Building a Home for Your HP 3000's
Data Center Design, Construction, and Operations

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Introduction

Electronic computer/data processing equipment has become a vital and commonplace tool for business, industry, government, and research groups in recent years. The use of such equipment is a direct result of the technological breakthroughs which have made the equipment available and the increased complexity of modern business, industrial, governmental, and research needs. Particularly pertinent are the increasing number of variables which must be taken into consideration in everyday decisions - overlooking any one item may spell the difference between profit and loss, success or failure, life or death. To keep track of all these variables, the computer offers practical answers.

This equipment is being used on an ever increasing basis to process large amounts of statistical, problematical, or experimental information, and to print out or display answers or information in very short periods of time. More and more reliance is being placed on the equipment to perform the repetitive, the experimental, and in some cases, even the whole programming operation for business, industry, government, and research groups.

This increased reliance on the computer has pushed the need for the ever more reliable computer and thus the necessity of "taking care" of the computer. While a computer's "needs" can be very exacting, they are few in number. Provide a computer with controlled temperature and humidity, dust-free air, freedom from radio frequency interference, and an uninterrupted source of filtered, regulated electric power and you'll keep those costly upsets to a minimum. Adequate fire protection, provisions for water-leak detection, and a realistic facility security system will defend against three more sources of trouble. An environmental-conditions monitor can put the finishing touches on a complete environmental-control package that will keep your computer on-line with a minimum of fuss. Each of these areas merits closer attention.

GENERAL DESIGN/CONSTRUCTION ISSUES

- Is the site large enough to contain the equipment? You should allow approximately 300 sq. ft. for each average size series 70. It is also prudent to plan at this time for expansion of the data center. If a second machine or significant expansion (i/o bay, disk drives, etc.) of the existing machine is likely then doing the construction now to include these needs would greatly reduce the impact on the future operations. If expansion is a probability at sometime in the distant future, you still need to insure that space adjacent to the existing room can be secured when the needs become current.

- Will the site/construction provide physical security? It was "fashionable" at one time for a company to put their computer operation on display. This showed their customers and visitors that they were an "automated modern company". Today, computer rooms are tucked away and do not have windows for viewing the operation. The walls are usually constructed of concrete block that go from floor to the primary ceiling. The doors to the room are steel fire rated doors with some form of locking to provide entry only to the authorized personnel. There are no signs in the rest of the building indicating the location of the data center.

- Has the site been checked for unique internal or external conditions such as excessive dust, vibrations, magnetic or electrical fields? The site selection also needs to be evaluated on this criteria that can be much more difficult to "see". Is the site near a transmitting tower, large motors, or motor controllers. These RF problems can be among the most elusive problems to diagnose and costly to solve. If in doubt an RF study by a consulting firm is in order.

- Can you get the equipment to the site? Walk the path that the equipment will take from the receiving dock to the room. Are the doorways big enough? Is the elevator large enough and can it handle the weight? Are the hallways wide enough and is there room to make the required turns with the equipment? Is the floor strong enough to support the equipment plus the equipment being used to move it?

- Are you meeting all code requirements? There are national, state, and local codes that must be met for a computer room. If you do not know these code requirements the best way to insure your compliance is to have knowledgeable people as your resources (from inside or outside of your company).

- Is raised floor necessary? Raised floor provides for very flexible cabling needs, gives a neat appearance, and safer for the personnel. It also provides the best method for distributing the conditioned air to the needed locations in the room. Raised floor should be a minimum of 12 inches above the primary floor if possible. Heights down to 6 inches require that the cabling under the floor be more managed so as not to restrict the air flow. Raised floor adds approximately $10/sq. ft. to the room cost, so the cost/benefits of it are well worth the added cost.

- Emergency stop buttons are required by the national electric code to be located at the exit doors of the computer room. These buttons should be shielded from accidental pushing and must turn off all power in the room except for the lighting.

- Emergency lighting should be provided in the room. You can not imagine what dark is until you are in the back of the computer room with no windows and the lights go out.

- An annunciator from the building fire alarm should be placed inside of the computer room. The rushing air sounds inside of the room make it impossible to hear anything that is located outside of the room.

- A high temperature cut-off switch should be connected to the computer grade power. In the event that the room reaches 85 degrees F, the power to the computer should be cut-off to automatically force it down. The system manager who allows the computer to be "cooked" will have a miserable life for the next 6-12 months while stressed components fail one after another.

- All computer grade power should be kept under the raised floor. The electrical outlets on the wall should be standard building power. This prevents the maintenance person from plugging in a piece of equipment that will generate noise on the output side of the clean power system.

Now let's look at three of the more critical components in maintaining a good computer environment.

ELECTRICAL POWER

ELECTRICAL POWER CONCERNS

Sensitive computer equipment requires special care. In today's competitive business environment, there is no question...computers play a major role in the survival of almost every company. Mainframes, minis and personal computers support entire operations from purchasing and production scheduling to word processing and accounting functions. Unscheduled downtime is frustrating as well as expensive. One of the leading causes of computer downtime stems from problems associated with the electrical power.

Recent studies show the typical computer site is threatened approximately 128 times a month with some sort of power disturbance. Obviously the types of power problems, severity and number of occurrences will vary from site to site. Experts say power disturbances are responsible for 62% of all computer problems.

Overall, our nation's power is 99% reliable. It's the quality of the power that has become the focus of increasing attention. In the past consumers have evaluated power quality by the simple standards of present (available) or not present (not available). With the implementation of micro circuitry in electrical devices such as computers, the requirement for more perfect power has increased. Over the years our standards have become much more sophisticated.

Not all power disturbances originate on the utility side of the meter. Consumers can generate problems simply by the normal use of electricity. Everyday activities like the operation or switching of a large load within your facility can generate a line disturbance. An example is heavy air conditioning loads operating during the summer months which can depress capacities and cause the voltage to drop. During this low voltage or sag condition, power can momentarily fall below the tolerance limit of the computer, long enough to crash the system or cause severe hardware damage. Another instance of "power pollution" is poor grounding. Multiple equipment grounds that are incorrectly isolated can cause ground loop currents that put noise into signal circuits. These are the reasons that every computer site is subject to power disturbances.

Unfortunately for computer users the list of power disturbances and the origins go on and on. The fact remains, a reliable source of quality electrical power is critical for dependable computer operation. The fact remains, a reliable source of quality electrical power is critical for dependable computer operation. Considering the significant investment made in automation, the computer and its power deserve special care. Remember, it is not only the equipment you want to protect but the valuable information stored inside as well.

POWER DISTURBANCES AND DIRTY POWER

Comprehensive studies have been done on power disturbances, typical causes, and the affects on computer systems. The experts have classified disturbances into three categories: Type I, Type II and Type III.

Power disturbances can happen at any time, and can be caused by events such as lightning strikes, utility equipment failures, large load changes, arc welders, motor speed controllers and other randomly occurring events.

Figure 1 thru 3 summarize each type of disturbance and depict the affects of each on a normal electrical (AC) sinewave.

PINPOINTING POWER PROBLEMS

System crashes, processing errors and repeated maintenance calls for computer repairs are obvious indicators of power problems. You don't have to live through these crises to find out there is a problem with power. The most effective way to pinpoint potential problems is to call in an expert for a power survey.

A power survey is a complete evaluation of the incoming power as well as the electrical design of the facility. A line disturbance analyzer is connected at the power input to measure and record the incoming power, the power actually used by the computer. Usually the analyzer is left in place long enough to collect data typical of the site. The electrical design is also evaluated in terms of circuits dedicated for the computer and equipment grounding.

This on-site study provides the data to identify specific power problems. It also provides a basis to determine the need or level of protection or refinement for the computer and its power.

Today computer vendors may recommend the installation of buffering or corrective devices to protect against power disturbances. The necessity of minimizing or totally eliminating disturbances depends on the sensitivity of the computer operation and the individual operating requirements. The question is not one of choosing protection but rather getting the return you anticipated on your computer investment.

MINIMIZING OR ELIMINATING THE EFFECTS OF POWER DISTURBANCES

With recent advancements in computer room power protection, most power disturbances can be minimized and even completely eliminated. In some cases it may only be necessary to modify the electrical design of the facility to correct a disturbance. Other cases require the installation of power conditioning or power synthesizing equipment to achieve optimum results.

In the latter case there is a number of devices to choose from, each offering a different level of protection.

POWER CONDITIONING EQUIPMENT

Power conditioning equipment is effective on Types I and II disturbances. These devices enhance the power and correct very specific problems. Conditioning devices include: 1. Isolation Transformers 2. Spike Suppressers 3. Voltage Regulators These are inexpensive solutions that provide a minimal level of protection. Often combinations of these devices must be used in order to obtain desired results.

POWER SYNTHESIZERS

Power Synthesizers actually use the incoming utility power as an energy source to create a new sinewave free from any disturbances. These regulatory devices can be as much as 99% effective against power disturbances. Synthesizers include: 1. Magnetic Synthesizers with the capability of generating a sinewave with the identical frequency (60 Hertz) of the incoming power. Since these devices use the utility power as an energy source to rebuild the sinewave and they are effective only against Types I and II disturbances.

2. Motor Generators use an electric motor to drive a generator which provides electrical power. If equipped with a heavy fly wheel, the MG may ride through momentary outages. These devices are relatively costly in terms of the initial purchase price and maintenance. MGs are effective against Types I and II disturbances.

3. Uninterruptible Power Supplies or UPSes provide the best protection against all types of disturbances. The system consists of a rectifier, battery and inverter working together to provide a continuous flow of power to the computer even when the utility power is completely off. The amount of protection time is determined by the battery capacity you choose. Generally sufficient battery capacity is chosen to conduct an orderly shut down or to start up a diesel generator. Two types of UPSes are available, stand-by and on-line. Stand-by are the least expensive of the two technologies but are somewhat limited by their inverter. With the stand-by technology, the switchover time could be long enough to lose the critical computer load. Any problems with the inverter cannot be detected until the crucial moment when it is required to carry the load. An on-line UPS differs in that the inverter is on at all times. There is no switchover time involved to make the transition to the battery discharging mode. An on-line UPS supplies the computer with continuous conditioned and regulated power. Because this type of system is on-line continually, potential problems can be sensed in real-time rather than waiting for a power outage to find out whether

all components are operational. A UPS is the ultimate in power protection and generally the most expensive.

CONCLUSION

The cost of each solution increases with the level of protection desired. The more protection required...the greater the investment.

Using a cost analysis, the true value of power protection is realized when compared with the cost of downtime and hardware damage from a single disturbance.

AIR CONDITIONING

Computers, like giant electric furnaces, generate vast amounts of heat and their components are very sensitive to extremes of temperature, humidity, and the presence of dust.

In the past, a substantial percentage of computer installations were designed to utilize central refrigeration systems with either a built-up or a modular fan-coil air treating distribution system. The pendulum has now swung in favor of unitary expansion systems.

Today, it is estimated that from 65% to 75% of the environmental control systems being designed for new or remodeled computer rooms employ unitary systems.

Why this significant trend away from central systems? Three principle benefits which accrue to the owner-user are: simplicity, flexibility, and economy. In conjunction, system security is becoming more of a factor in the application of unitary systems. If the security of the computers and their peripheral equipment is important-and it is-then why not make every effort to maintain the same degree of security over the environmental control system? Physically locating the entire air conditioning system within the computer room itself, with simple connections to indoor or outdoor heat rejection systems-which can be located in any secured area of the building system, virtually assures total systems security.

PRECISION AIR CONDITIONING VS. COMFORT AIR CONDITIONING

Precision air conditioning is the simultaneous control of temperature, humidity, air motion and cleanliness in a specified area, continuously and accurately. It is as far in advance of comfort air conditioning as the computer is of the adding machine.

Modern office buildings have long accepted comfort air conditioning as a definite influence on increased productivity,health, attendance, and comfort of their tenants. The design of the system varies with the types of buildings and their geographical location.

Industrial air conditioning is very common where certain processes require control of temperature and humidity not only for the sake of the product process, but also the factory worker. Generally speaking, the control for these types of systems is not accurate enough for today's sophisticated electronic equipment such as in computer rooms. The computer room requires precision air conditioning year round.

Conventional comfort air conditioning is not precision air conditioning. Conventional systems cannot handle computer room loads that demand close tolerances in both temperature and humidity year round.

Comfort air conditioning primarily conditions people. Precision air conditioning primarily conditions equipment. There are distinct and important differences in the design parameters.

1. DESIGN CONDITIONS The average skin temperature of people is 80 degrees F. If the room is cooler, bodies radiate heat; if warmer they absorb heat. Consequently, comfort air conditioning systems are designed at 80 degrees F in the summer, and at 60 degrees F in the winter. This is too wide of a range for computer room applications. A computer radiates considerable heat and requires a stable temperature of 72 degrees F to 75 degrees F.

2. SENSIBLE HEAT RATIO (See Figure 4) People emit latent heat through normal metabolism, and the heat contains moisture. Equipment gives off dry electronic sensible heat which is moisture-free.

The sensible heat ratio - the amount of sensible cooling as a percent of total cooling capacity (sensible plus latent heat) - is 65% to 70% of the total load in a comfort system. The dry heat generated by computers requires a sensible heat ratio of 90% to 95% from the cooling equipment. This creates additional confusion when the only measure of cooling capacity is "tons". A comfort air conditioning system nominally rated at 10 tons may only provide 6 or 7 tons of precision air conditioning. This has resulted in unpleasant circumstances when the room cannot be cooled; there may not be enough cooling. This same concept holds true with smaller 1-3 ton requirements.

3. LOAD DENSITY (See Figure 5) Because of this high

sensible heat, the cooling capacity in terms of BTUH per square feet is greatly increased. Office buildings, where the total load results from many people and considerable outside air, are designed for 40 to 48 BTUH per square foot. Data centers average 120 to 240 BTUH per square foot, 3 to 5 times as much as in a comfort system.

Translating this to another "rule of thumb", square feet per ton, we have:
COMFORT AIR CONDITIONING-250 to 300 sq.ft./ton.
DATA CENTERS-50 to 100 sq.ft./ton.

4. AIR QUANTITY Comfort systems with room cooling design temperatures of approximately 80 degrees F normally supply 350 to 400 CFM per ton of cooling capacity. Computer rooms, because of the lower design temperature requirement of 72 degrees F, require 50% to 60% more air; on the order of 500-600 CFM/ton. In addition to air quantity, the air distribution pattern is critical.

5. HUMIDITY CONTROL Both humidity and temperature must be "just right" for computer rooms or there can be expensive shut-downs. Comfort air conditioning systems do not normally have any humidification capability. Dehumidification occurs during cooling modes of operation, but will not occur if the humidity level rises and with no increase in temperature. Precision air conditioning systems provide for the simultaneous control of humidity and temperature. They also insure that the humidification and dehumidification operate separate from each other.

6. ANNUAL HOURS OF OPERATION Usually comfort air conditioning is in operation some eight hours a day, five days a week, from April to September. That's almost 1200 hours intermittently. Precision air conditioning operates continuously all day, every day, all year long. That's 8760 hours, non-stop.

7. PRECISION CONTROLS Computer room air conditioning demands temperature and humidity controls which are fast acting, and capable of holding rood limits within a temperature swing of plus or minus 1 degree to 3 degrees F and a humidity swing of plus or minus 2% to 4% RH. Without fast-acting precise control, computer hardware and peripheral equipment are susceptible to many types of shutdown problems.

COMPUTER ROOM PROBLEMS Problems such as equipment failure ... hot spots ... low air quantity ... condensation ... tape deterioration ... processing gibberish ... read-write errors ... paper sticking ... card jams and head crash are the result of the improperly controlled temperature-humidity and cleanliness due to inadequately designed computer room air conditioning.

INVESTMENT Computer systems represent a substantial investment of tens of thousands of dollars...often hundreds of dollars per hour! Heat, moisture, and dirt can cause breakdowns resulting in tremendous financial losses. To protect against these losses, a unitary air conditioning system is relatively inexpensive.

Investment in precision air conditioning can be as low as 1% of the value of the computer equipment installed in the data processing center.

SYSTEM OPTIONS There are four types of computer room environmental systems...air cooled...water cooled...glycol cooled...chilled water.

UNITARY

Air Cooled is the simplest type. It uses refrigerant to absorb the computer room heat. Then, in a closed loop, it takes the heat outside through an air cooled condenser where it is discharged into space.

The Water Cooled system uses refrigerant to absorb heat but it transfers the heat to a water cooled condenser that is built into the unit. The cooling water is circulated through an outside cooling tower where the heat is removed.

The Glycol Cooled system also uses refrigerant to absorb the heat but transfers it to a glycol solution through a condenser within the unit. The solution is then pumped to a drycooler which dissipates the heat to the outside air.

CENTRAL

In its simplest form the Chilled Water system uses water to directly absorb the heat in a computer room. This is usually done by a chiller which removes the heat from the water and returns chilled water back to the unit. This is not a totally independent system unless a separate chiller is provided for the computer room.

ENERGY EFFICIENCY RATIO AND OPERATING COST

Not surprisingly, EER data and operating cost analyses favor the simplicity of direct heat rejection from refrigerant to outside air-as in the case with air cooled systems.

Acknowledging key features in basic equipment design which include the use of semi-hermetic compressors, shallow evaporator coils coupled with low face velocity for high sensible heat factor performance and low fan horsepower-EER's on the order 8.5 to 10.5 are not uncommon for air cooled unitary systems. And these compare to 6.5 to 7.0 for comparable capacity glycol systems utilizing sealed hermetic compressors.

Recent computer studies for industrial users and also experience with the Federal Government (GSA) Value Management Program, point to a significant increase in selection of air cooled unitary systems.

An on-line system typically would require equipment operation 8760 hours per year. Experience dictates approximate operating time for various possible modes of system operation will be:

Percent	Mode
50	Full cooling
20	Dehumidification w/full reheat
20	Dehumidification w/no reheat
5	Heating and humidifying
5	Full cooling and humidifying

For a given system, once the KW required for each of the above mentioned operating modes is determined, it is a simple matter to apply the time percentages, calculate the total KWH per hour of operation - and project annual operating cost over an 8760 hour year at an average cost of power of so much per KWH.

SUMMARY The user is encouraged to review the basic differences between comfort air conditioning systems - and precision air conditioning systems as commonly applied to computer rooms today. Trends away from central systems to unitary systems for reasons of simplicity, flexibility, economy and security should also be noted. The selection of air cooled unitary systems for the primary reasons of simplicity and economy represent a significant trend in the industry.

FIRE PROTECTION

Much has been written on the procedural steps required for study before installing electronic computer/data processing equipment. These requirements embrace selection of proper equipment, checking and planning for areas to receive the equipment, utility requirements, orientation and training of personnel to operate the equipment, as well as consideration for expansion of the initial facility. One other factor should be included in this vital study - namely, protection against fires of either accidental or deliberate origin.

In addition to the hazards of fires from accidental causes, many computers and data processing installations have become prime targets for sabotage and arson.

Oftentimes, the strategic importance placed upon electronic computer/data processing equipment by the user is vitally tied to uninterrupted operation of the system. Consequently, by the partial or entire loss of this equipment, an entire operation of vital nature could be temporarily paralyzed.

Not to be overlooked are the "one-of-a-kind" electronic computer systems. These are the "custom-made" models that are designed to perform specific tasks. Replacement units for this type of equipment are not available and the probability of the existence of duplicate facilities, which could be used to perform vital operations in the event the "one-of-a-kind" system is partially or totally impaired by a fire, is remote.

Computer equipment and materials for data recording and storage may incur damage when exposed to elevated sustained ambient temperatures. The degree of such damage would be variable depending upon exposure, equipment design and the composition of materials for data recording and storage. The following are guidelines reflecting concernable sustained ambient temperatures:

a) Damage to computer equipment may begin at a sustained ambient temperature of 175 degrees F with the degree of damage increasing with further elevation of the ambient temperature and exposure time. This temperature would be the temperature inside the computer cabinets that the components "see" and not the temperature of the computer room.

b) Damage to magnetic tapes, flexible discs, and similar materials may begin at sustained ambient temperatures above 100 degrees F.

c) Damage to hard disc may begin at sustained ambient temperature above 150 degrees F with the degree of damage increasing rapidly with further elevations of ambient temperature.

d) Damage to microfilm may begin at a sustained ambient temperature of 225 degrees F in the presence of high humidity or at 300 degrees in the absence of high humidity.

Planning for fire protection is vital due to an organization's dependence upon the computer equipment. Once management commits itself to a program of dependence on any such equipment, simple economics dictates doing away with former methods and procedures. The personnel, equipment, and facilities are no longer available to pick up the load assumed by the data processing equipment if it is put out of operation by fire or other unforeseen occurrences. Often, the major cost involved to management by disruption of the computer operation is from business interruption rather than from the actual monetary loss represented by the equipment itself.

Exposure to destruction can come from within a computer cabinet, from within the equipment room, from the immediate area around the data processing room, from floors above and below the computer, and from outside of the building in which the equipment is located. This exposure can be evaluated and then controlled as needed.

METHODS OF PROTECTION:

- halon or carbon dioxide flooding under raised floor - a high level, fast acting method in which halon vapor is discharged automatically into the space under the raised floor. Halon use minimizes the noxious, corrosive effects of smoke vapors produced from the combustion of PVC insulation on computer cabling. Smoke films which remain may cause unexpected and recurring operational problems months after a cable burns. Thus it is vital to quench the generation of smoke in under floor areas as quickly as possible. Carbon dioxide is a potential alternate to halon but the freezing effects and density of this gas can make it less effective in tight, under floor areas. Use this protection (in addition to primary room protection methods) where cables exist under a raised floor.

- local halon flood of enclosure panels - a fast acting protection method which involves directing halon nozzles directly into electronic equipment enclosures. This method reduces the cost of filling an entire room, but carries some risk that the fire won't be extinguished unless all sources of ignition are surrounded by halon vapor.

- carbon dioxide flooding of room - enough carbon dioxide gas is discharged into the room (upon sensing a fire) to suffocate combustion by displacing all oxygen. Restrict use to unoccupied rooms unless special alarm and delayed actuation precautions are taken. **Special Note** ... this method represents a severe personnel hazard and the required delayed actuation allows a fire to progress after detection.

- halon flooding of room - a high level, fast acting protection method in which halon is discharged into the room from fixed ceiling heads (usually discharge also occurs under raised floor from smaller heads placed in the under floor space). Halon expands quickly throughout the room. The halon/air mixture chemically breaks the combustion chain and the fire goes out. Maintaining the mixture for a fixed period of time to minimizes the risk of re-ignition. Use sprinklers as a back-up on critical equipment systems.

- auto wet-head sprinklers in room - disaster level protection which uses fusible links or quartzoid cylinder wet head sprinklers within the computer room. Each head is individually activated by exposure to ceiling temperatures of at least 165 degrees F. This protection senses catastrophe or disaster size fires, but may not respond to minor electrical short circuits or burn-outs.

- pre-act water sprinklers in room - disaster level protection which reduces the risk of accidental water release, and uses an early warning detection system to fill the normally empty sprinkler

- building or perimeter sprinklers external to room - external area protection which minimizes hazards external tot he computer room. It may protect the computer room from major fire damage should a fire start outside of the room. Only the outside perimeter area around the computer room may be sprinklered if the surrounding building area is not. Use this protection in addition to primary protection inside the room.

A CLOSER LOOK AT HALON

Halon 1301 is a colorless, odorless, electrically non-conductive gas with the chemical name "bromotrifluoromethane". It is used in a fire suppression system to protect valuable or irreplaceable materials and equipment which could be damaged or destroyed by other types of fire extinguishing agents. Halon 1301 extinguishes fire by inhibiting the chemical reaction of fuel and oxygen. It is a "clean" agent because it leaves no water, foam, or powder residue behind to damage delicate equipment.

Halon 1301 versus water

Water is a conductor of electricity and generally not selected for fire protection of electrical equipment. It also is not recommended for use on fire in record storage areas, libraries, rare document rooms, etc. because it often causes more damage than the fire itself.

Halon 1301, on the other hand, is highly effective on electrical equipment since it is a non-conductor of electricity. It leaves no residue so it won't harm records, books, and other valuable documents.

Halon 1301 versus carbon dioxide

Carbon dioxide will not conduct electricity nor will it leave residue which could damage equipment. But carbon dioxide works by displacing oxygen from the atmosphere of the fire area and this results in a dangerous situation for personnel.

Halon 1301 works by interfering with the combustion process, not by diluting or displacing oxygen. Accordingly, an atmosphere containing enough halon 1301 to put out the fire (5-7% concentration) also will safely support human life (check with a fire protection vendor for the safe exposure times for halon).

SUMMARY

In short, the computer has some basic needs that when fulfilled will insure you of maximizing the uptime of your investment. HP's "Site Preparation Set" provides an excellent guide toward this goal and the HP customer engineer is another excellent source.

Maintain and test your equipment per the manufacturers recommended P.M. schedule and it will support your needs for maximized computer uptime.

THANK YOU

My sincere thanks to Mr. Dick Hackman (HP Senior CE, Procter and Gamble Major Account Team) not only for his collaboration and support on this paper but also for the many years of dedicated service supporting the HP effort within P & G.

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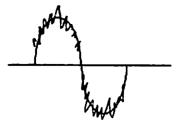
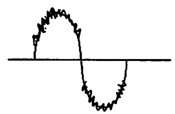
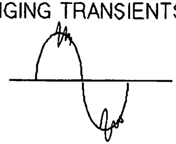
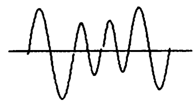
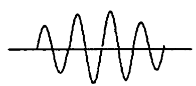
"Protection of Electronic Computer/Data Processing Equipment 1976", National Fire Protection Association Inc.

POWER DISTURBANCES	DEFINITIONS	CAUSES	POSSIBLE COMPUTER SYMPTOMS
COMMON MODE DISTURBANCES 	Impulses and EMI/RFI noise with respect to ground superimposed on the power conductors. Amplitude–Millivolts to several volts for noise. hundreds of volts for impulses	Radio transmission. Normal computer operation. Arcing contacts. Lightning. Poor grounding and shielding.	Incorrect data transfer from CPU to disk or tape. Terminal or printer errors. Input/output hardware damage. Power supply damage.
NORMAL MODE NOISE 	Low level signals super-imposed on the power sinewave. Amplitude – 0.5 V to 25 V.	Normal computer operation. Switching power supplies. Power line modulation equip-ment (i.e. Simplex™ clocks). Motor speed controllers.	Processing errors. Incorrect data transfer from CPU to memory. Printer or terminal errors.
NORMAL MODE IMPULSES and RINGING TRANSIENTS 	Typically a narrow, fast-rise voltage variation. Can be followed by a damped oscillation decaying to nominal in less than one cycle. Amplitude – 50V to 6kV. Duration – 0.5 usec to 2000 usec.	Switching loads on or off. Normal computer operation. Fault clearing. Utility switching. lightning.	Incorrect data on disks or tapes. Processing errors. Printer or terminal errors. Hardware damage.

Type I

FIGURE 1

POWER DISTURBANCES	DEFINITIONS	CAUSES	POSSIBLE COMPUTER SYMPTOMS
SAGS 	A low-voltage condition on one or more phases. RMS voltages below 80-85% of nominal. Duration - Greater than 1 cycle.	Ground faults. Starting large loads. Inadequate power system capacity. Utility switching. Utility equipment failure. Lightning.	Computer system crashes. Hardware damage.
SURGES 	A high-voltage condition on one or more phases. Voltages above 110% of nominal. Duration-Greater than 1 cycle.	Rapid load reduction. Utility switching.	Hardware damage.

Type II

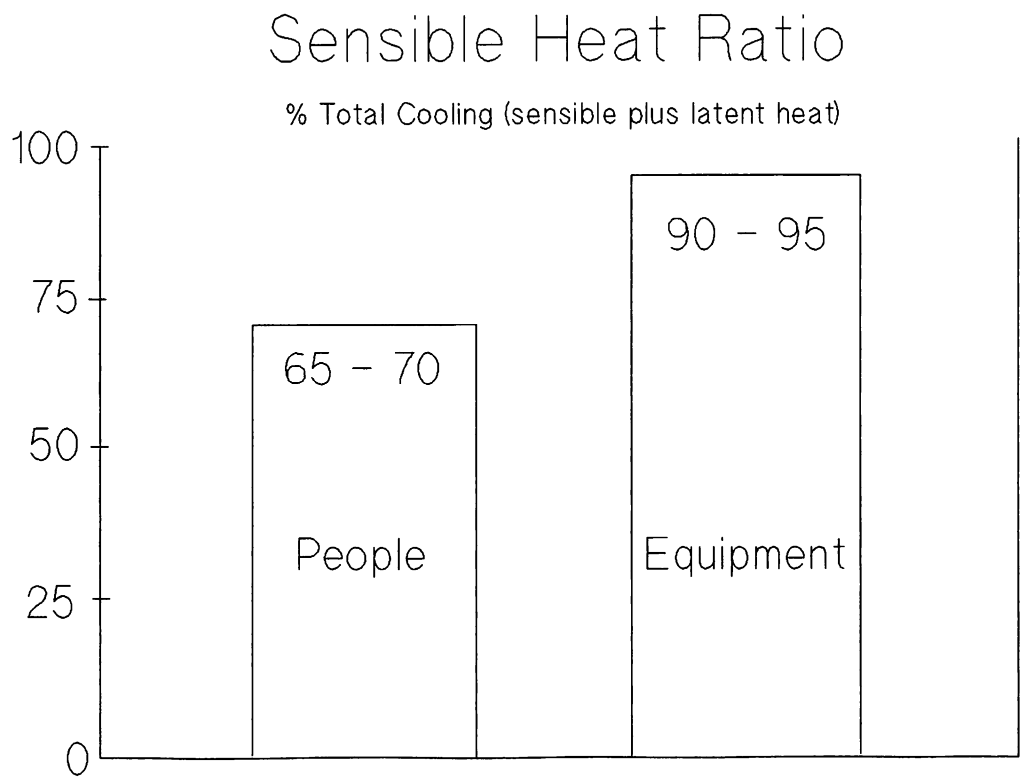
FIGURE 2

POWER DISTURBANCES	DEFINITIONS	CAUSES	POSSIBLE COMPUTER SYMPTOMS
OUTAGE	A zero-volt condition lasting longer than a half-cycle.	Ground faults. Equipment failure. Accidents. Utility Equipment failure. Lightning. Acts of nature.	System crashes. Hardware damage.

Type III

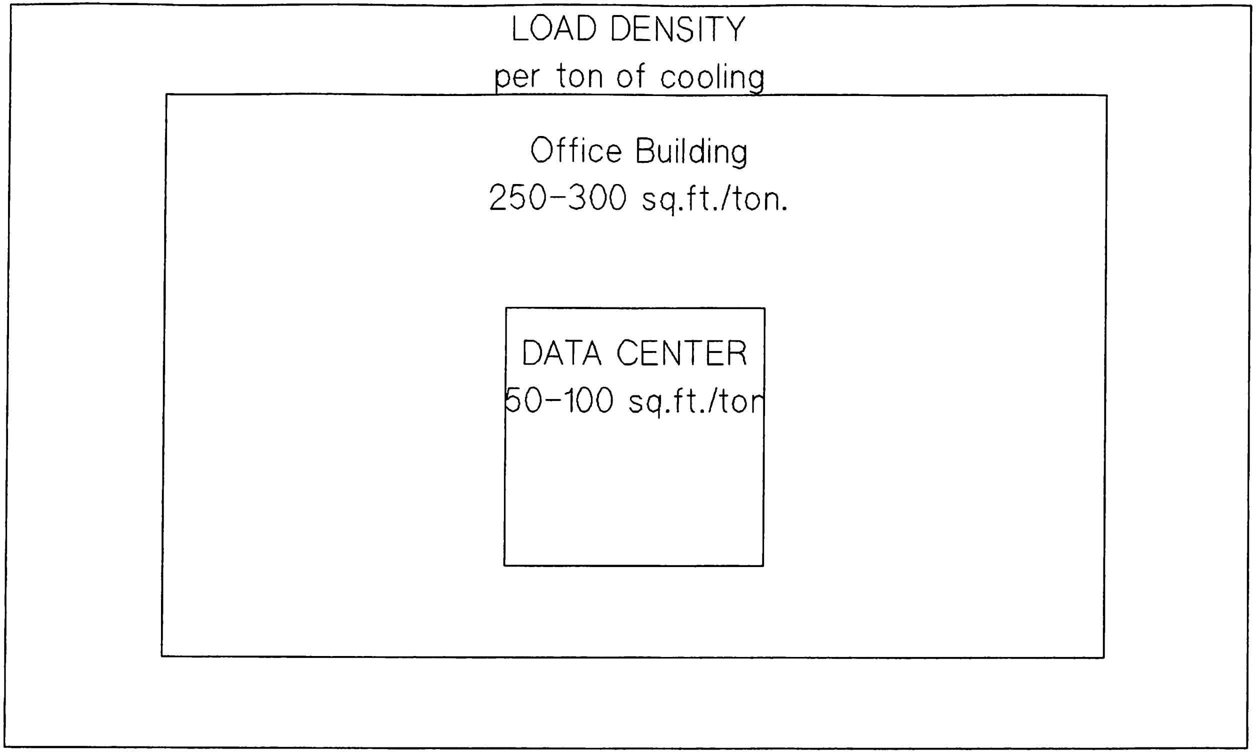
Building a Home...0119

FIGURE 3



Building a Home...0119

FIGURE 4



Building a Home...0119

FIGURE 5

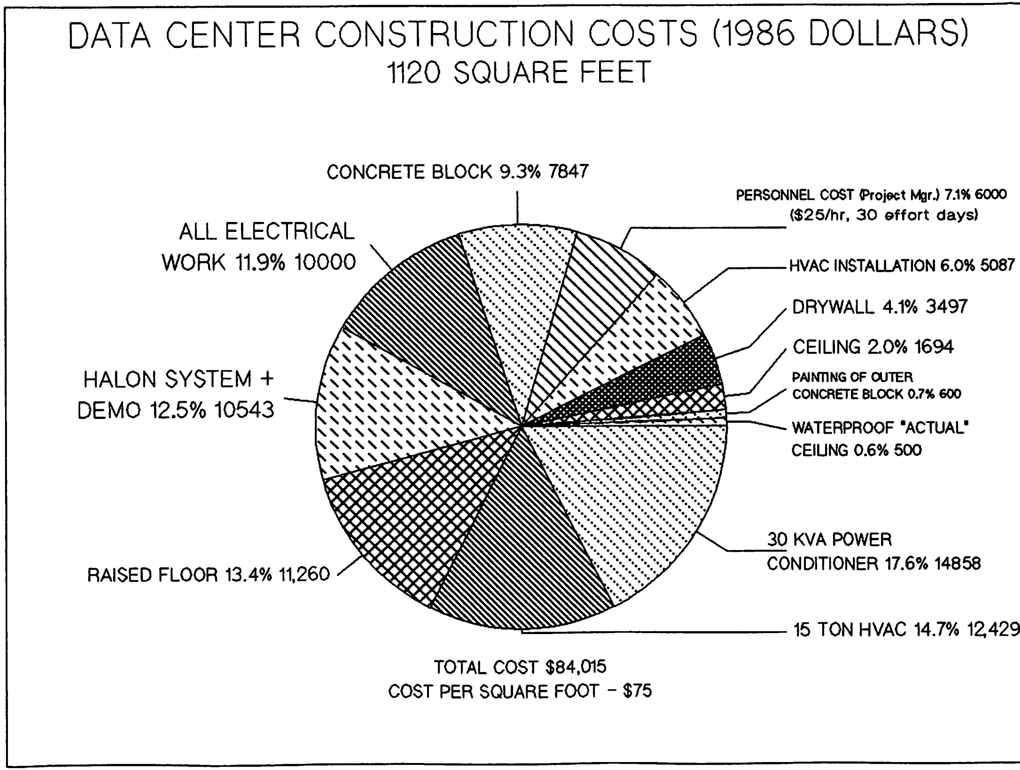

DATA CENTER CONSTRUCTION COSTS (1986 DOLLARS)
1120 SQUARE FEET
CONCRETE BLOCK 9.3% 7847
PERSONNEL COST (Project Mgr.) 7.1% 6000
($25/hr, 30 effort days)
HVAC INSTALLATION 6.0% 5087
DRYWALL 4.1% 3497
CEILING 2.0% 1694
PAINTING OF OUTER CONCRETE BLOCK 0.7% 600
WATERPROOF "ACTUAL" CEILING 0.6% 500
30 KVA POWER CONDITIONER 17.6% 14858
15 TON HVAC 14.7% 12,429
RAISED FLOOR 13.4% 11,260
HALON SYSTEM + DEMO 12.5% 10543
ALL ELECTRICAL WORK 11.9% 10000
TOTAL COST $84,015
COST PER SQUARE FOOT - $75

FIGURE 6