
- Occupancy Category IV with an Ip = 1.5
- Seismic design category of C, D, E or F and a component Ip = 1.5

Power system structure must also resist wind loading

The IBC also addresses wind loading and its effect on the performance of an emergency standby power system. For those states that have adopted the IBC-2003, IBC-2006 or IBC-2009, the building (or enclosure) that houses the emergency standby power system must resist any overturning forces caused by expected high winds, and the generator set must stay mounted to its foundation and be operable after the event in all Occupancy Category IV structures (essential facilities).

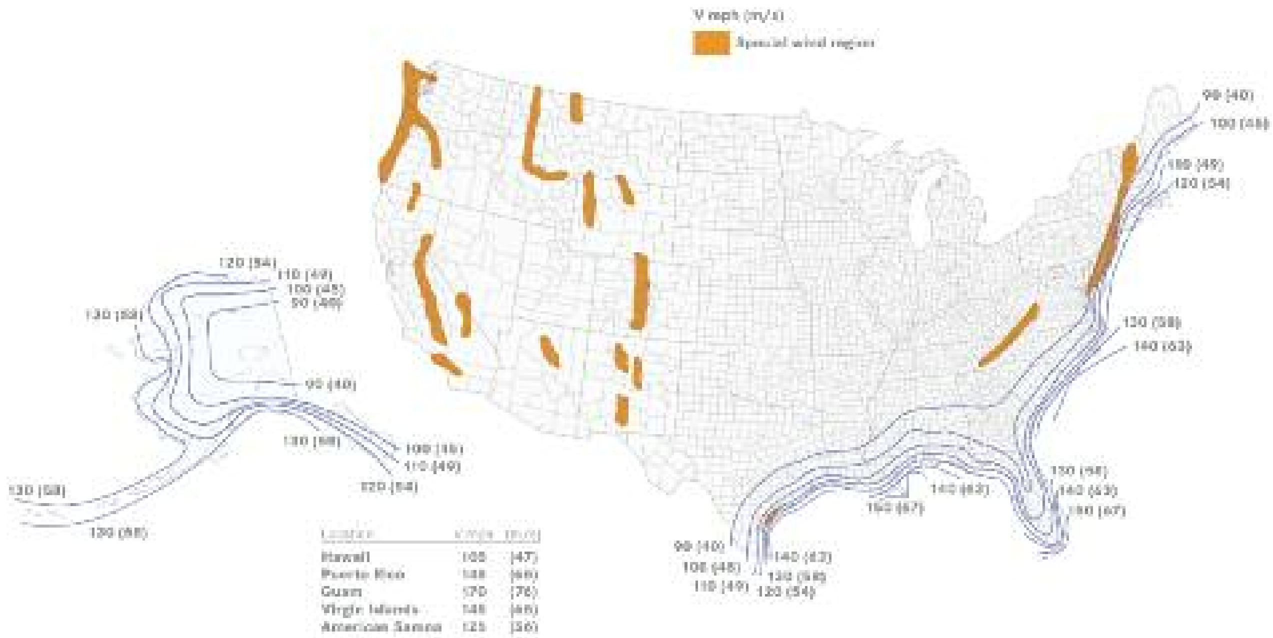


Figure 2

Figure 2 shows the areas of the country where high wind loading needs to be considered in the design of structures that house emergency standby power systems. The minimum wind speed for design of structures in the United States is 85 mph.

Seismic design responsibility

According to the provisions in IBC standards, the entire design team is responsible for making sure an emergency standby power system stays online and functional after a seismic or high wind loading event. This group includes: emergency standby power system manufacturers, suppliers, installers, design team managers, architects and consulting engineers. Each has a critical role to play in making sure that structural and nonstructural components perform as designed.

IBC Chapter 17, the Contractor Responsibility states:

Each contractor [i.e., all members of the design team listed above] responsible for the construction of a main wind- or seismic-force-resisting system, designated seismic system or a wind- or seismic-resisting component…shall submit a written statement of responsibility to the building official and the owner prior to the commencement of work on the system or component. The contractor's statement of responsibility shall contain acknowledgment of awareness of the special requirements contained in the statement of special inspection.

Seismically certified emergency power systems

It falls to the emergency standby power system manufacturer to provide a product that is certified to withstand the typically expected seismic and high wind loading forces and to continue operating after a seismic event has occurred. The provision in IBC-2009, Section 1708.4 Seismic Certification of Nonstructural Components states:

The registered design professional [usually the architect, consulting engineer or electrical contractor] shall state the applicable seismic certification requirements for nonstructural components and designated seismic systems on the construction documents.

1 The manufacturer of each designated seismic system component subject to the provisions of ASCE 7 Section 13.2.2 shall test or analyze the component and its mounting system or anchorage and submit a certificate of compliance for review and acceptance by the registered design professional responsible for the design of the designated seismic system and for approval by the building official. Certification shall be based on an actual test on a shake table, by three-dimensional shock tests, by an analytical method using dynamic characteristics and forces, by the use of experience data (i.e., historical data demonstrating acceptable seismic performance) or by more rigorous analysis providing for equivalent safety.

2 Manufacturer's certification of compliance for the general design requirements of ASCE 7 Section 13.2.1 shall be based on

analysis, testing or experience data.

An emergency standby power system consists of a base, engine, alternator, fuel supply, transfer switches, switchgear and controls. While the engine generator set is naturally a robust piece of equipment, designing for survival of a seismic event also focuses attention on the generator set mounting to the foundation and external attachments, such as fuel lines, exhaust and electrical connections.

To certify the components of an emergency standby power system, the generator set and its associated systems are subjected to a combination of three-dimensional shake-table testing and mathematical modeling. The IBC requires that these tests be performed by an independent, approved, third-party supplier that can issue a seismic certificate of compliance when the seismic qualification is successfully completed. Once a particular generator set passes the seismic qualification, it is the responsibility of the manufacturer to label the equipment, indicating the seismic forces to which the equipment was subjected. Figure 4 illustrates a typical label on a seismically certified generator set.

> **"a seismically certified emergency power system is only required in locations and structures that meet certain criteria..."**

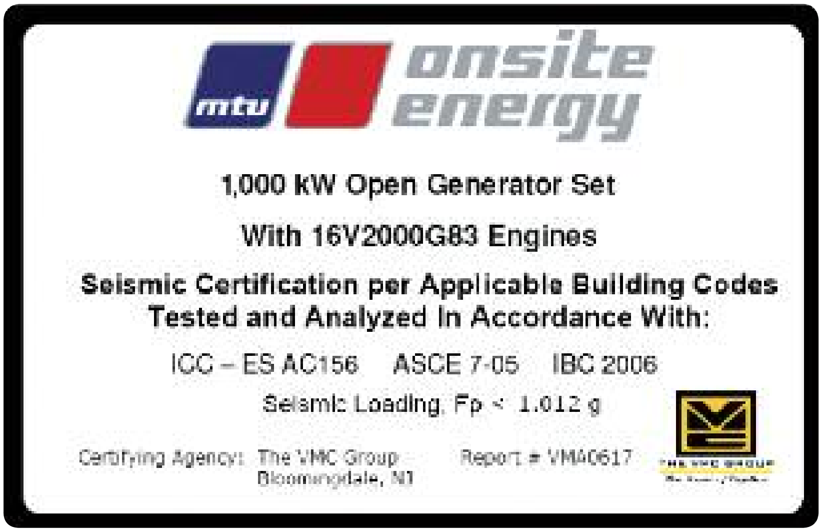


Figure 4

Local regulations may be more stringent

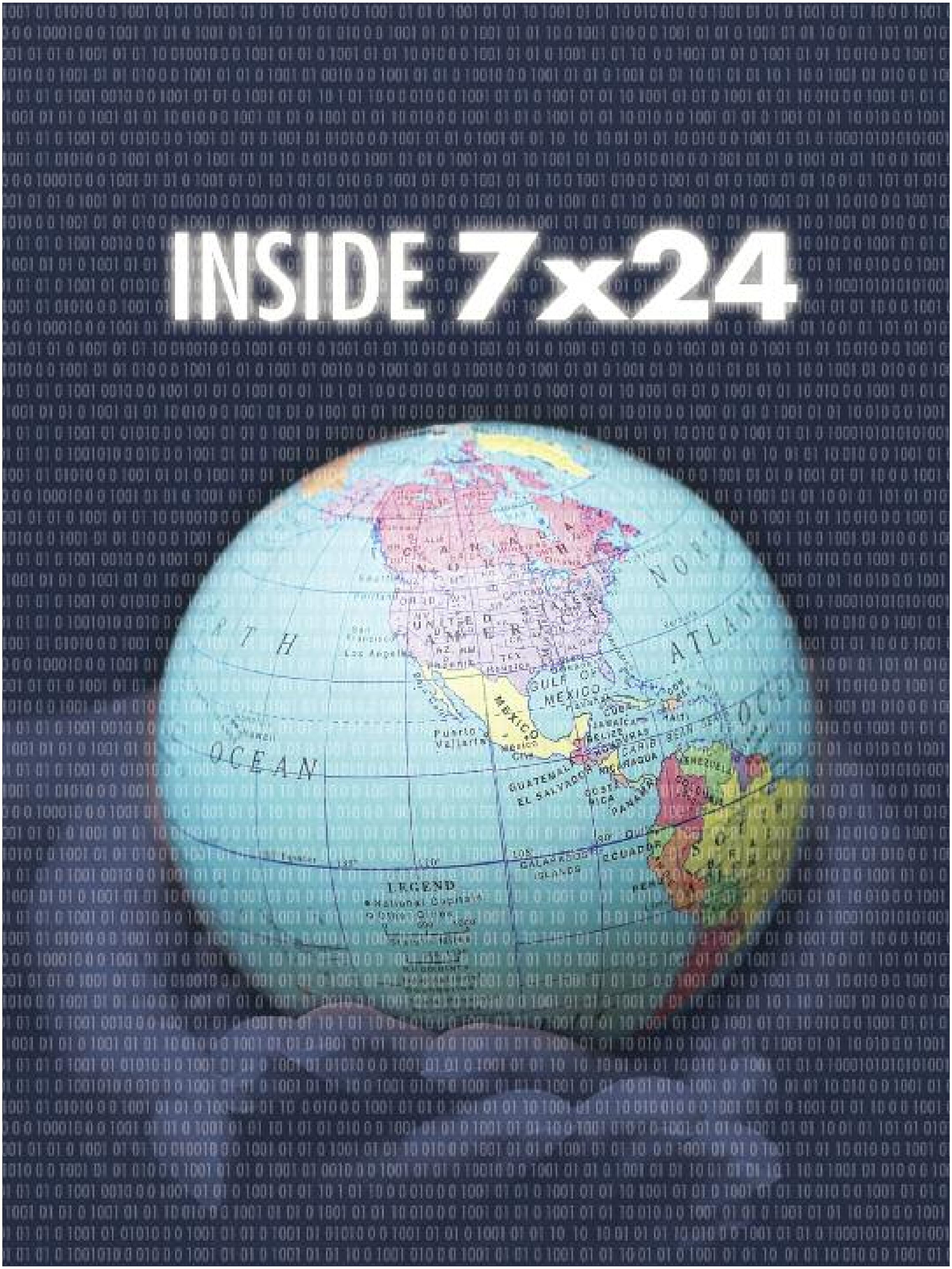
While the general provisions of the IBC have been largely adopted as the de facto building code in many states and localities, the project engineers should consult with local jurisdictions to verify that all applicable local standards have been met. In California, for example, the Office of Statewide Health Planning and Development (OSHPD) has set seismic standards for hospitals and health care facilities in accordance with both the 2007 California Building Code and IBC. While these local codes and recommended seismic testing protocols are largely harmonized with IBC, consultation with local authorities can reduce the risk of installing a system which may ultimately prove to be non-compliant.

Conclusions

While the IBC addresses all facets of structure design and construction in all 50 U.S. states, it also addresses the performance of a number of nonstructural systems, such as emergency standby power systems. The IBC's requirements for emergency standby power systems are intended to ensure that structures within certain occupancy categories will have emergency power after a catastrophic event, such as an earthquake or wind event. As such, it has set seismic design and testing standards for the manufacturers of emergency standby power systems.

All members of a structure's design team – emergency standby power system manufacturers, suppliers, installers, design team managers, architects and consulting engineers need to be aware of the seismic and wind loading provisions within IBC for emergency standby power systems. Power system manufacturers have undertaken advanced design and testing programs to comply with the seismic provision within IBC involving three-dimensional shake-table testing, finite element analysis, mathematical modeling and experience data. Certified power systems are labeled as having passed seismic testing by a qualified, independent testing organization. By working with a power system manufacturer that offers seismically certified products, the structural design team can be assured that it will have an emergency standby power system that will perform as designed after a seismic or high wind loading event.

Dwight Wells is Product Manager for MTU Onsite Energy. He can be reached by Dwight.Wells@mtu-online.com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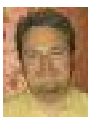
The President of MTechnology, **Steve Fairfax,** will open the second day with a keynote presentation entitled **"Hidden Threats to Data Center Security".**



Kevin Kealy, Security Architect for AT&T will provide the closing keynote **"Control Systems – The New Target".** In keeping with the theme, additional presentations on leveraging innovation will be delivered with topics such as:

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- Deutsche Bank – ECO Data Center
- EPA – Enabling Energy Savings in Data Centers with ENERGY STAR
- Facebook – Open Compute Program
- Green Grid – Data Center Maturity Model
- Uptime Institute – Global Data Center Concerns Affecting the North American Market
- Panel – The Hunt for Talent
- Optimizing Cloud Uptime: Data Centers and the Hybrid Cloud
- Planning the Key to Replacing Critical Cooling in a Live Data Center

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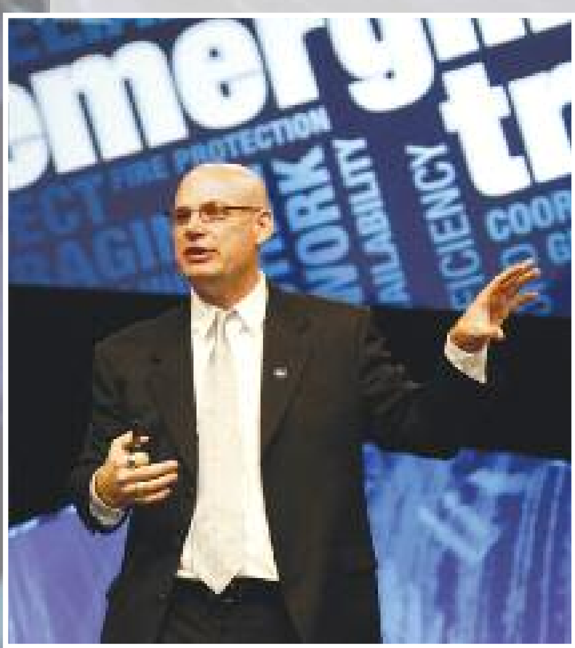
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1/3 Vertical	2.5″	10″
1/4 Horizontal	4.5″	3.25″
1/4 Vertical	3.25″	4.5″

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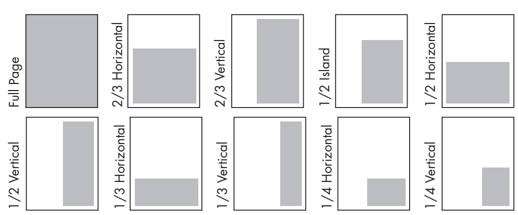

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Trim Size: 8.5″ x 11″
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