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

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www.feace.com

Professional Engineering Services
For Mission Critical Industries

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Facilities Engineering Associates (***FEA***) is entering its fifteenth year of providing mission critical design services. During that time, we have developed very specialized expertise in the design of utility systems in support of information technology, telecommunications and broadcast facilities. In order to keep our clients current with the latest trends in mission critical systems, we have decided to publish a newsletter highlighting new developments and general information. We hope you find the designPLUS Newsletter both useful and timely.

Mission Critical Presentations

Facilities Engineering Associates (***FEA***) has been involved in the design of mission critical facilities for the past 15 years. These projects primarily involved developing data centers for Fortune 500 companies.

During the 90's, we found that many other industries were being confronted with reliability issues much like those already addressed by the data center community. These industries included telecommunications, broadcast and continuous industrial processes to name a few. With the expansion of the global economy and the Internet, even office buildings began requiring the need for hardening portions of their infrastructure to meet the ever-growing demand to be on-line twenty-four hours a day, seven days a week.

In the past five years there have been major technological advances in equipment and system architecture, which now allows for the design of true 7x24xForever facilities where the requirement to shut down for maintenance, system upgrade and expansion is totally eliminated. Some of these technologies are relatively new and we have found that many people in the information technology community are not aware of them. In other non-traditional mission critical communities, there is a greater lack of knowledge of these 7x24 capabilities and how they can assist in meeting the new business requirement of continuous availability.

As a firm closely associated with the mission critical industry, we feel it is necessary to educate technical societies regarding the present day state-of-the-art technologies available. Recently, we conducted a presentation at the 7x24 Exchange Fall Conference, the Society of Broadcast Engineers and the Society for Information Managers. We are preparing a presentation for the technical broadcast personnel of a major broadcast company so they will better understand the reliability and redundancy issues of the power and support utilities serving their equipment. This is especially pertinent because their conversion to digital technology makes their facilities resemble large data centers.

If you would like ***FEA*** to provide a presentation about mission critical design technologies to upper management, your technical staff or a technical society where you are a member, please feel free to contact us.

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" 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.

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

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:

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

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.

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

Diesel Fuel Shelf Life

Many facility managers are so caught up in the day-to-day operation of the facility that they have little or no time to think about the proper storage of the emergency generator diesel fuel. It seems to be an accepted practice to buy the fuel, run the generator for testing and check the storage tank for water and sludge. Removing sludge and water only occurs when the budget allows or a problem is imminent.

A considerable number of maintenance engineers do not realize that diesel fuels are refined from middle to light distillates of crude oil. Crude oil is a mixture of over 200 different hydrocarbons. Diesel fuel is just one final product of crude oil. Diesel fuel is not always the same since it is also a mixture of several of the over 200 compounds which make up unrefined crude oil. Each delivery of fuel many vary slightly from the last thus providing differing fuel performance. Also, diesel fuels are hydrocarbons and will tend to oxidize and degrade over time. If water is present in the fuel, bacteria and slime growth will occur and reduced lubricity will result.

Stored diesel fuel will begin to break down within 30 days of storage. For over the road trucks that burn the fuel quickly, this is not a problem. Emergency generator power systems must store large quantities of fuel for much longer periods of time. The storage problems of this small segment of the diesel fuel market are of no concern to oil companies.

Facility managers who try to adhere to the recommendations of the National Fire Protection Associations NFPA 110 can be fooled into thinking that the NFPA outdated recommendations are applicable to today's fuels. Diesel storage life is stated as being from 1½ to 2 years, and they go on to recommend, "tanks should be sized so that the fuel is consumed within the storage life, or provision should be made to replace stale fuel with fresh fuel." This was true 10 years ago but not with today's fuels with broken molecular carbon chains that have a propensity to repolymerize and form gums and varnishes. A six to nine month storage life is all that can be expected from reformulated diesel fuel. Gums and varnishes can cause serious problems with fuel filters and injectors in today's tight tolerance diesel engines. Facility managers must approach this problem in an intelligent manner.

There are f*our simple steps* to preserve the integrity of stored diesel fuel.

1. *Kill the bacteria.* A biocide introduced into the fuel, following the manufacturer's recommendations, will control the growth of bacteria within the storage tank. The biocide used must be appropriately registered with state and federal agencies. The biocide kills the bugs; however, it does not eliminate the exoskeleton that the bacteria leave behind. These accumulate over time and can clog fuel filters in addition to adding to the sludge at the tank bottom.

2. *Use additives.* There are many chemical additives that can be employed to increase the stability of diesel fuel. Most do not require costly injection or mixing systems and are self dispersing.

3. *Water and sludge removal.* Typical tanks collect water and sludge on their bottoms. A filter/water separator and pump which recirculates the fuel in the tank is a good way of "polishing" the fuel and ridding it of the undesired build up. Portable equipment can also be employed to do the same job. It is best to design such a system into the initial installation but retrofitting is also possible.

4. *Annual testing.* It is imperative that an independent testing agency be contracted to test the fuel in your tanks once each year. Samples should be taken from the very bottom of the tank to check for water and sludge as well as from the middle of the tank to get an idea of the average fuel quality in the tank. Laboratory analysis of the sample should be done as well as a quick visual inspection to observe any water present.

A scheduled maintenance program specifically addressing stored diesel fuel will help to keep the emergency generator system operating properly for years. Remember, the emergency generator is there to overcome the emergency not to be part of the emergency.

Interesting Facts About Redundant Systems:

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