in this ISSUE:

Special Edition

BLACKOUT of 2003

design PLUS

FEA
facilities engineering associates
128 Garden Street, Farmington, CT 06032

Professional Engineering Services
For Mission Critical Industries

designPLUS

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Blackout of 2003

*by Leo P. Soucy, Jr., P.E. - **FEA***

We all have another common reference to add to the Blackouts of 1965 and 1977; and September 11. We will all remember where we were during the Blackout of 2003 and how this and the other events affected our lives.

As we get back to "normal" the "finger pointing" has begun not only within the utility industry and the political arena, but also within our own organizations. It is better to take this opportunity to evaluate how we view up time and reliability, and whether our systems met our expectations. If you look closely at most organizations, you will find that the decisions to spend or not spend for hardened systems are based on a known set of circumstances. Unfortunately, August 14 drastically changed these circumstances with the simple fact that massive power outages are still possible.

As a professional in this field, I can assure you that this problem will not be corrected any time soon. There are already estimates that it will cost $50 - 100 Billion to upgrade the system. It is interesting to read articles about the blackout and realize that there are many different conflicting opinions on how to correct the problem and these are from the "experts". Any fix will involve the federal government as well as every state's Department of Utility Control Commission. The initial reasons cited for the outage is the lack of transmission capabilities and generation. Addressing these issues will attract the attention of environmental groups and other interested parties; so, you can see this is a very complex problem.

If your initial review indicated that your systems did not meet your requirements for reliability, it is in your best interest to attack this problem internally and not rely on the government or utility to fix the problem. Remember, up until the blackout the trend was to deregulate the utility industry, which will only result in a further fragmented system. This is not a "utility network" but a "network of utilities" each having their own agendas, government over sight, investors and financial constraints.

During the past two years, ***FEA*** has published dozens of articles about the mission critical design industry in our "designPLUS" newsletter. We have reviewed these articles and compiled the most appropriate ones in this special Blackout of 2003 newsletter.

We have talked with a number of our clients and they all had no problems with their systems performing as designed but the real challenge was keeping these systems operating for a long period of time. The need for accurate documentation as indicated in the "Documentation" article on page 2 quickly became very crucial to keeping these systems on-line.

We talked with one client who was

contemplating a major upgrade that had yet to be approved and he related the following story: "*After the outage occurred, we switched over to generator immediately without incident but encoun*tered *some drama when we discovered that the fuel pump was not on emergency power."*

The article "Don't Forget Mechanical Hardening" on page 4 reviews the other aspects of hardening a site that are often overlooked.

After 9/11, the federal government issued guidelines regarding the recommended separation in miles between the primary and secondary mission critical facilities. There was general discontent regarding this requirement so it was relaxed. Maybe the requirement should have been separating the primary and secondary facilities in different electrical power grids. See "The Importance of Back-Up" on page 3.

Page 3 also features an article on "Choosing A Mission Critical Design Firm" to assist in developing your upgrade plans and on page 5 is the article "7x24xForever Facility Evaluation Check List" to assist you in quickly determining your facility's 7x24xForever capabilities.

As you review your facility's reliability, you should understand the meaning of reliability and probability of failure. The article on page 6 "Understanding Availability and Unavailability" shows that the utility system reliability of 99.9% availability has a 99.9% probability of failure.

Facilities Engineering Associates initially decided to publish the "designPLUS" newsletter as a way to highlight the issues surrounding the design of mission critical facilities. We hope you find these articles informative and of assistance in reviewing your systems' capabilities and developing your contingency plans.

Documentation - Eliminate the Guesswork

by Marc Soucy, FEA

In the world of 7x24 operation, the main focus of all facilities managers should be on the anticipation of problems rather than the reaction to problems. There are times when unforeseen situations arise where a quick decision must be made to prevent an untimely shutdown. It is these times where good documentation plays a crucial role. Having up-to-date documentation is very important because it can serve as a "road map" to the facility to show how it operates. If kept up to date, it can help you instantly locate virtually any piece of equipment anywhere in the facility, and by seeing the 'whole picture' one can develop a better plan of action. Knowing exactly where to go in a facility when there is a problem can be the difference between keeping the facility up and running or taking a shutdown.

Documentation does not stop with just having up-to-date drawings. It is a facility-wide practice, which includes identifying all equipment in a logical manner. This includes durable, legible labeling of all electrical cabinets, mechanical equipment, piping, valves, individual breakers, and anything else related to the mechanical and electrical infrastructure of the facility.

Not only does good documentation aid in a crisis situation, it also helps out in the day-to-day maintenance and facility upgrades. Knowing such things as which panels feed particular equipment and which pipes are chilled water supply and chilled water return, can save a lot of time, money, and eliminate any of the guesswork as to how the facility is operating.

Another benefit to having accurate documentation and identification is that they can be used as a training tool for new employees and outside service technicians. Being able to study the drawings and locate equipment in the field will increase the understanding of the facility and instill a sense of confidence in the facility staff. With this information available to everyone in the facilities group, you eliminate the scenario which a lot of companies unknowingly face. Relying on one person, and that one person's memory, to keep the facility up and running and problem free. What if that one person were to leave the company, as it is very common in today's society. How do you recover all those mental notes they have made over the years?

Some good practices to help improve your documentation are:

* Attach electrical one-line diagrams and piping schematics to the wall of the mechanical or electrical rooms. This serves as a quick reference to any equipment located in the room. These diagrams should be easily readable. A detailed design drawing of a system may not be appropriate as it may be confusing and have a lot of extraneous information that is not required for quickly locating a problem.

* Create panel schedules in spreadsheet form identifying each breaker, its panel location and what it feeds.
* Create valve schedules in spreadsheet form identifying each valve and its location in the facility.
* Keep all drawings, specifications, spreadsheets, and any other related documentation together for easy access in a crisis situation.
* Avoid part plan drawings or sketches, and maintain a Master drawing set that completely documents the facility without referring to numerous other documents or part plans.
* Label all mechanical and electrical equipment. Labels should be large with large lettering, permanent and easily distinguishable. Labels for equipment located overhead (pipes, conduits, valves, etc) should be positioned so they are legible from the floor.
* Establish a color code system to differentiate between various systems.
* Whenever possible, keep duplicate copies of all documentation material.
* Lastly and most importantly, keep all information up-to-date and accurate. Request the consulting engineer to provide "record" drawings and updated valve and panel schedules when new projects are completed.

The Importance of Backup

by William H. Flaherty, Jr., P.E. - FEA

Users have many opinions as to what constitutes a proper backup for a data center. Some feel that duplicate files stored either on site or off site will suffice. These users have no protection when considering the potential problems that could arise with power, equipment or weather related failures. When their systems go down they must rebuild their infrastructure and databases before they can continue with their mission, which may be acceptable to some users. Other organizations feel they are adequately protected once they build a 7 x 24 facility and provide redundant UPS, STS, cooling and generator power systems

It is possible to build a facility with N+N redundant systems but many users do not go that far and assume that N+1 will protect their operations but these local systems are still at the mercy of major catastrophic occurrences such as fire, seismic events or weather. The best solution to total redundancy still remains having geographical remoteness between sites.

Site mirroring has been implemented by some users but is limited to about 20 or 30 miles with weather or seismic events still being potential troublesome factors.

The events of September 11 brought into sharp focus how important remote backup facilities can be to data centers. The traditional contingencies were planned for in New York City but an intentional catastrophic terrorist action was not considered. The pre September 11 thinking was that it was prudent to have a backup facility somewhere in the New York City area. As a result of the September 11 event, many data centers located in Manhattan were severely damaged or totally destroyed. Copper, fiber and satellite links were lost for weeks. The resulting air quality problems and damage to transportation routes and infrastructure made it impossible for many employees to report to work. Some firms took days or even weeks to get back into operation. As a result, federal regulators are reassessing their guidelines for financial institutions concerning backup facilities. Hard and fast rules have not been issued but they are considering a 200 to 300 mile requirement for the distance between primary and backup facilities. This type of geographical remoteness would insulate each facility from local catastrophic events whether they are due to terrorist activities, weather, seismic events, or fire. Such drastic measures do have a high cost and must be weighed against the benefits derived. In the quest for reliable backup, it is always prudent to consider geographical remoteness as one component.

Choosing a Mission Critical Design Firm

by Leo P. Soucy, Jr., P.E. - FEA

During the past few months ***FEA*** has been involved in several mission critical projects, which required substantial upgrade of the infrastructure to meet the Owner's business objective.

In one project, the plan was to upgrade an old data center based on a report provided by a major computer equipment supplier. ***FEA*** was

engaged to implement the recommendations. In reviewing the recommendations, we pointed out to the Owner that the proposed upgrades would not provide N+N reliability nor accommodate dual power cord technologies. ***FEA*** provided a management presentation outlining our findings, which resulted in placing the project on hold while the original recommendations were reviewed. Based on the extent of the recommended revisions it was also decided to look at the construction of a new data center that would incorporate 21st century mission critical design concepts. ***FEA*** provided a preliminary design with probable construction costs for the new facility to assist upper management in making an informed decision. The project review delayed the hardening of the existing data center but little work had been implemented on the original marginal recommendations so there wasn't much of a cost impact.

In another project, ***FEA*** was to extend base building services to serve a new mission critical facility. In reviewing the base building services it was determined that they would not provide 7x24 redundant services. A major study was conducted which reviewed all critical systems and it was decided to substantially upgrade the existing infrastructure resulting in a large increase to the project budget.

A mission critical facility is a very expensive project. In order to avoid the problems previously discussed it makes sense to carefully choose a consultant on the basis of their ability to do the job, and not exclusively on price.

In order for the Owner to evaluate a consultant's experience, you should request a list of previous mission critical projects they have completed and talk with the Owners of these projects including a tour of the facilities. You should also find out if the firm belongs to any associations devoted to mission critical design. Another excellent approach is to talk with the salesmen and vendors of mission critical equipment - chillers, air conditioning, uninterruptible power supplies, generators and switchgear - asking if this consultant is knowledgeable in 7x24xForever mission critical design concepts, or if they can recommend consultants that are.

Designing numerous mission critical facilities is one of the best ways to develop mission critical design experience. The design concepts necessary for mission critical systems are often not obvious until implementation and start-up in the field. Experience is the best teacher. Any firm that performs comprehensive integration testing of mission critical systems in addition to the basic design will have gained extensive field expertise in system reliability and equipment inter-relationships. A consultant engaged in mission critical design should provide extensive testing services including on-site review, factory witness testing of critical equipment and extensive integration testing of the various systems.

Don’t Forget Mechanical Hardening

by Marc Soucy, FEA

In today's society of 7x24 operation, many companies are creating what are called Mission Critical Facilities. The first thing that comes to most people's minds when talking about a Mission Critical Facility is power. Uninterruptible power for the facility is what everyone is trying to provide and where most people are willing to invest hundreds of thousands of dollars. It is true that reliable power is the most important element to any Mission Critical Facility; however, there are a host of other key elements to the mission critical system which, if neglected, could very quickly shut down any facility. These other key elements being mechanical in nature are often overlooked, viewed as not as important, or not worth the extra money to harden. On the contrary, it is these systems that allow the UPSs, Generators, and other equipment to operate properly and be more reliable.

As a server or UPS operates throughout the day, it generates a great deal of heat. If there is an inadequate or unreliable mechanical system supplying cool air to the server or UPS room to remove this heat, the equipment will eventually overheat and shut down. An inadequate or unreliable cooling system can be caused by many different things. Some of the obvious situations are not having enough redundant cooling units, pumps or chiller capacity; or not being capable of performing maintenance, upgrades, and/or surviving an individual unit failure. Less apparent situations could be having an unhardened cooling tower make-up water system or building management system. These shortcomings can go unrecognized for many years but are truly the weakest link and have a great failure

potential in an otherwise hardened system.

There are a number of other situations where the mechanical systems aid in the operation of electrical equipment. One example would be the processing and distribution of fuel oil to the generator. As fuel oil sits idle in a tank, various bacteria will begin to grow. If this bacteria or sludge were to reach the generator fuel injectors, they could become fouled over time and cause the generator to fail. Installing a reliable fuel filtering and distribution system would greatly reduce the possibility of "dirty" fuel reaching the generators and in turn increase the reliability of the whole emergency power system.

A lot of focus is directed towards the electrical equipment in a system because it is the first line of defense against a power failure. A quick evaluation of a facilities electrical system could give the illusion that it is a very hardened system. However, when evaluating a Mission Critical Facility, one must look at the whole picture. Saying a facility has multiple redundant UPS units with multiple redundant emergency generators sounds pretty good. However, if the one pump supplying fuel oil to the generator daytank fails or the pump alternator on a dual pump system fails during a power outage, the multiple redundant generator installation will become useless.

The previous examples demonstrate some possible failures to a system that could result in a substantial amount of downtime. One thing to remember is that downtime is not only described as a loss of power due to unplanned equipment or power failures. It could also be a loss of power by shutting equipment down to tie in new equipment or perform maintenance. A good 7x24 design takes all this into consideration and provides the owner with such things as redundant piping and equipment to eliminate any single point of failure and the need for maintenance windows. This will give the owner the ability to isolate parts of the system, both electrically and mechanically, without shutting the system down.

In the world of Mission Critical Facilities, the main goal of all business owners is to reduce the probability of any type of downtime. Whether downtime comes as a planned or unplanned event, having a true 7x24 electrical and mechanical design gives you the confidence that the system can handle any type of failure yet is flexible enough to meet your future needs.

7x24xForever Facility Evaluation Check List

by William H. Flaherty, Jr., P.E. - FEA

The following check list will allow the reader to get a quick snapshot of the 7x24xForever viability of their facility. It is not totally comprehensive and has been generalized to cover a variety of applications. Such a list could be custom written for a specific facility and would provide valuable information for the manager. The questions are intended to be answered by a responsible person tasked with maintaining the facility.

How the Data Center is operated as well as staff training can affect system reliability and 7x24xForever availability. The following items are indicators of attention to detail and the ability to react to situations that may threaten the availability of the facility.

MAINTENANCE	LAST TEST/MAINT DATE	CRITICAL LOAD AT RISK WHEN PERFORMING MAINTENANCE	ABILITY TO REPLACE W/O INCREASE IN RISK TO CRITICAL LOAD
UPS			
Generators			
Chillers			
Cooling Towers			
Pumps			
Valves			
Cooling Units			
Automatic Transfer Switch			
Circuit Breakers			

OPERATIONS	LAST TEST/MAINT DATE	CRITICAL LOAD AT RISK WHEN PERFORMING MAINTENANCE	ABILITY TO REPLACE W/O INCREASE IN RISK TO CRITICAL LOAD
Simulated power failure			
Generators at full load			
Staff at full strength			
Cross training elect/mech			
Posted system documentation			
Equipment identification			
Dual Power cord: load update			
InfraRed reading on panels			

Understanding Availability and Unavailability

"Five Nines" is not 5 minutes

It has become very common to describe the reliability of a mission critical facility by the number of "Nines" reliability - "Four Nines", "Five Nines" or "Six Nines." The examination quickly follows that a "Five Nines" system will result in 5 minutes of downtime per year or a "Six Nines" system will result in 32 seconds of downtime.

Nines	Availability	Unavailability	Downtime
'one nine'	90%	10%	876 Hours
'two nines'	99%	1%	87.6 Hours
'three nines'	99.9%	1.0.E-3	8.76 Hours
'four nines'	99.99%	1.0.E-4	53 Minutes
'five nines'	99.999%	1.0.E-5	5.3 Minutes
'six nines'	99.9999%	1.0.E-6	32 seconds

"Nines" are a crude shorthand method to describe the availability of a system. Availability is the fraction of time that a system is available for use, so it is always a number between zero and one. Very high availability systems can theoretically get very, very close to an availability of one. It has become common to express such high availability as a percentage, which is nothing more than 100 times the availability. A system whose availability is 0.999 is 99.9% available.

Knowing the "Nines" availability, it is now possible to determine the unavailability. Unavailability is the fraction of time that a system is NOT available for use. It is simply 1 minus the availability. So, in a "Six Nines" system, it will be unavailable (1-.999999) or .000001 times the time it operates. If we want to determine the time of unavailability over a period of a year, one needs to multiply the unavailability by the number of seconds per year (.000001 times 365 days/year times 24 hours/day times 60 minutes/hour times 60 seconds/minute) which equals 32 seconds per year for a "Six Nines" system. The following table shows the Downtime for each level of "Nines" availability.

While the simplistic math used to construct this table is correct, there is an important, generally overlooked assumption that renders most of this exercise meaningless: downtime does not come in chunks as small as 5.3 minutes or 30 seconds or less.

Consider what happens in a real-world data center that is subjected to a facility-wide power outage of 0.1 second. Every computer, DASD, tape silo, router, and switch in the facility will fail. After power is restored, system operators must reboot the computers, repair or restore databases, re-establish communications and synchronization, and perhaps reload applications or data from backup storage. This process takes time. Our work with corporate data center users who have experienced such failures suggests that restoration of normal processing can require 16 hours. Our worst case was a client whose sensitive manufacturing processes required 34 hours to re-qualify after at 4-second outage; our best case was a corporate data center who had assembled all senior staff in case of mishap during changes to the power system. The mishap occurred, and it took the ready and waiting team only 12 hours to restore normal operations.

There is no such thing as a five-minute or thirty-second outage. Even if the electricity is off for only a blink of an eye, the business process will be down or degraded for many hours.

Suffice it to say there is a whole study of probability that deals with this subject, which allows us to look at the probability of unavailability over the life of a mission critical facility. If we assume that a facility is designed for a 20-year operating life, we can calculate the "Probability Of Failure" of AT LEAST ONE (there may be more than one) failure for a system. With a constant failure and repair rate and a Mean Time To Repair of 16 hours over a 20-year period, the following table summarizes the results:

This table shows the real meaning of "Five Nines" versus "Four Nines" or "Six Nines" systems. It is not the amount of **time** that a facility will be down but the **probability** that a facility will be down. A true "Five Nines" system has a **10% probability** of at least one, facility wide power outage during a 20-year operating life. If an outage occurs, it will require about 16 hours to recover fully from the event and resume normal operations.

Nines	Availability	Unavailability	% Probability of Failure
"one nine"	90%	10%	100
"two nines"	99%	1%	100
"three nines"	99.9%	1.E-03	99.9
"four nines"	99.99%	1.E-04	67
"five nines"	99.999%	1.E-05	10
"six nines"	99.9999%	1.E-06	1

FEA *would like to thank Steve Fairfax, President, MTechnologies, Inc., for providing the information for this article.*

Disaster Avoidance

by William H. Flaherty, Jr., P.E. - FEA

Almost every conversation concerning 7x24 facilities eventually touches on the topic of Disaster Recovery. Many organizations have a specific individual designated as the Disaster Recovery Manager whose job is to prepare a plan which will streamline the recovery process if or when a major disaster occurs. We believe that more planning and thought should be given to being proactive rather than reactive when a situation occurs. Certainly there are occurrences that make disaster recovery plans necessary such as the aftermath of the 9/11 disaster or a major weather anomaly which causes structural damage or flooding of the facility. These events are rare but must be planned for. However, there are many more subtle occurrences which can cause outages that have a significant financial or operational impact on the mission of the organization.

Thought should be given to changing the title of the Disaster Recovery Manager to Disaster Avoidance Manager. This person would not only be reactive to events but also be proactive to foresee potential problems before they occur. A Disaster Avoidance Manager would be responsible for the overall system design and overseeing the reliability aspects of all facets of the facility. Careful consideration of the ramifications of deferred maintenance and the risks associated with maintenance windows being made available during peak operational periods are critical decisions that could result in disaster avoidance. The Disaster Avoidance Manager should review facility modifications or new designs as to their 7x24 suitability. This would aid in helping to prevent outages rather than reacting to them after the fact which could require implementation of the disaster recovery plan.

Preventative Maintenance

by Leo P. Soucy, Jr., P.E. - FEA

During the Blackout of 2003 one of the more challenging aspects of keeping systems on-line was being able to perform preventative maintenance. It was imperative that there was sufficient on-site supplies as it was impossible to secure these supplies during the blackout. Some of the items required included sufficient lubrication and oil; air, fuel and oil filters; belts; and other essential spare supplies. In addition to having the necessary supplies, your operating personnel must know how to perform basic preventative maintenance on all your critical systems.

An example of just one system is the standby generators. They are very different from automobile gasoline engines as they require more frequent preventative maintenance. This is due to the fact that the fuel may have been stored for an extended period of time and the sulfur in the fuel affects the life of the lubricating oil. It may be necessary to change oil and filters during an outage, which can only be done if the system is properly designed. No matter how flawless your systems reacted to the initial problem, if they were not designed for concurrent maintainability, the systems are useless.

Interesting Facts

September 11, 2001, highlighted that Contingency and Disaster Recovery Plans did not adequately address personnel and organizational issues.

A redundant generator system is 74 times more reliable than a single generator.

A redundant UPS system is 15 times more reliable than a single module UPS.

A dual bus UPS (N+N) system is 12 times more reliable than a redundant UPS system and 184 times more reliable than a single module UPS system.

Contact Leo Soucy at ***FEA*** with any comments or questions.
Facilities Engineering Associates
128 Garden Street
Farmington, CT 06032
Tel. 860-677-2285
Email LSoucy@feace.com