HP 3000 Computer Systems

SERIES 64/68 SITE PLANNING and PREPARATION GUIDE

HEWLETT PACKARD

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The List of Effective Pages gives the date of the current edition, and lists the dates of all pages of that edition and all updates. Within the manual, any page changed since the last edition is indicated by printing the date the changes were made on the bottom of the page. Changes are marked with a vertical bar in the margin. If an update is incorporated when an edition is reprinted, these bars and dates remain. No information is incorporated into a reprinting unless it appears as a prior update.

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The software product part number printed alongside the date indicates the version level of the software product at the time the manual edition or update was issued. Many product updates and fixes do not require manual changes, and conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

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PREFACE

This manual contains site preparation information for HP 3000 Series 64/68 Computer System. The manual is part of the Site Preparation Set, part number 30140-60085. The set consists of:

HP 3000 Series 64/68 Computer System Site Planning and Preparation Guide, Part Number 30140-90011 (this manual)

HP 3000 Series 64/68 Computer System Site Planning Workbook, Part Number 30140-90012

HP Computer Supplies, Part Number 5953-2450

Proper site preparation is vital to the reliability of the computer system. As the customer, it is your responsibility to ensure that facility conditions are maintained in accordance with the specifications in this manual. This will allow Hewlett-Packard to provide support services in accordance with the "Customer Support Services Agreement."

You should study and become familiar with the contents of this manual before starting site planning and preparation.

HP representatives are available for consultation regarding the objectives, courses of action, and progress of installation. However, where recommendations are needed for electrical, environmental, air conditioning, and construction, you should hire specialized consultants.

This manual refers to various associations and standards. These references apply only to the United States (and, in some cases, Canada). As it is impossible to provide equivalent references for each locality, you must determine who your local authorities are, especially for safety codes.

SITE PLANNING

SECTION I

INTRODUCTION

This section introduces the task of site planning for your HP 3000 Series 64/68 Computer. Your HP representative will be available to answer questions regarding the contents of this document and explain Hewlett-Packard's specifications. More detailed information for site preparation is contained in the subsequent sections.

INITIAL PLANNING

All factors related to proper site preparation should be considered when the order for your system has been placed and confirmed. Items to be considered are:

- o Selection of Site Coordinator
- o Identification of Site Planning Team
- o Site Selection and Size
- o Equipment Location
- o Construction Requirements and Schedules
- o Safety Precautions / Regulations / Requirements
- o Scheduling Contractors
- o Data Communications Equipment Including Installation
- o Checklists
- o User Training
- o Consumables
- o System Installation
- o Delivery Schedules and Receipt

Site Coordinator

You should designate a site coordinator who will interface with contractors, Hewlett-Packard representatives, facilities personnel, and any consultants to ensure the timely completion of site preparation and acceptance of the computer system upon delivery. The site coordinator may be the

system manager or data processing department manager and will be responsible for schedules and construction efforts, and will be the primary liaison with Hewlett-Packard representatives.

Site Planning Team

It may be desirable to establish a site planning team under the direction of the Site Coordinator. Members of the team should include contractors for electrical installation, site construction contractor, and air conditioning specialists. Hewlett-Packard representatives will participate in planning meetings. The function of a site planning team is to determine site location, size, construction requirements (including electrical and environmental factors), review local codes and insurance carrier requirements, and schedule all events related to site completion.

Site Selection

Site selection is determined after a review of local building, electrical, fire, and other safety codes. In particular, environmental conditions must be considered. Existing sites that are to be expanded must be reviewed for size adequacy along with power and environmental requirements. However, new sites require a review of the entire building with regard to power source, environment, system accessibility by users, and space limitations. The key to a successful installation and long-term reliability of your new HP 3000 computer system is through effective and thorough site preparation.

Construction Requirements

Requirements for construction and types of contractors or specialists needed should be determined in the planning phase. After consulting with these people a schedule should be prepared by the Site Coordinator and all events monitored for progress and completion.

Safety Precautions

When safety precautions are reviewed, emphasis should be exercised on all matters concerning personnel and equipment. Careful scrutiny of all codes may avert reconstruction costs at a later date because of oversights in planning and implementation. Careful study will eliminate inadvertent introduction of potential hazards. Your insurance carrier and local building inspectors can advise you on these matters.

Equipment Location

When planning equipment location, ensure that adequate working space is available for personnel and that all equipment is readily accessible. Use the materials in the Site Preparation Workbook to prepare a site floor plan. See Figure 1-1 for an example site floor plan.

Data Communications

In addition to the equipment furnished for your system by HP, you must provide for the ordering and installation of:

o Modems

o Telephone equipment

o Equipment supplied by companies other than HP.

Remember that communications systems at your site are not part of the computer and must be considered separately for power, space, electrical, interface cable lengths, and cooling requirements. It is your responsibility to learn these requirements from the equipment vendors and to arrange for equipment installation.

Remote support significantly enhances hardware and software support through the use of an electronic data link established between your system and the local Hewlett-Packard Service Office. To be eligible for credit on hardware and/or software charges under this program, you must meet the following requirements:

NOTE

The following applies to the U.S.A. only. In other countries, refer to local authorities.

o An HP-approved modem must be connected to a direct data telephone line (not part of a PBX system) and installed on the remote console port of the eligible system. (Eligible systems are specified in the Remote Support Program data sheet.)

  HP-approved modems are:

  Hewlett-Packard 35016A
  Racal-Vadic VA3451S
  Bell 212A

o The modem must be connected to the system and the direct data telephone line at all times. Access to the equipment must be available when required by HP, although authorization from the system operator may have to be obtained.

o A separate telephone line must be located near the system console for voice communication.

The direct data line must have the following specifications when ordering from the telephone company:

o If using the HP 35016A or VA3451S, specify:

  a. RJ36X telephone connector jack
  b. RJ45S programmable data jack
  c. RTC exclusion key telephone handset, either a RTC503 dial with options A2, B3, C6, and D7, or a RTC2503 touch tone with options A2, B3, C5, and D7.

NOTE

Prior to connecting any device to the switched telephone network, FCC regulations (U.S.A. only) specify that you must provide the telephone company with the name of the manufacturer, FCC registration numbers, and ringer equivalence numbers of the devices to be used.

The data required by the FCC is:

	HP 35016A	VA3451S
Manufacturer	Racal-Vadic	Racal-Vadic
Model	35016A	VA3451S
FCC Registration No.	AJ496M-67213-DM-N	
Ringer Equivalence	0.9B	0.9B

If using the Bell 212A Data Set, specify:

Bell 212A Data Set with telephone handset and options A2 (T, Y, R), B3, C& (ZE, A, Q, W, interface speed indication out), D8 (YG, YJ, YP, YL, YR), E10 (YF).

Ordering Consumable Supplies

A catalog of consumable supplies available from HP is included in this set. Place an order promptly for all necessary supplies.

Schedule Training

Identify and enroll personnel who are expected to be HP 3000 users in the appropriate classes. Contact your HP representative for a schedule of classes.

Checklists

A Site Planning Workbook accompanies this document. It contains the checklists and worksheets that are to be used during site preparation. Review these lists and complete each as planning and work progresses.

o SYSTEM CONFIGURATION TABLE

The system components table lists the processors and peripherals.

o SITE COORDINATOR PLANNING CHECKLIST

This checklist is used by the site coordinator to monitor all tasks that are to be performed.

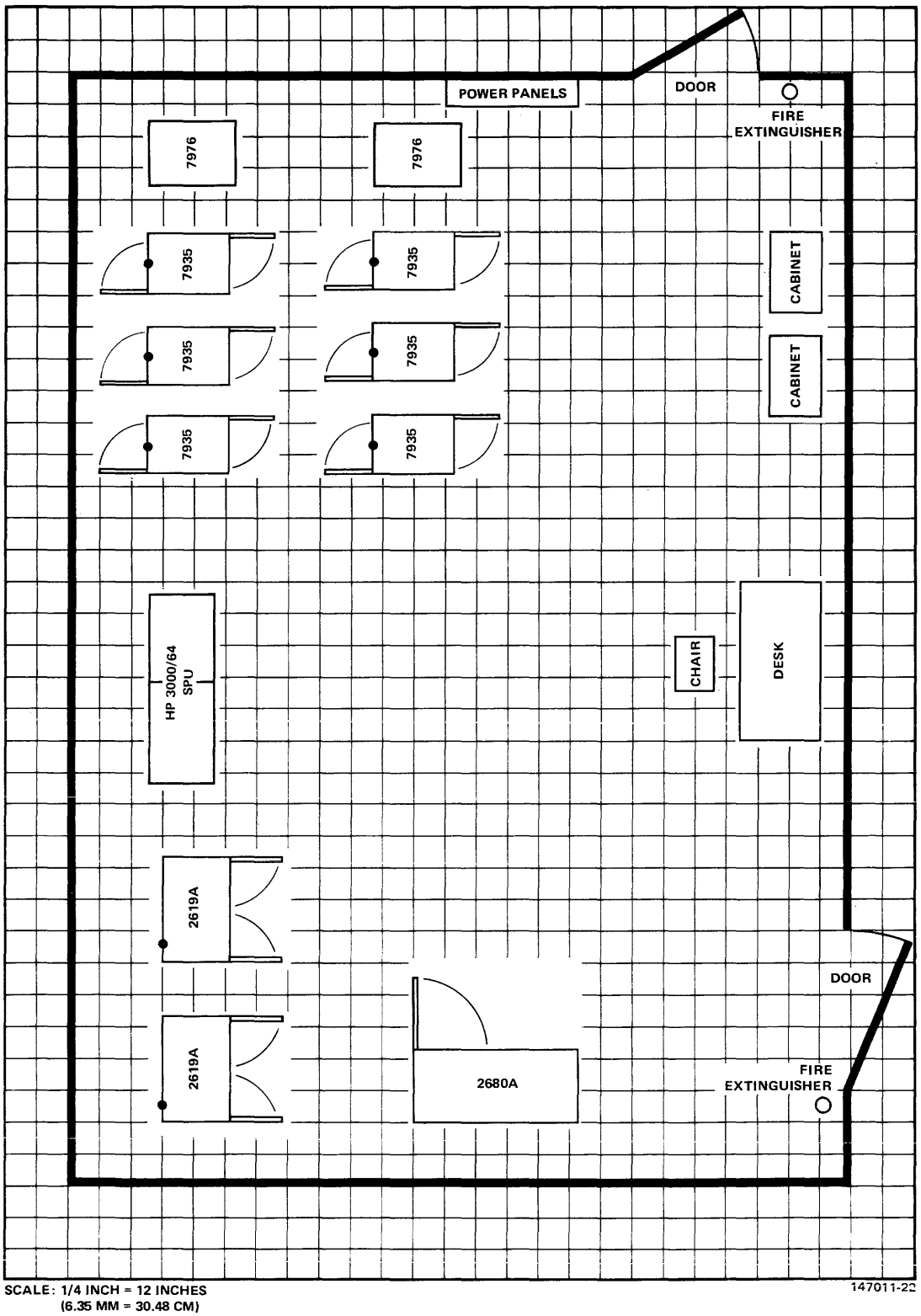

Figure 1-1. Example Site Floor Plan

o CONSTRUCTION PLANNING CHECKLIST

The construction planning checklist is used by the construction specialist as a guide to the tasks to be performed.

o AIR CONDITIONING PLANNING CHECKLIST

This checklist aids the air conditioning specialist in planning and installing the air conditioning system. It also includes a section for computing total heat dissipation, to help determine the size and type of air conditioning system and air quality needed.

o ELECTRICAL PLANNING CHECKLIST

This checklist allows the electrical specialist to plan and record the electrical installation tasks necessary for the site. It also has a separate section for recording the power consumption of the computer system lines and the utility power lines.

o SITE VERIFICATION CHECKLIST

This checklist is filled out at the time site preparation is complete. Site verification is performed by the HP Customer Engineer; the results are recorded on this checklist. The purpose of site verification is to ensure that the site is ready for installation.

o FLOOR PLAN KIT

The floor plan kit consists of a scaled-grid mylar sheet and adhesive-backed sheets on which component models are printed. These models are to be used for laying out the equipment in the computer room or site.

System Delivery

The system is sold F.O.B. origin. You must choose the type of carrier for hauling and delivery. There are three shipping methods from which you may choose. You should contact your HP sales representative as early as possible to indicate the shipping method of your choice:

o Padded Van

o Air Consolidation Program (used for International shipments)

o Common Carrier

The advantages and disadvantages of the three shipping methods are:

Type	Advantages	Disadvantages
Electronic Padded Van	Carrier will place computer system on site at the exact location designated by the customer. No crate required. Least susceptible to shiping damage. Short shipping time.	Cost slightly higher than Air Consolidation Program
Air Consolidation Program (Used for all International shipments)	Fastest shipping method	System is delivered to customer dock but not the actual installation site. Customer must uncrate the system.
Common Carrier	Lowest cost to customer	Longer shipping time than other methods. Most susceptible to shipping damage. System is delivered to customer dock but not to actual installation site.

Providing Insurance Coverage

It is your responsibility to provide insurance for all components of the computer system. Be sure to obtain adequate coverage to be in effect at the time the system and components are loaded onto the carriers, and to be terminated after the equipment is positioned at the installation site.

You are responsible for moving the system from your receiving area to the installation site. Therefore, be sure that you have insurance coverage during this move since accidental damage is your responsibility.

Receiving the System

The system will be delivered to the address on the "SHIP TO" portion of the system order. The processor unit will be shipped from Computer Systems Division. Peripherals will be shipped from the respective manufacturing divisions, as part of the general consolidated shipping plan. Circumstances beyond anyone's control can affect delivery schedules; therefore, allow two weeks for receipt of the components after you been notified of the shipments. If a component fails to arrive in two weeks, contact your Hewlett-Packard sales representative.

Upon receipt of the system, check the carrier's bill of lading against the boxes, crates, cabinets, and other items received. Inspect all packages for damage such as crushed corners, dents, scratches, breakage, or stains from liquids. If any sign of damage is discovered, have the carrier's representative

present when you unpack the item. If the item is damaged, file a written claim with the carrier's representative and notify the HP Customer Engineer.

A Master Packing List is attached to one carton of each shipment. This is the only list provided. Before moving the equipment to its final location, and before unpacking items, check the Packing List against all items received. Report any missing items to your Hewlett-Packard representative. Hewlett-Packard will replace missing or damaged parts without waiting for settlement of claims. Items shipped to replace missing or damaged parts will be billed to you and you have the responsibility of collecting all settlements from the carrier. Therefore, it is important not to release the carrier until the shipment is verified to be on hand and in good condition.

Moving the Equipment

Refer to the specifications in Appendix A of this manual to determine the size and weight before attempting to move any unit. Move all items to the location planned for their installation, using proper moving equipment and taking all the precautions noted below. If the site does not have proper moving equipment or the people who will handle it do not know the proper techniques, hire someone experienced in moving heavy electronic equipment.

CAUTION

Do not use a forklift to move cabinets unless no alternative exists. An offset center of gravity and/or point of balance could cause a cabinet to tip in any direction, possibly causing serious injury to personnel or damage to the equipment. If you must use a forklift, move only one cabinet at a time by placing the unit on a pallet and then lifting the pallet. Some units are equipped with casters; some are not. In either case, the units can be moved short distances providing that extreme care is taken to avoid tipping or jarring the units. Push slowly, being careful to avoid jamming casters or cabinet feet on debris or in seams or cracks in the floor.

CAUTION

Do not connect the system to its power source until all components are safely installed. This prevents someone from accidentally powering-up the system.

System Installation

When the site is complete and the shipments have been verified in good order, your HP Customer Engineer will install the system and ensure that it is operating according to factory specifications.

PHYSICAL SITE CONSIDERATIONS

SECTION II

INTRODUCTION

This section describes the physical requirements of the installation site. In addition, be sure to check your local building, fire, and electrical codes for requirements that may be more stringent.

SITE AND EQUIPMENT LOCATION

Preparation may involve modifying an existing site or building a new one. In either case, maintain close liaison with the person who is coordinating site preparations. If questions arise or you need assistance, check with the Site Coordinator at once.

It is advisable to plan the site with future expansion in mind so that equipment can be added with minimal disruption to the existing system. Be sure to allow at least three feet (one meter) at the front and rear of the equipment for servicing.

Partitions

Metal and glass partitions are acceptable for the computer room when the adjacent areas are noncombustible or have light combustible loading with sprinkler protection. Consideration should be given to unfavorable exposure from outside the building, glare from sunlight, and forced entry. Generally, blank masonry walls or an equivalent will suffice.

To enable proper humidity control within a partitioned room, seal off spaces above suspended ceiling and seal wall connections and all concrete surfaces; also double-glaze windows. This ensures an adequate vapor barrier.

Security

Computer room security can be an important factor even where classified work is not involved. Because of the potential damage to equipment or programs resulting from ignorance, carelessness, vandalism, or deliberate forced entry, and the delay and expense that could result, it is important that existing practices of building security be extended and improved to provide adequate protection for the computer area.

Safeguards such as tamperproof keylock door controls and electrically taped glass doors and windows can be tied into a comprehensive alarm system. If desired, this system could also be supplemented by a closed-circuit television monitoring unit.

Basements and Multistory Buildings

Basements should not be used for computer installations or record storage. However, if a basement area is unavoidable, ensure that ground water drains away from the building and any ground level

openings are watertight. In multistory buildings, the floor above the computer site and related storage areas should be made watertight.

Maintenance Area

In larger installations, a maintenance area may be useful to optimize system availability. In these cases, the area should be within or adjacent to the computer room. A maintenance area is needed for spare parts and necessary supplies. The environmental requirements for this area are the same as that for the overall system. A small area where a cabinet can be placed for storage purposes will generally suffice.

STORAGE FACILITIES

Whenever possible, locate your operating records, permanent records, and operating supplies in separate cutoff areas having no other occupancy. These rooms or cutoff areas reduce the amount of combustibles in the immediate area of the computer system. Furthermore, the rooms or cutoff areas should be made fire resistant to the extent of exposure, but generally not less than a one-hour rating. Additionally, access doors should be self-closing.

Two types of supplies are generally used in or with computer systems: paper supplies and magnetic storage media. The paper supplies may include line printer paper, punched cards, and paper tape. The magnetic storage media includes magnetic tape and disc packs. Both types are used for record storage which can cause a shutdown of operations if destroyed or lost. It is therefore a major consideration that proper storage is provided for these items. Paper supplies are more combustible than magnetic media even though the temperature at which damage occurs to paper is higher than magnetic media. Because fire is a major concern in the loss of stored data, these two types of supplies should be stored separately.

Paper Storage

One manufacturer recommends that line printer paper be stored at 75 degrees F (24 degrees C) with the relative humidity maintained at 45 percent. Recommended operating ranges include temperatures from 60 degrees F to 85 degrees F (15 degrees C to 30 degrees C) and the relative humidity from 40 to 60 percent. Containers are available that are designed to limit interior temperature to 350 degrees F (177 degrees C), in case of a fire, for one, two or four hours. This is generally considered adequate for paper supplies. However, before using paper that has been subjected to extreme temperatures, it should be stabilized at the recommended temperature range.

Magnetic Media Storage

Containers for magnetic tape should be able to limit the interior temperature to 150 degrees F (66 degrees C) in emergency situations, such as a fire. However since magnetic media tends to degrade at high temperatures in long-term storage, the permanent storage facility must not exceed 80 degrees F (27 degrees C). Also, the relative humidity should be maintained from 40 to 60 percent.

NOTE

Keep the temperature in the storage area as close as possible to the temperature in the computer room. Magnetic tape, disc packs, and printer paper must be at the same temperature as in the computer room for at least 24 hours prior to use.

NOTE

In both the storage area and the computer room, racks or hangers must be available to store magnetic tape vertically.

DATA PROTECTION

Safeguards should be taken to protect vital data such as business records or other information that is either very expensive or impossible to duplicate. Adequate duplicate copies of vital data should be stored well away from the computer area, normally in a fireproof storage vault. In many cases, a regular updating program may be necessary to maintain the value of such duplicate data storage.

Evaluating and protecting your records is your responsibility. The amount of protection needed is related to the importance of records in the system and re-establishment of operations after a fire. The following classifications of records are based on recommendations of NFPA Standards 232 and 75 (in countries other than the USA, refer to the equivalent documents concerning data protection). Records should be assigned to one of these categories to ensure adequate protection where necessary.

- Class 1 (vital) - These are irreplaceable records, record data which does not have the same value as the original, records needed to recover money promptly or records needed to avoid delay of products, sales or services. These records need to be stored in a fire-resistant vault, in safes, or areas afforded maximum fire protection.

- Class 2 (important) - These records are reproduced only at a considerable expense and labor, after a long delay. These records should be protected as Class 1 records, or stored in a fire resistant file storage room.

- Class 3 (useful) - The loss of these records might cause some inconvenience, but could be readily replaced. They should be housed in closed steel containers, where they are not exposed to combustibles.

- Class 4 (nonessential) - These records are not valuable enough to warrant special protection and should be destroyed to reduce fire hazard if any undue accumulation occurs.

THE SITE FLOOR

The computer room floor must support the total weight of the system, as well as the localized weight at each caster or foot. The most common method of preparing a floor for a computer room or area is to construct a raised floor over the building floor. This spreads the weight more evenly and provides an area through which interconnecting cables can be run conveniently and unobtrusively, while allowing optimum distribution of conditioned air.

Floor Strength

Part of the information you will need in order to estimate floor requirements will be provided by the Site Coordinator in the form of a System Configuration Table and the Site Floor Plan. The System Configuration Table lists all equipment to be installed. The Site Floor Plan depicts the system layout, accessories, and support equipment.

To determine the necessary floor strength, consider the following items:

- Total weight of the system (refer to the System Configuration Table).
- Weight of the support equipment (includes desks, cabinets, chairs, tables, etc.).
- Approximate weight of operating personnel (live loading).
- Weight of moving equipment (live loads presented by forklifts and other equipment moving devices).
- Distributed and concentrated loads. You may need to distinguish between a distributed load (the overall weight that theoretically could collapse the floor) and the concentrated load (the weight at a bearing point, such as a leg or caster, that might result in penetration of the flooring material).

  Floors of office buildings are usually rated at 50 pounds per square foot (244 kilograms per square meter) with an additional allowance of 20 pounds per square foot (98 kilograms per square meter) for partitions. If a large system is anticipated, floors must be able to support 100 pounds per square foot (488 kilograms per square meter). Any questions regarding the adequacy of floor construction should be evaluated by a qualified structural engineer.

  Finally, determine that all floors, stairs, and elevators which might be used when the system is moved to its destination can support both the system and the moving equipment.

Raised Floors

Small systems with few peripherals do not require raised floors, and large systems can be installed without it. However, for most systems a raised floor is desirable because of the following advantages:

- Relatively unrestricted cable routing beneath the floor.
- Eliminates the need for covering exposed cables.
- Allows equipment layout to be changed more readily.
- Enhances the appearance of the computer area.

The most common type of raised flooring used in computer rooms is the pedestal type. (See Figure 2-1.) The pedestal type is desirable because it allows cable routing in any direction, minimizing cable lengths and increasing layout flexibility. In addition, the space under the raised floor is often used for air ducting.

Raised floors are usually tile-covered panels supported by a grid system of either pedestals or pedestal support stringers, which provide lateral stability. The raised floor must be able to support a load of 100 pounds per square foot (488 kilograms per square meter). The preferred height for raised floors is 12 inches (30 centimeters), but should not be less than 4.5 inches (11 centimeters) in any circumstance.

The floors should be constructed of noncombustible materials. Acceptable materials include concrete, steel, aluminum, and metal-clad plywood on noncombustible supports. If a raised floor is to be installed over a combustible main floor, the main floor should be flameproofed with an airtight hard sheet rock or equivalent. Openings into the space under the raised floors should be covered or screened to keep out combustible debris. Additionally, if there is any possibility of water accumulation from air conditioners, the main floor (beneath the raised floor) must be provided drainage.

NOTE

If metal is used in the raised floor, ensure that there is a common ground connection between it and the main floor to avoid a possible buildup of different voltage potentials.

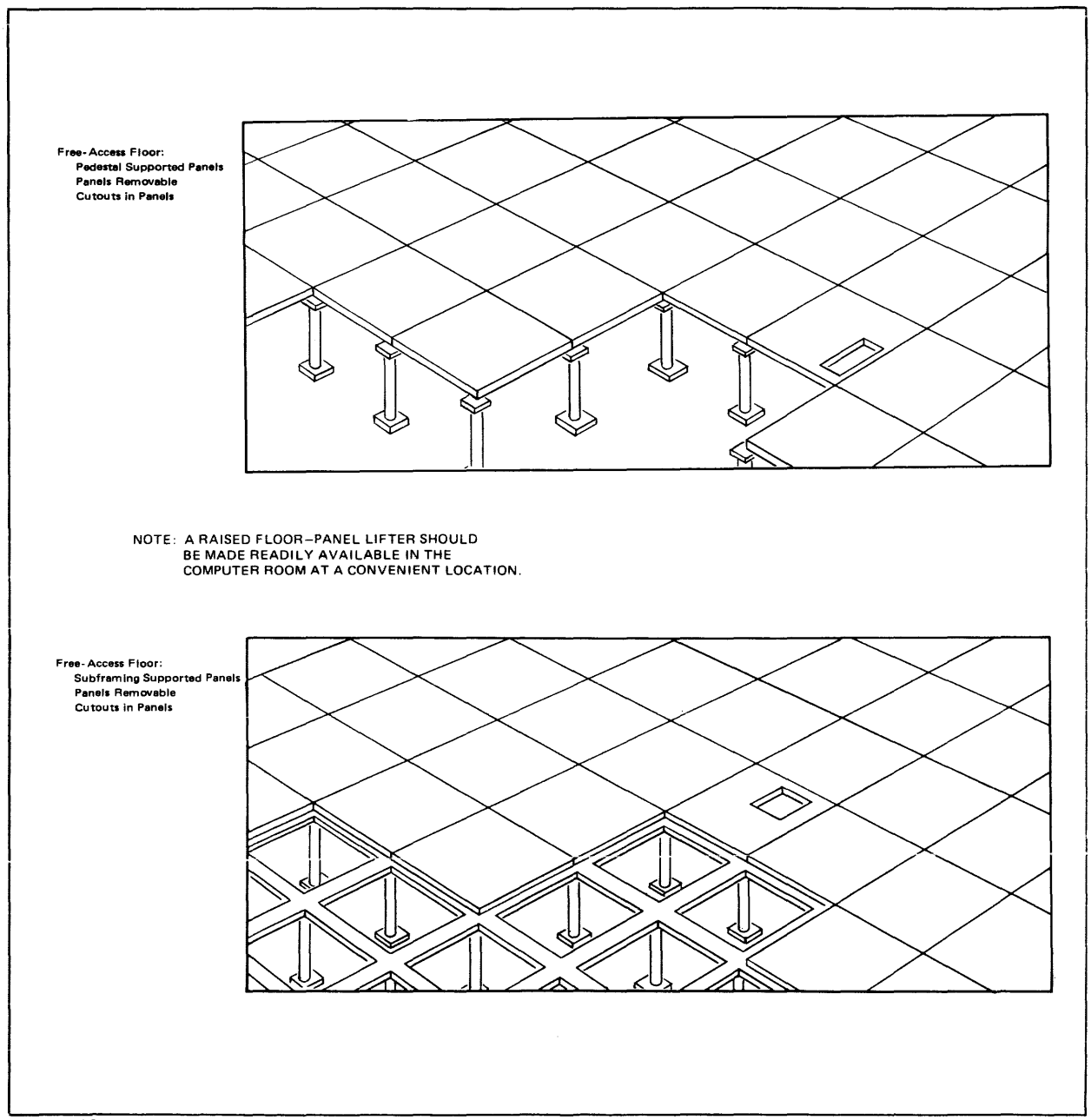

Figure 2-1. Examples of Raised Floors

Floor Covering

When planning a computer room floor, consider such factors as surface resistivity, ease of maintenance, durability, appearance, and cost. Floors should resist scuffing, gouging, marking and staining.

Asphalt tiles should not be used since they easily chip with wear and produce dust that can cause equipment breakdowns. Usually vinyl tile is preferred because of its attractiveness, strength, and maintainability. High-pressure laminated fiber-resin floor surface tiles are the most desirable. These tiles are very hard and only require occasional mopping to maintain a good appearance. They are highly resistant to scratches, burns, and dents. (Refer to Section VI for cleaning techniques.)

Sealer and wax should be applied by experienced floor treatment specialists. Sealer should be applied as soon as possible after the floor has been laid, except for linoleum, which should be left for a week or so until the oils settle. A polyurethane sealer should be used for linoleum, wood, and cork. For other materials, a water emulsion sealer is more suitable.

Wax is necessary to form a durable yet replaceable coating over the sealer, but should be applied sparingly, and only to traffic routes as necessary. Other areas may simply be machine-buffed.

Standard wax should not be used as a protective coating for floors in computer areas because it tends to increase surface resistance. This can result in the formation of a dielectric that allows static electricity to build up on personnel and furniture. Tile floors should, however, be finished frequently with a polymer mixture which includes microscopic metal flakes.

Computer systems are susceptible to static discharges that build up in carpeting. The HP 3000 Series 64 System Processor Unit (SPU) is designed to withstand discharges up to 15 kilovolts; some disc drives, however, are susceptible to problems at levels as low as 500 volts. Static discharges in excess of these levels can and do cause system failures such as loss of data.

CAUTION

Hewlett-Packard strongly discourages carpeting, including so-called anti-static varieties, within 20 feet (six meters) of the computer system. If this advice is not followed, you should at least place static discharge mats where the computer operator or serviceperson must walk across them before touching any part of the system. Failure to comply may result in equipment damage.

Cable Ramps

A method of routing cables without the use of a raised floor is shown in Figure 2-2. The cable ramp above the floor is less expensive than a raised floor, but does not provide the same cabling flexibility and may also constitute a safety hazard.

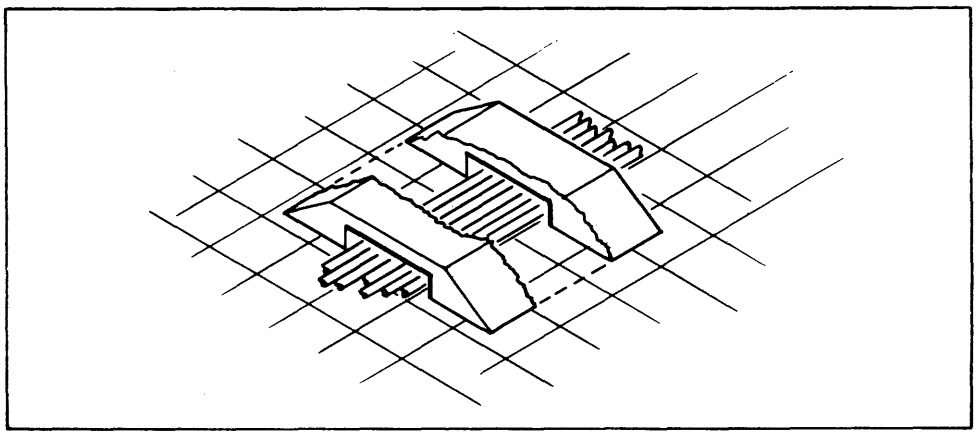

Figure 2-2. Example of Cable Ramp

FURNITURE

Furniture can provide a source of static discharge. Ensure that chair upholstery consists of materials that resist static buildup. Cloth-covered chairs are less susceptible to static buildup than plastic-covered chairs. Casters and ball bearings should be made of conductive materials or be lubricated with graphite or other conductive substances.

DUST-PRODUCING EQUIPMENT

Avoid dust-generating equipment in the computer room. This includes paper bursters and collators. Install such equipment outside the computer room.

FIRE SAFETY

When considering fire safety, your insurance carrier should be consulted for suggestions and recommendations as to the adequacy of existing or proposed fire control systems. Also, if a new site is to be built or an existing structure modified, be sure to consult local building codes for fire prevention and protection.

Fire Prevention

The best method to prevent fire is to construct the site enclosure with noncombustible materials. If an existing structure is being modified, add noncombustible false ceilings and cover the floors with fire-resistant material. The normal fire rating for a site is one hour. This is the time that a ceiling or wall can remain structurally sound when subjected to fire.

Fire prevention precautions should be exercised in the computer room. These precautions include:

- Use noncombustible office furniture and furnishings.
- Use flame retardant interconnecting data cables
- Provide nonflammable cleaning agents. If solvents must be used, the flash point should be greater than 100 degrees F (37.8 degrees C).
- Limit records, paper supplies, spare tape, and disc packs or other combustibles in the computer room to the working minimum needed for current or daily requirements. Store all other materials in proper noncombustible containers.

Fire Warning Systems

Many warning systems are available that detect overheating of computer equipment before either fire or smoke becomes apparent. In the United States, detection systems designed for computer sites are listed in the National Fire Protection Association (NFPA) Handbook. To obtain a copy, write:

National Fire Protection Association
470 Atlantic Avenue
Boston, Massachusetts 02110

Outside the United States, consult local regulations regarding fire protection.

For highly-valued or important installations, provide an approved automatic smoke-actuated fire alarm system in the computer room, under any raised floors, in the air conditioning system return air duct, and in rooms or areas containing numerous wires and cables. The location of detectors should be based on air flow and other physical arrangements. For spot-type detectors, a spacing of about one detector for every 250 sq ft may be used as a guide, subject to modification depending upon the actual conditions which exist.

Fire Control

Studies of fire losses and surveys of the amounts of combustibles in computer systems, and especially in the neighboring areas, show that automatic sprinklers afford the most practical protection for computer installations. Automatic sprinklers will localize a fire originating either inside or outside the computer units and constitute the most effective safeguard against major damage. However, important damage can still result if the fire involves the interior of an unusually valuable or important unit. For such units, sprinkler protection can be effectively supplemented by automatic halogenated gas or carbon dioxide protection. In many instances, portable extinguishers are used as adequate supplements to sprinkler systems.

The selection of adequate fire control systems will depend upon local building codes, insurance regulations, and other influencing factors such as costs and serviceability of the systems. It may be

necessary to supplement existing or proposed systems with an additional gaseous system, or to include portable extinguishers in the computer room.

o HALOGENATED GAS SYSTEMS

Halogenated gas chemically reacts directly to the burning combustibles and temperature of the fire to produce an extinguishing agent. This type of system is most effective against electrical fires and least damaging to the equipment. A concentration of five percent Halon 1301 produces extinguishing effects in approximately 10 seconds.

o CARBON DIOXIDE FLOODING SYSTEMS

Carbon dioxide (CO_2) is also a gaseous substance, but is not an extinguishing agent in itself. The extinguishing effects result from the displacement of oxygen in the combustible area. This effect generally takes place in approximately one minute after discharge, depending upon the volume to be flooded. The most commonly used portable extinguishers are of the CO_2 type.

o SPRINKLER SYSTEMS

Three types of water-sprinkling systems in general use that are not subject to accidental discharge are:

o The pre-action sprinkler system.

o The high-temperature sprinkler head system.

o Automatic sprinkler head system

In the pre-action system, a heat-sensing valve turns on the main water supply to the sprinkler system when the temperature in the computer area exceeds a specified value. Since a heat-sensing device is not located in each sprinkler head, accidental discharge caused by damage to a single head is avoided.

In the high-temperature sprinkler head configuration, all sprinkler heads are fitted with temperature-sensing devices. This type is better than the standard fusible links because the high-temperature device is immune to slight increases in temperature.

The automatic sprinkler head system, similar to the high-temperature device, will turn off when the temperature falls below a specified level, thus reducing water damage.

ACOUSTICS

Acoustical treatment of the computer room is desirable to provide more efficient and comfortable operation. Proper acoustic design of the computer room may require the services of a specialist.

The total noise level is affected by all noise sources in the room, the physical arrangement of the noise sources, and the acoustical characteristics of the room surfaces. The noise level can be reduced by proper spacing and orientation of mechanical equipment and providing sufficient space around these units. The farther apart these units, the lower the overall room noise.

Consider placing the quieter electronic units between the mechanical units. Also, an effective method of noise reduction is to place mechanical units at an angle to aisles or open work areas.

Air conditioning blowers and other external noise sources, if improperly installed, can contribute substantially to the overall noise level. Ducts may transmit noise to and from other rooms. This can be reduced by acoustical treatment of the ducts.

Ceilings and walls should be made of sound absorptive materials. In addition, the walls should be constructed from the structural floor to structural ceiling, and be properly sealed. Doors should also have a good seal. Ensure that any acoustic materials used are of the non-flaking variety to prevent added dust particles from accumulating.

Avoid the use of drapery because of possible static buildup and dust abatement problems.

Acceptable sound pressure levels are stated for two operating environments: the office-oriented installation and the computer room environment. For the office environment, the sound pressure level generally should not exceed 55 dbA. The computer room sound pressure level generally should not exceed 65 dbA, excluding printers. If printers present an undesirable noise level, noise suppression covers may be necessary. These covers are available through Hewlett-Packard for some models and must be fabricated for others.

ILLUMINATION

To properly light the computer area, plan to:

- Maintain an average of 50 to 75 foot-candles of total illumination as measured 30 inches (91.4 centimeters) above the floor. Ensure that lighting is uniform throughout the computer room to provide adequate lighting at the rear of the cabinets.
- Avoid installing lights that produce excessive reflections on system indicators.
- Never use direct sunlight for illumination.
- Plan to use circuits separate from the system equipment power source for the lighting.
- Provide for emergency lighting.
- Comply with all local electrical codes.

NOTE

Dimmer switches should not be used in computer areas; they generate electrical noise and heat.

ENVIRONMENTAL CONSIDERATIONS

SECTION III

AIR CONDITIONING

Prior to receiving your system, suitable air conditioning must be installed. Before selecting the air conditioning, system heat dissipation and operating environment must be considered.

Although comfort (home) air conditioners can be modified to provide temperature and humidity control, specialty computer air conditioners are preferred since they are designed to maintain closer control of the environment and cost less to operate.

Calculating Heat Dissipation

To provide your site with adequate air conditioning, follow these steps:

- o Estimate the total heat dissipation by the system, accessories, lights, and personnel at the site. Record this information on the air conditioning planning checklist in the site planning workbook. (Refer to the temperature specifications for recommended operating conditions.)

- o Plan the location and installation of air conditioning equipment in compliance with local codes and regulations.

- o Take humidity into consideration. A comfort (home) air conditioner is designed to de-humidify as well as cool; an air conditioner designed for computer areas will maintain a proper temperature without de-humidifying.

To calculate the total heat dissipated in the computer room, use the following guidelines and record the resulting data on the air conditioning planning checklist in the site planning workbook.

- o Determine the total amount of heat dissipated by your system (total configuration).

- o Consider the heat dissipated by special interface equipment (supplied by other vendors) as well as that produced by auxiliary equipment such as keypunches and electric typewriters. Consult vendor data sheets for this information.

- o Estimate the heat produced by the lights used to illuminate the facility.

- o Calculate the heat dissipated by operating personnel working within the facility, using the values given in the air conditioning planning checklist.

- o Allow for heat dissipation by equipment to be added during future expansion.

- o Calculate the heat dissipated by any other elements not considered above. This includes rate of heat transfer through walls, windows, and ceilings plus the effects of climate. The air conditioning planning checklist provides guideline values for estimating heat dissipation through walls, windows, etc.

- o Calculate the total heat dissipation for the site by adding the values recorded in the air conditioning planning checklist. For 60-Hz systems, heat dissipation is given in BTU/hr, and is given in kilocalories for 50-Hz systems. The values given in BTU/hr and kilocalories do not necessarily

correlate, since 50-Hz systems generally consume more power than 60-Hz systems. Therefore, do not convert BTU/hr to kilocalories to determine heat dissipation.

Air Conditioning Equipment

Two air distribution methods are commonly used. One uses the space under a raised floor as a plenum chamber, forcing air up through floor openings into the room. The second method uses the space above the ceiling as a plenum chamber, and air is drawn down into the room.

The raised floor method is preferred since it eliminates ducting and provides a draft-free flow from floor to ceiling. If you choose this method, be sure to seal all openings in the raised floor. For example, seal cable cutouts with one-inch foam and z-section trim.

Whatever method you choose, observe the following general requirements:

- Maintain positive air pressure within the computer room or area. This causes airflow away from the system, minimizing contamination by dirt or dust. Cleaned air should be brought into the room. In some places, safety codes dictate what the air volume exchange rate should be. Refer to your local codes for this information.

- Avoid ducting air directly into disc drives. This will exert too much pressure within the drive and cause the heads to lift away from the discs, thereby causing errors or loss of data.

- Provide sufficient fresh air for the people who will work in the room.

An HP 3000 Computer System should be operated in an environment in which temperature and humidity are maintained within the recommended ranges specified in this manual. Also, the environment should be contaminant-free to the extent specified. The effects of climate should be carefully considered when selecting the air conditioning system.

Effects of Climate

You must consider the effects of outside temperature, humidity, vibration, altitude, airborne contaminants, and other characteristics of the region. For instance:

- At higher altitudes, the efficiency of a cooling fan decreases because of air density. Consider maintaining the site enclosure at a lower temperature to compensate for the reduced air density at the equipment air intake vents.

- Consider after-hours conditions, when the air conditioning may be shut off, and the possible effects on the system because of temperature and humidity variations. This condition generally occurs in installations where the heating and air conditioning are central to the entire building.

- In locations where extreme temperature and humidity prevail, consider the effects of such conditions on the system when main power is shut down. For example, in northern regions, consider the effects of night-time temperatures during winter when system power is shut off.

- Seasonal temperature and humidity variations must be considered, especially when a non-dedicated air conditioner is used. In the late spring, it is not uncommon to experience a slow but constant temperature increase because the air conditioning system has not been turned on for summer use. Be sure that provisions are made to monitor the temperature and humidity during cold-to-hot and hot-to-cold seasonal transitions. However, the air conditioning should never be shut down in the computer room, except for emergency situations.

- At coastal installations, the site may require special air conditioners, dehumidifiers, and other items to compensate for high humidity or corrosive salt air.

- In locations where airborne contaminants are common, filtering may be required in the air ducts. Since filters restrict airflow and increase the load to the air conditioning unit, the size of the installation may be affected. Many locations experience corrosive contaminants that eventually destroy the electronic circuitry. In these instances, special filtering or air conditioning configurations may be required, such as positive pressure rooms fed by air through activated charcoal or metallic filtering techniques. (Refer to the paragraphs on airborne contaminants.)

- To maintain the recommended conditions in the computer room, the air conditioning system should be on at all times.

Emergency Considerations

To further protect the air conditioning and computer systems:

- Plan to control power to the air conditioning system with push-button switches that can shut the air conditioning system down in case of emergencies. In addition, consider thermostat-controlled cutoff switches where the sensors are installed in the conditioned air ducts, and the switch cuts off power to the air conditioner.

- Consider installing a temperature-humidity recorder at the site for monitoring the air conditioning equipment for possible malfunctions. An alarm system should be considered to warn of temperature or humidity extremes.

Planning Equipment Installation

In your area, city and county codes and regulations may exist covering the use of air conditioning devices in general and as applied to computer sites in particular. You are responsible for ensuring that your plans comply with these codes before the computer system is delivered. As you plan for the location and installation of the air conditioning equipment, refer to the Site Floor Plan for computer system equipment locations. Then:

- Provide adequate space for the air conditioning system.

- Locate any return air ducts above the computer system output ducts, and the cold air ducts near the computer system intake ports. Ensure that the cold air ducts are suitably located so that they are not affected by other equipment at the site. Also ensure that room air is mixed with cold air so that the temperature when entering equipment is not below 16 degrees C (60 degrees F).

- Do not use window-type air conditioners to cool the area because the on-off cycling of such units can cause them to exhaust high-humidity air.

- Locate all thermostats away from the primary points of heat flow from the mainframe and accessory equipment cabinets.

- Make sure the on-off cycling is set for a narrow temperature range (recommended range) to avoid wide temperature and humidity swings. When operating the system over wide ranges in relatively short periods of time, the development of corrosion products is accelerated. This shortens the life of the computer system.

o Locate all humidistats away from ducts and heat exhausting equipment.

When your plans are complete, sketch the locations of the air conditioning unit and the air ducts with reference to equipment shown on the Site Floor Plan. As you complete the planning of temperature and humidity control facilities, check off the items on the planning checklists. Answer all questions so that the HP Customer Engineer will have the information available if problems arise. After installation, the Site Coordinator inspects the site and verifies that all temperature and humidity requirements have been met.

ENVIRONMENTAL SPECIFICATIONS

The remainder of this section deals with environmental specifications relating to reliable computer operation. While all factors are somewhat interrelated, temperature and humidity are especially related since both are controlled by the air conditioning system. In addition, the rate of corrosion is influenced by temperature and humidity. Figures 3-1 and 3-2 show the relationship between temperature, absolute humidity, and relative humidity in English and metric units.

Temperature Ranges

Two temperature ranges must be considered: the recommended and the minimum/maximum. The recommended range is within the minimum/maximum range; this is the range in which the system will operate best. High temperatures increase the rate of deterioration of virtually every material. Therefore, continued operation outside the specified ranges will cause loss of data, system failures, and lead to shortened equipment life.

The minimum and maximum values are provided as a temporary safety margin in the event a malfunction occurs in the air conditioning system. The maximum time that the computer system should operate outside the recommended temperature range but within the maximum and minimum range is 48 hours. This time allows abnormal environmental situations to be corrected and still operate the system. If abnormal conditions continue, shut the computer down.

Operating Temperatures: Recommended = 20 to 25.5 degrees C (68 to 78 degrees F)

Maximum = 30 degrees C (86 degrees F) (48 hours maximum)

Minimum = 15 degrees C (59 degrees F) (48 hours maximum)

Rate of temperature change: 10 degrees C/hr (50 degrees F/hr) maximum

Instantaneous rate of change: 0.09 degree C/min. (0.167 degree F/min.)

Humidity

The recommended relative humidity range is the range over which the system will reliably operate over long periods of time. The maximum and minimum values provide a safety margin for short periods of time to allow for correcting an abnormal condition. This time period is 48 hours. If the abnormal condition persists longer than 48 hours, the computer should be shut down. Continued operation outside the recommended range, or any operation outside the maximum and minimum values, will result in poor reliability.

High absolute humidity (dew point) causes moisture to form in the equipment and on paper and plastic media. Moisture absorption can cause dimension and handling changes in paper and plastic media (line printer paper, cards, paper tape, magnetic tape, etc.). High humidity, and rapid and wide humidity swings also allow corrosion to develop more rapidly, thereby decreasing the operating life of the computer.

Low humidity allows the buildup of static electricity which, if discharged through the computer, will cause data errors and equipment failures.

Relative Humidity: Recommended = 40 to 60 percent, no condensation

Maximum = 80 percent (48 hours, maximum)

Minimum = 30 percent (48 hours, maximum)

Vibration

Vibration can cause slow degradation of mechanical parts and, when severe, can cause data errors in disc drives; hence it should be avoided or controlled. Also, mechanical connections such as PCA connectors, cable connectors, and processor backplane wiring may be affected. The best preventive measure is to build the site away from vibration-generating sources, such as heavy industrial machinery (stamp mills, etc.). Care in handling the system components will also avoid problems resulting from sudden shock.

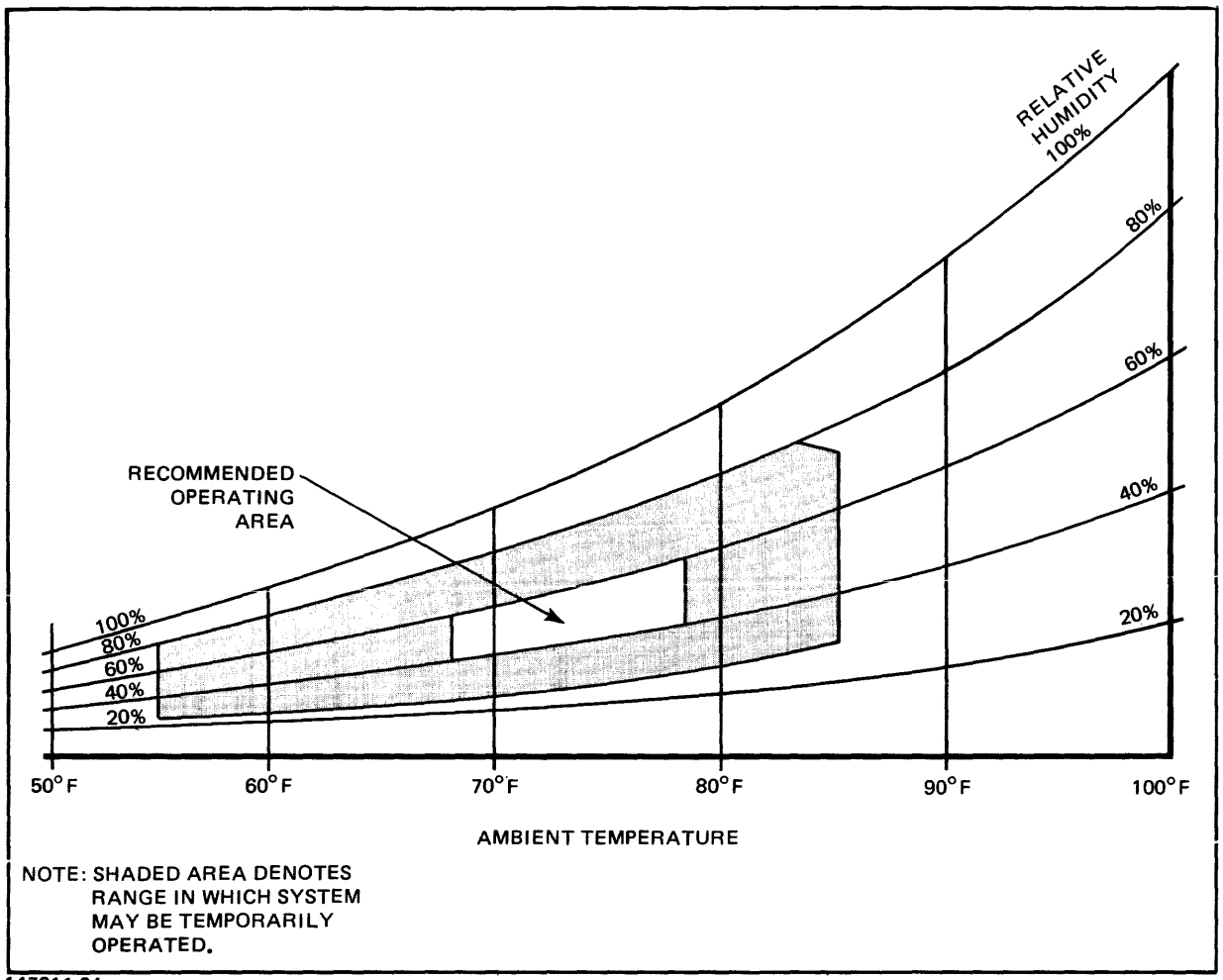

Figure 3-1. Psychrometric Chart (English Units)

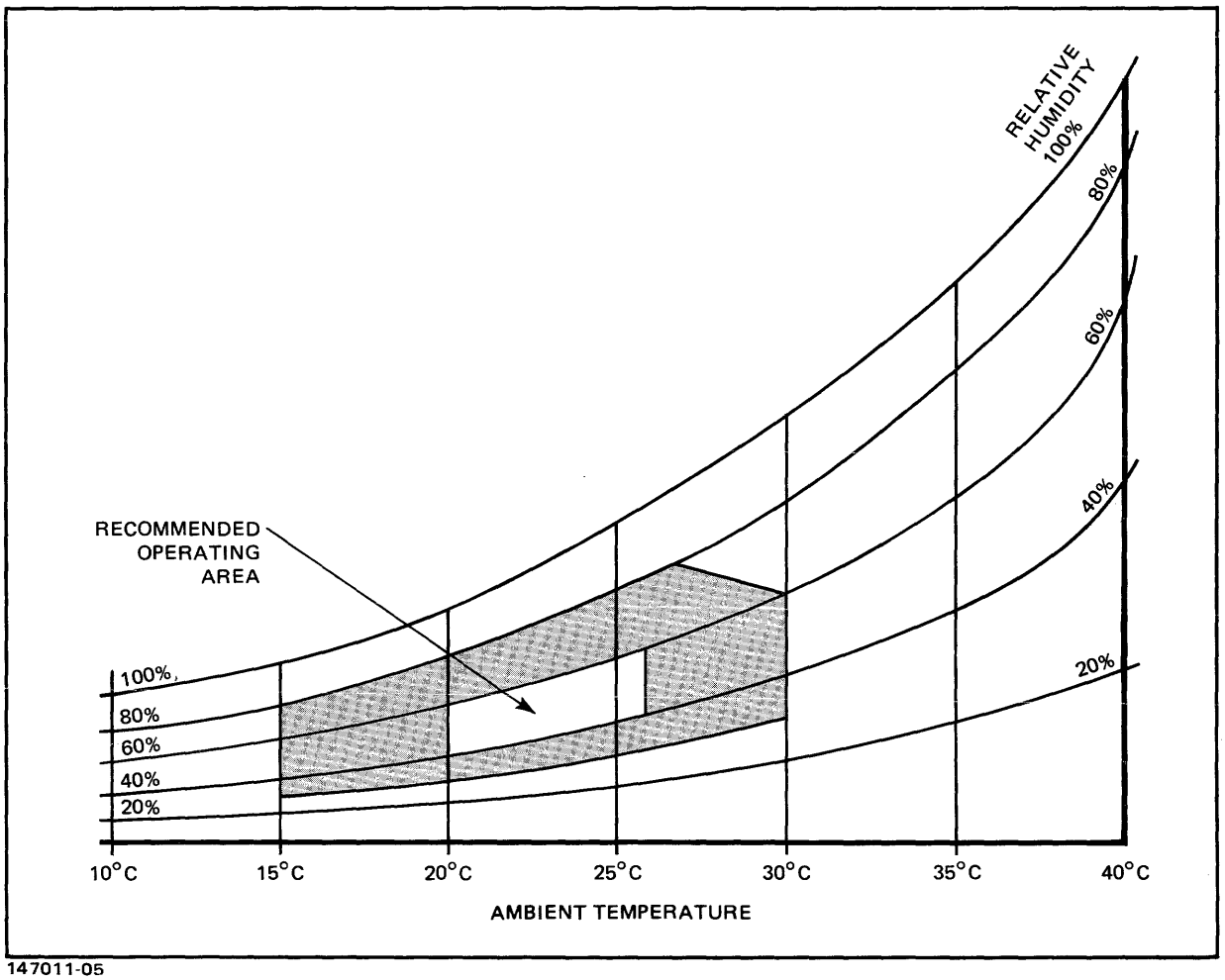

Figure 3-2. Psychrometric Chart (Metric Units)

Altitude

Altitude must be considered for two conditions, operating and non-operating. In the operating environment, the lack of adequate air density at extremely high altitudes may be insufficient to allow disc drive heads to lift off the disc surfaces and thereby cause a disc failure. In the non-operating environment, two problems arise. One problem results from the excessive pressure present that can collapse hermetically-sealed components and the second problem is the rapidly changing temperatures, which leads to condensation inside the system cabinets.

Operating Altitude - Sea level to 15,000 ft (4600m)

Non-operating Altitude - Sea level to 50,000 ft (15,300m)

NOTE

There are two exceptions to the altitude limits above. The limits for these two exceptions are:

HP 7976A Magnetic Tape Drive:

Operating altitude = 6500 ft (1981m).

HP 2680A Page Printer:

Operating altitude = 8250 ft (2500m).

AIRBORNE CONTAMINANTS

Atmospheric dust is a complex mixture of smokes, mists, fumes, dry granular particles, and fibers. The components of any mixture may consist of soot and smoke, silica, clay, organic materials, and metallic fragments. A sample may also include living organisms such as mold spores and bacteria. These components vary with locality, season of the year, direction and strength of the wind, and proximity of dust sources. Size of the particles also varies with differing conditions. Figure 3-3 shows size ranges of typical airborne particles; Figure 3-4 shows the relationship between some particles and the gap between the flying heads and oxide coating on a disc.

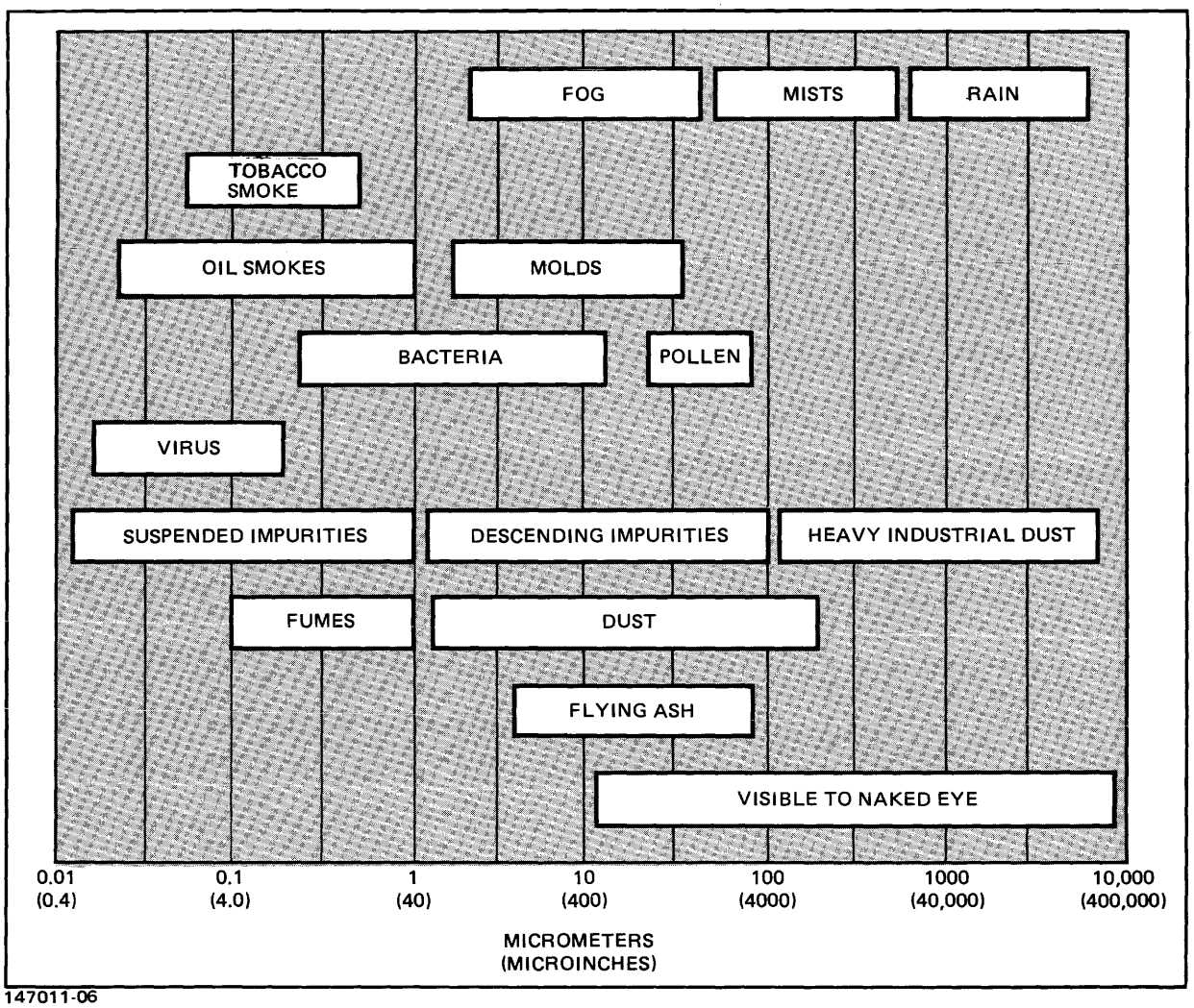

Figure 3-3. Sizes of Common Air Contaminants

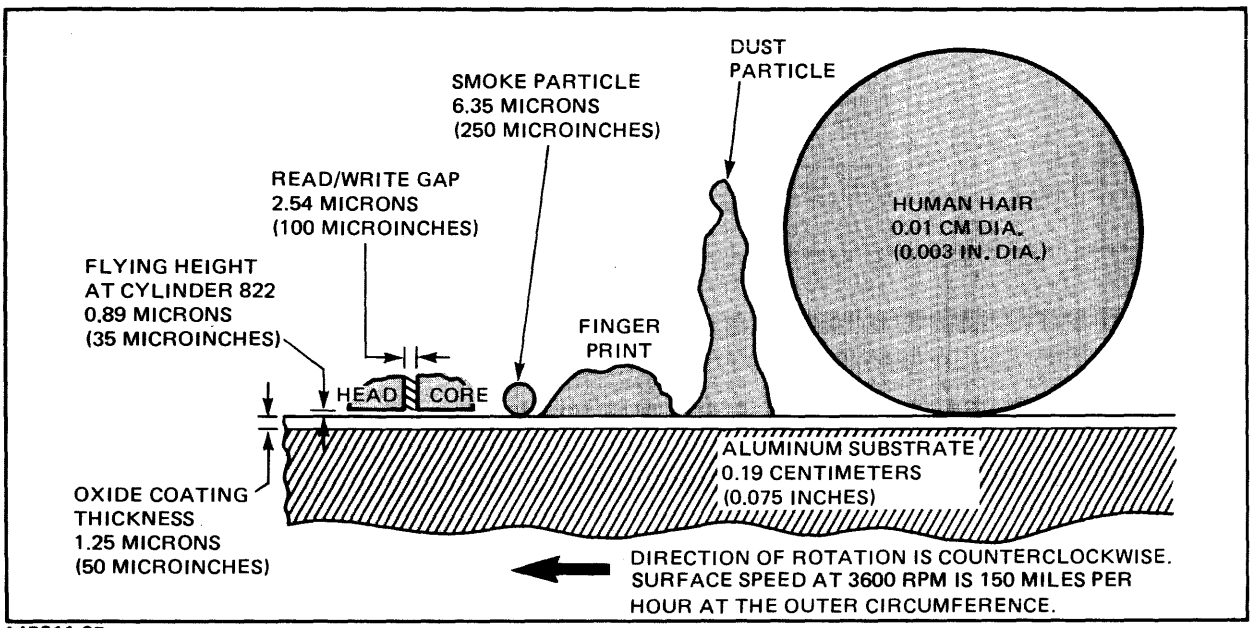

Figure 3-4. Contaminant Sizes Relative to Disc/Head Spacing

Hard Contaminants

Hard contaminants consist primarily of dust particles of various physical compositions. These particles are particularly hazardous to disc drives. In some instances, particles are conductive and can short circuit wiring in any of the system components. Also, film-forming particles and residues cause connector problems. The maximum density of dust particles that will permit long-term reliable operation is 85,000 particles (0.5 microns or larger) per cubic foot.

Corrosive Contaminants

Corrosion is the destruction of material by chemical or electrochemical reaction with its environment. Some effects of corrosion in computer systems are the destruction of magnetic surfaces on discs and tape, deterioration of plastics used in the equipment, and general degradation of conformal coatings on printed circuit assemblies (PCAs). Also, corrosion buildup on metals, particularly metal connector contacts such as copper, nickel, and silver, eventually destroy electronic circuitry. Many common problems can be avoided by isolating the computer system from contaminant-producing machinery. Examples of this type are office copiers, milling machines, and equipment that produces corrosive vapors or particulants. However, in areas where the atmosphere contains large amounts of various corrosive contaminants, more drastic measures must be taken to ensure clean air in the computer room.

Most environments are corrosive to some degree. Examples are air and moisture; fresh, distilled, or salt water; urban and industrial atmospheres; steam and other gases such as chlorine, ammonia, hydrogen sulfide, sulfur dioxide, and fuel gases; mineral acids such as hydrochloric, sulfuric, and nitric. In general, inorganic materials are more corrosive than organic. For example, corrosion in the petroleum industry is due more to sodium chloride, sulfur, hydrochloric and sulfuric acids, and water than oil, naptha, or gasoline.

Modern chemical process industries utilize higher temperatures and pressures, making possible new processes to obtain better yields, greater speeds, or lower costs of production. Unfortunately, these higher temperatures and pressures often mean more corrosive environments.

Corrosive environments such as that found in steel, acid, and paper manufacturing industries usually preclude the use of filtered ambient air for forced convection cooling. Corrosives generally cannot be filtered out by normal filtration methods, and the techniques that must be used are complex and costly. In these cases the computer system must be enclosed in a highly- controlled environment.

Although the term environment as used here refers only to atmospheric contaminants, there is a strong link between corrosion rates and temperature and humidity conditions. Many corrosion processes (film thickness buildup, etc.) accelerate rapidly at high humidities and temperatures. This means that corrosive environments that possess high temperatures and humidities should be of particular concern.

Corrosives

- Chlorine. Compounds of chlorine are highly destructive to most metals, particularly nickel. When combined with sulfur compounds, these two elements form the most destructive corrosives, not only to metals, but to many plastics.

- Hydrogen Sulfide. Hydrogen sulfide is a rapid corrosive agent, particularly to copper and silver. Hydrogen sulfide is a common atmospheric contaminant found near oil fields, sulfur springs, and marshy areas, and occasionally is emitted from industrial or sewage treatment activities.

- Sulfur Dioxide. Sulfur dioxide is one of the more common contaminant gases. In combination with water, it forms sulfuric acid mist, an active and rapidly corrosive compound. It is known to produce molecular separation in polymers, and to cause spots on microfilm materials. This acid is found in industrial environments and causes deterioration in electronic circuits.

- Total Hydrocarbons. Hydrocarbon vapors are corrosive to precious metals such as the gold in PCA contacts.

- Oxides of Nitrogen. Oxides of nitrogen cause nitrate stress cracking in electrical contacts, and the absorbed gases react to form nitric acid on component surfaces. Also, small amounts of nitrogen oxide cause deterioration in polymers.

- Total Oxidants. The presence of oxidizing gases in the atmosphere, particularly ozone, is known to be potentially harmful to any organic material. The damaging effects most often encountered are the cross linking of elastomers, the cracking of stressed rubber, and the oxidation of silver.

- Ammonia. In sufficient concentrations, ammonia has been found to cause cracking of stressed brass, decrease insulaton resistance, and increase loss factor in certain insulators.

Filtration

Since airborne contaminants exist in all localities to some degree, attention must be given to filters in the air conditioning system. No one type of filter will solve all needs, therefore, air samples should be obtained and analyzed to determine which type(s) should be employed. Four factors should be considered for filter selection:

- The degree of air cleanliness required
- Disposal of the dirt after it is removed from the air
- Amount and type of dust in the air to be filtered
- Corrosive oxidants or gases

These factors affect initial costs, operating costs, and the extent of maintenance that will be required. The long-term reliable operation of the computer system should be taken into account when considering operating costs and maintenance.

Three types of air filters are commonly used:

- Dry Surface Filters - These filters are made of fiber mats of varying thickness, size, and density. Bonded glass fiber, cellulose fibers, wool fibers, and synthetics are commonly used for the filter medium. This category of filter varies greatly in particle removal efficiency. If this type is to be used, be sure to consult vendor data to obtain the level of desired efficiency.

- Electronic Air Cleaner - Electronic air cleaners use electrostatic precipitation principles to collect particles. Various types are available and are very efficient in cleaning air that contains chargeable particles. For example, petroleum or petroleum derivatives, metallic substances, and most dust particles are readily cleaned from the air. However, some plastics cannot be charged and therefore are not removed. Also, electronic air cleaners have little or no effect on certain toxic and corrosive gases, such as chlorine gas.

  Since electronic air cleaners use ionizing principles, care must be exercised in the installing location of these devices. A static charge is present and if these devices are installed in the computer room ducts, they may contribute to static buildup within the room and cause loss of data through a resulting discharge. Also, high-voltage devices are capable of producing ozone, which is toxic and corrosive. Be sure to consult the manufacturer of these devices to ensure that ozone oxidants are not of the level to be hazardous to equipment and personnel.

- Activated Charcoal Filters - This type of filter is very effective for almost all contaminants, including gases such as the various sulfur compounds. To maintain maximum efficiency with this type of filter, the charcoal must not be allowed to saturate with agents that are to be removed from the air. Consult vendor data to determine maintenance frequency for the agent to be removed.

- Metallic filters - Metallic filters are available from consulting vendors for use in extreme environments. These filters are particularly efficient for use in filtering chlorine compounds.

All filters have saturation points; when a filter is saturated it must be replaced or cleaned. If allowed to oversaturate, the excess will be blown into the computer room, thereby defeating the purpose of filtering. The results may be poor system reliabilty, loss of data, and may even present a hazard to people.

If the filters are not properly maintained at the vendor-recommended intervals, the air conditioning equipment can be harmed, as well as the computer system. For example, when fibrous filters are clogged, a back pressure is built up in the ducting and causes reduced life of the blowers. In addition, particles will be forced through the filter into the computer room. In electronic air cleaners, excessive buildup of particulate matter will flake off and be introduced into the computer room. Charcoal filters produce hazardous effects to the equipment and personnel if allowed to operate beyond saturation, especially when toxic and corrosive gases are involved. Charcoal absorbs gas until saturation, then passes high concentrations of the gas into the computer room. If the charcoal becomes clogged with hard particulants, the effect upon air blowers is the same as that for fibrous filters.

ELECTROMAGNETIC COMPATIBILITY

SECTION IV

INTRODUCTION

The term Electromagnetic Compatibility (EMC) describes an environment in which the computer neither affects other equipment nor is itself affected by that equipment.

Satisfactory operation of your HP 3000 Series 64/68 Computer requires that the environment be controlled to minimize the effects of electromagnetic interference (EMI). This section describes the types of EMI in the environment and the potential hazards to the equipment, common sources of EMI, and solutions to problems that could arise.

EMC CONSIDERATIONS

The two categories of interference that are considered are emissions originating in the computer system that may interfere with other equipment, and external sources of interference to which the computer system may be susceptible. Figure 4-1 provides examples and external sources of interference that may affect the computer.

Emissions that may be radiated or conducted from the computer should be considered only to the extent that sensitive receiving equipment should not be placed close to the computer, or use the same power line. Since HP computer systems are designed to meet the standards of various regulatory agencies, this is normally not a problem. In addition, proper site construction further reduces the possibility of interference by the computer. Some components that may contain magnetic material, such as magnets in some disc drives, present a field that may interfere with highly sensitive compasses or gyro systems in aircraft or ships. In this case, the main concern is that shipping containers are appropriately marked to inform the carrier (particularly air freight) about shipping constraints. However, this equipment is designed to operate compatibly with other system components.

Interferences to which the computer system may be susceptible include electrostatic discharge (ESD), power line transients (conducted interference), radiated interference, magnetic interference, and lightning. When any of these types of interference exceed levels listed in this section, problems will result.

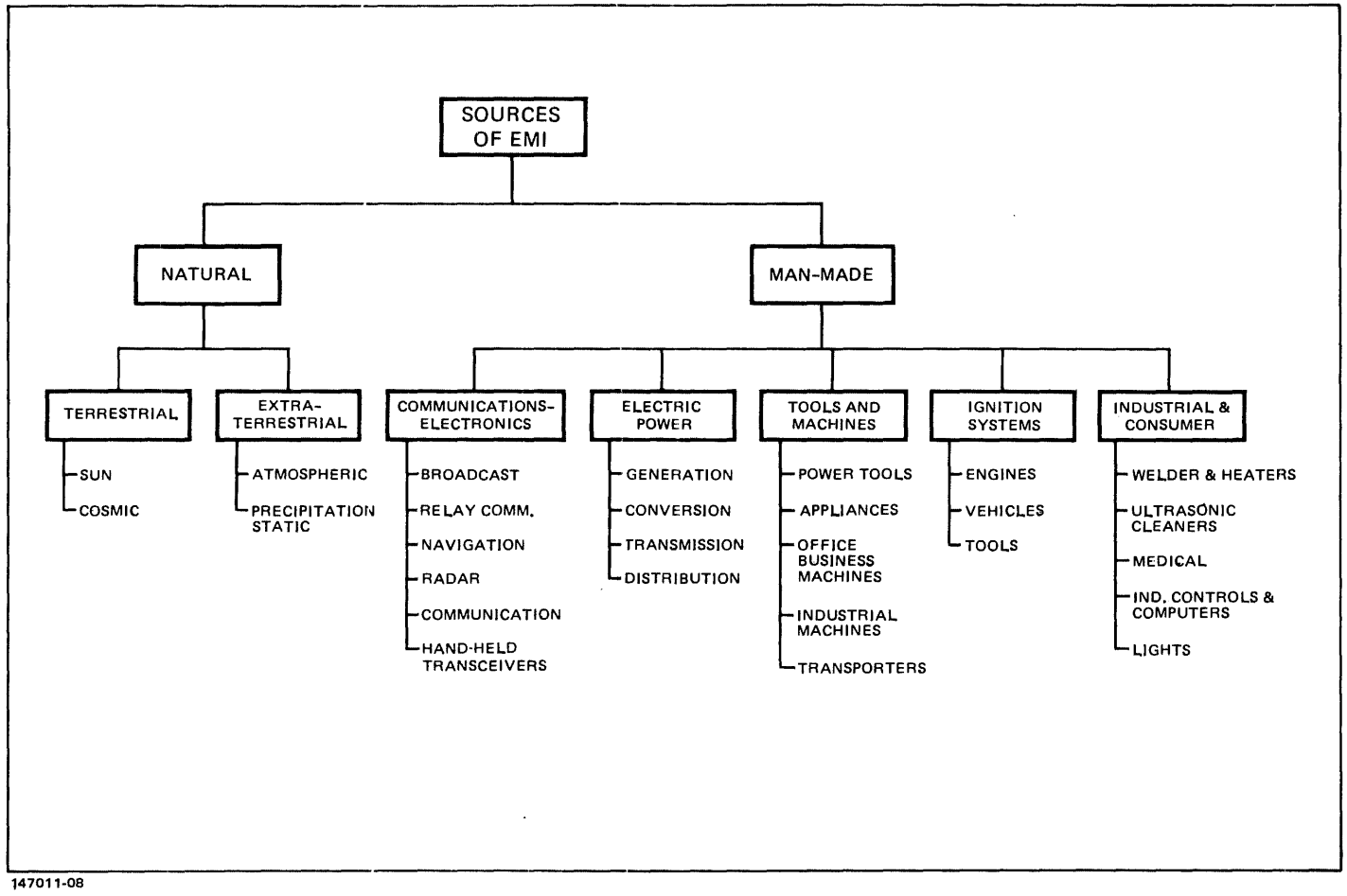

Figure 4-1. Sources of Electromagnetic Interference

Susceptibility to ESD

Electrostatic discharge (ESD) results from static buildup on nonconductive surfaces. ESD can cause computer failures if it takes a path through one of the system components. Two common causes of static buildup are carpeting and low humidity.

Humidity can be controlled by installing humidifiers. Your air conditioning contractor can determine the need and type when you design the computer room. But even then, terminals in other areas may be subject to high static potential. It may be advisable to place antistatic mats under them. The most effective method of preventing static discharge damage to terminals (or other computer equipment) however, is to place static discharge mats where people must walk across them BEFORE they touch the equipment.

The HP 3000 Series 64/68 System Processor Unit (SPU) is susceptible to discharge levels greater than 15 kilovolts. However, some disc drives are susceptible to levels as low as 500 volts.

Power Line Transients

Power line transients, or conducted interference, is any undesired electromagnetic energy that is propagated along a conductor. The conductors that are most affected are the power lines to the computer system. Some sources of interference are pulse-controlled clocks, elevator motors (or any motor that frequently starts and stops), vending machines, flourescent lights, or any other noise-producing machinery.

Power line transients may originate nearby and be of short, fast duration, or they may originate as distantly as the regional power substation and constitute wide voltage variations or frequency deviations. Also, power drop-out may occur. Sudden power surges in excess of the specified levels will also cause system failures. The effects of transients are the same as that which may occur from the various types of emissions.

Some internal regulating capabilities are provided by the computer's ferro-resonant transformers. The DC power system will not disturb the computer when the AC line to the power supplies is subjected to the following transients in normal or common mode:

Rise Time	Duration (50%)	Peak Voltage
100 ns	100 us	1000
1.5 us	10 us	1000

Additionally, DC power will not disturb the computer for AC line dropouts below the minimum operating level if their duration is not more than 20ms (one cycle at 50Hz).

Radiated Interference

Radiated interference causes many problems in computer systems. In locations where moderate levels of radiation are present, read/write errors can occur at a rate dependent upon intensity and duration of the interference. At extremely high levels, radiation may be hazardous to operating personnel and destructive to equipment components. The most common sources of radiation are airports which have communications and radar installations, high power transmissions such as radio stations, and freeways where a certain amount of radiation is generated by moving vehicles. Hand-held transceivers (i.e., walkie-talkies) produce the same effect as radio stations when used in or near computer equipment and should therefore be prohibited from the areas in which computer equipment is installed.

Additionally, microwave links are sometimes aimed from adjacent buildings. This will present trouble for the computer system if it is installed in the transmission path.

HP 3000 Computer Systems are designed to withstand radiation levels of one-half volt per meter, or three volts per meter, over a frequency range of 14kHz to 1GHz, depending on which disc drive is included in the system. If the system includes an HP 7920 or HP 7925 drive, the specification is one-half volt per meter. If any other disc drive is included, the specification is three volts per meter.

Because hand-held transceivers are used in many buildings, warning signs should be posted near the computer room. These signs will serve to alert people not to use these devices near the computer system. For example:

CAUTION

Do not operate transmitting devices in this area.

SHIELDING. Interference should be suppressed at the source. Unfortunately, this is not always practical, either mechanically or economically. In such cases, shielding must be used to reduce radiated interference on power lines, data cables, or other external sources. The shielding of equipment and cabling enclosures serves as a barrier to external interference. In cases where shielding does not work, and the computer system is properly grounded, you should consult a radiation specialist. He may recommend such steps as grounding window screens and other large metal surfaces.

Magnetic Field Interference

Magnetic field interference should be considered for two conditions, the operating environment and the non-operating environment. In the operating environment, this interference may be encountered when magnetic field-producing equipment is located in an adjacent room and the separating wall does not afford adequate shielding. Excessively strong magnetic fields may cause data stored on discs or tapes to be scrambled. Also, tapes and discs that are not properly stored when not in use can be similarly affected.

Data on tapes or discs can be altered if transported through a strong magnetic field. This condition can be avoided by packing magnetic tapes and discs in metal transit cases when transporting, and then storing in appropriate cabinets or rooms.

LIGHTNING PROTECTION

Two aspects of lightning protection must be considered: direct strikes and indirect strikes. Protection against these two aspects involve different techniques.

People, equipment, and buildings must be protected against direct lightning strikes. The National Fire Protection Association's Lightning Protection Code (NFPA Standard 78) specifies practical safeguarding of people and property from hazards arising from exposure to lightning. In addition, local safety and fire codes may provide additional or more stringent requirements.

The primary objective of lightning protection is to prevent lightning or resulting damaging effects from entering the building. This may not always be possible to achieve on an absolute basis, however, if the structural protection is properly installed, destructive results can be prevented. The NFPA Standard 78 illustrates methods of installing lightning protection systems for various types of structures and soils. By following the recommendations set forth in this standard, it can be assured that lightning discharges will be conducted harmlessly from the point of contact into ground. Hewlett-Packard does not recommend any particular method but does recommend adhering to published standards, regulations, and codes.

While the structure can be adequately protected against destructive lightning entry, power lines and signal cables, which are highly susceptible to lightning effects, cannot be protected in the same manner. Power lines must be protected in accordance with local regulations. Data cables are virtually impossible to protect against direct or very strong indirect discharges and, therefore, should never be exposed.

The second consideration for lightning protection is that of indirect strikes. This is more common and, while not having visible effects upon the structure, will almost always produce voltage transients on power and signal lines. Transients resulting from lightning are unpredictable in frequency and time of occurrence, magnitude, and location. Therefore, protection for the computer system must be considered in terms of isolation, separate from that of the structural protection.

Hewlett-Packard specifies transient voltage levels to which the computer system is designed to withstand in normal, controlled environments. The controlled environment is that in which the facility is constructed in accordance with data presented in this document. This means that normal precautions, such as proper grounding systems, cable terminations, etc., have been considered and implemented.

Transients on power lines are generally resolved by adding some form of isolation device at the power entry panel, and subsequent locations in the service voltage lines, as required.

Transients on signal lines are typically much faster and of higher magnitudes than that experienced on power lines, primarily because of the difference in impedance levels and the nature of termination. Impulsive transients of this type, with rise times of less than 50 nanoseconds are the most damaging to digital circuitry. In order to benefit the most out of implementing transient suppression devices for data communication circuitry, the devices should be capable of guarding against 10 kV impulsive transients as well as 6 kV transients on longer duration (1 to 100 microseconds). Hewlett-Packard has installed devices that meet these goals on all data communications circuits in the HP 3000 Computer Systems. This is considered to be adequate in locations where lightning activity is moderate to mild. Also, this protection is still adequate in areas of high activity if the facility has been given proper attention.

In areas where lightning problems become severe, additional protection may be required. Since the effects of lightning cannot be accurately predicted, optional protection is available that can be added to the extent that local conditions dictate.

EIA Specification RS-232-C states that the maximum withstand voltage for data communications cables to be +25 volts. The nominal operating voltage shall be no greater than 15 volts nor less than 5 volts in magnitude. The capacitance of the receiving end shall not be greater than 2500 pF, and the load shall not be inductive. With these constraints in mind, the following protection is recommended:

- Installation of a transient voltage suppression device with a breakdown voltage of 18 volts at 25 degrees C. This device has a breakdown voltage range of 15.8 volts at 0 degrees C to 20.6 volts at 70 degrees C. The capacitance of this device will range up to 2000 pF, depending upon bias conditions.

These devices must be installed on the data-in, data-out, and signal ground lines in RS-232-C applications. Also, the devices should be installed at both ends of the data communications cables. Methods for implementing the use of these devices are as follows:

- o Install HP-manufactured data communications cables that include these features and which are available from the factory.
- o Fabricate junction boxes through which each data cable is routed with the proper lines connected to these devices. Precautions must be taken to ensure that subsequent terminal installations are also connected to the devices in the same manner.

All devices connected to the data lines must be terminated on the outside of each unit to ensure that transients are not introduced into the unit enclosures. Further precautions should be taken to minimize lightning-induced transients. These are:

- o Ensure that each computer system component is grounded to earth.
- o Route data communications cables away from power lines and other possible sources of transients.
- o Run data communications cables through shielded conduit that is grounded to earth.

Do not route data communications cables outside the building, between buildings, or through any other exposed conditions.

POWER LINE TREATMENT DEVICES

Power lines feeding computer facilities act as antennas for some forms of electromagnetic interference. Also, the voltages on these lines are affected by transients, power outages, and brownout conditions. These power line disturbances can degrade system performance. In areas where these conditions are extreme, power line protection must be employed to ensure reliable system operation. Depending upon a particular condition, one of the following power line treatment devices may be required for the system:

- o Isolation transformer
- o Line regulator
- o Line conditioner
- o Motor generator
- o Uninterruptable power source (UPS)
- o Combinations of the above

Isolation Transformer

Isolation transformers are designed to eliminate transients on the incoming AC power line. These devices provide common-mode noise suppression only. They are useful in situations where transients are of moderate levels and common-mode noise suppression is the primary concern. They do not regulate line voltage however; therefore they provide no protection against voltage variations.

When isolation transformers must be installed, the following isolation transformer specifications are required for an acceptable level of reliable system operation of the HP 3000 computer systems:

a. 0.001 pF coupling capacitance

b. Compliance with UL specifications

Line Regulators

Line regulators provide auto regulation by switching taps. They are useful for regulating the output voltage, even in deep brownouts.

Line Conditioners

Line conditioners provide high protection against common- and normal-mode transients. Also, this device regulates the output voltage through moderate sags and surges (approximately 20 percent).

Motor Generators

Motor generators reject all external noise and regulate the output voltage through sags, surges, brownouts, and momentary dropouts. To protect against blackout conditions, the motor generator set would have to be equipped with a diesel-motor drive.

Uninterruptable Power Source (UPS)

UPSs are used in hospitals and other buildings where an uninterruptable source of power is a critical necessity. The greatest degree of power regulation and power line isolation is provided by the UPS system. Because it is a source of AC power that is not affected by fluctuations in commercial power, the UPS system guards against even momentary voltage disturbances. Since the UPS contains battery backup, blackout control is afforded, the duration of which is dependent upon the size of the battery bank. The battery bank has a typical maximum of 60 minutes. If longer durations are required, it may be necessary to back up the UPS system with a diesel generator.

CAUTION

When a UPS is installed, a line treatment device must be installed at the output, power source originated interference might otherwise result.

Summary of Power Line Treatment Devices

Isolation transformers provide the least protection; UPS devices provide the most. Selection of devices depends on local conditions and must be determined after a power survey has been performed, or from some other statistical knowledge.

The devices described are the more commonly used power line treatment devices. Other types are available and may be utilized where conditions warrant. Table 4-1 lists the devices and their associated features, including advantages and disadvantages. In any case, the device must conform to all local safety requirements. If used, a safety ground is required on all units connected to the secondary of the isolation device.

All line treatment devices except motor generators and UPSs are positioned in the electrical system after the branch circuit panel. Motor generators and UPSs must be installed before the branch circuit panel.

If power line treatment is necessary, consult with your HP power/site preparation specialist in choosing the appropriate device.

CAUTION

The HP 3000 Series 64/68 Computer can only be powered from a WYE-wired 208V, 380V, or 415V source. The computer is a Delta-connected load however; thus it requires stability of line-to-line voltages, NOT line-to-neutral voltages. Additionally, the computer maintains a large one-cycle surge current due to its ferro-resonant front end. As a result, the computer cannot operate properly when powered by a conventional three-phase line conditioner. Consult your local HP power specialist for help in choosing proper line conditioning equipment.

	VOLTAGE VARIATION PROTECTION	NORMAL MODE TRANSIENT PROTECTION (DIFFERENTIAL)	COMMON MODE TRANSIENT PROTECTION	PROTECTION FROM LINE FREQUENCY VARIATION (+ 3%)	LINE DISTORTION PROTECTION	GREEN WIRE HIPOT LEAKAGE	ADDITIONAL COMMENTS	
							POSITIVE	NEGATIVE
ISOLATION TRANS. UNSHIELDED	○NONE AUTOMATICALLY ●CAN BE MANUALLY SET BY JUMPERING WINDINGS	○VERY LITTLE	○SOME, AT LOW FREQUENCY ○CAPACITIVE COUPLING MAY PASS MOST HIGH FREQUENCY SIGNALS	○NO PROTECTION	○NO PROTECTION ○WILL ADD DISTORTION 1-2%	●FULL PROTECTION	●READILY AVAILABLE FROM VENDORS IN MANY SIZES ●EFFICIENT POWER CONVERSION	○HEAVY; 5KVA ≈ 100 POUNDS
SUPER ISOLATION TRANS.	○NONE AUTOMATICALLY ●CAN BE MANUALLY SET BY JUMPERING WINDINGS	○VERY LITTLE	●HIGH PROTECTION 120dB BECOMES FUNCTION OF WIRING LAYOUT	○NO PROTECTION	○NO PROTECTION ○WILL ADD DISTORTION 1-2%	●FULL PROTECTION	●READILY AVAILABLE FROM SEVERAL VENDORS ●EFFICIENT POWER CONVERSION	○HEAVY: 5KVA ≈ 100 POUNDS ○APPLICATION INVOLVES TOTAL APPROACH TO PROPER AC/DC SYSTEM LAYOUT TECHNIQUES
LINE CONDITIONER, SCR SWITCHED TAPS	●AUTO REGULATION BY SWITCHING ADD'L TURNS IN/OUT ●V_{IN} +13% - 25% V_{OUT} ±7%	●> 55dB @ 100 kHz	●HIGH PROTECTION 120dB BECOMES FUNCTION OF WIRING LAYOUT	○NO PROTECTION	○NO PROTECTION ○WILL ADD DISTORTION 1-2%	●FULL PROTECTION	●AVAILABLE FROM SEVERAL VENDORS ●EFFICIENT (>90%) POWER CONVERSION	○HEAVY: 5KVA ≈ 100 POUNDS ○APPLICATION IS PART OF TOTAL APPROACH
LINE CONDITIONER, FERRORESONANT	●AUTO REGULATION BY CORE SATURATION AND RESONANT CAPACITOR. SINE WAVE OUTPUT ●V_{IN} +8% - 20% V_{OUT} ±2%	●HIGH PROTECTION DUE TO SATURATED CORE. 120dB 1kHZ - 1MHz	●HIGH PROTECTION ●CMRR BECOMES FUNCTION OF AC WIRING LAYOUT 120dB 1K - 1KHz	○NO PROTECTION ○DEVICE IS VERY SENSITIVE TO LINE FREQ. ± 1%	●HIGH PROTECTION ●REMOVES DISTORTION FROM LINE TO BELOW 5%	●FULL PROTECTION	●AVAILABLE FROM SEVERAL VENDORS	○HEAVY: 1.5KVA ≈ 100 POUNDS ○70 - 80% EFFICIENCY (MAY REQUIRE A FAN)
PASSIVE FILTER	○NO PROTECTION	●HIGH PROTECTION, FUNCTION OF DESIGN	●HIGH PROTECTION, BECOMES FUNCTION OF WIRING LAYOUT	○NO PROTECTION	○NONE ○ADDS DISTORTION AS SERIES INDUCTORS SATURATE	○ADDS LEAKAGE ○OPTIMUM DESIGN FROM RFI STANDPOINT MAY FAIL. SPECIAL COMPONENTS REQUIRED	●AVAILABLE FROM SEVERAL VENDORS, CAN BE CUSTOMIZED. USER CAN DESIGN HIS OWN	○NEW OR CUSTOM DESIGNS CAN TAKE MONTHS FOR AGENCY APPROVAL
MOTOR GENERATOR	●HIGH PROTECTION OVER WIDE RANGE ●"RIDES THROUGH" BLACKOUTS OF < 3 SECONDS	●HIGH PROTECTION	●HIGH PROTECTION	●PASSES THRU ALL VARIATIONS THAT ARE > 3 SECONDS IN DURATION. EXTREME VARIATION.(?) CAUSES MALFUNCTION	●COMPLETE ISOLATION FROM AC LINE ●DISTORTION IS FUNCTION OF GENERATOR OUTPUT % OF FULL LOAD	○SEPARATE ISSUE FROM COMPUTER CHARACTERISTICS, SINCE IS EXTERNAL TO MAINFRAME	●LARGE POWER CAPABILITY	○BIG APPLICATIONS *ONLY* 15KVA AND UP ○NOISY, MUST BE REMOTED ○REQUIRES PM ○USUALLY REQUIRES A SITE PREP SUBCONTRACTOR FOR AN EFFECTIVE INSTALLATION
UNINTERRUPTIBLE POWER SOURCE	●COMPLETE ISOLATION, SUBJECT TO STAYING POWER OF BATTERIES OR FUEL IN ENGINE	●HIGH PROTECTION	●HIGH PROTECTION	●COMPLETE ISOLATION	●COMPLETE ISOLATION FROM AC LINE ●DISTORTION IS FUNCTION OF OUTPUT AMPLIFIER % OF FULL LOAD	○SEPARATE ISSUE FROM COMPUTER CHARACTERISTICS, SINCE IS EXTERNAL TO MAINFRAME	●AVAILABLE FROM SEVERAL VENDORS ●SIZES AVAILABLE FOR ALL APPLICATIONS	○ENGINE POWERED IS NOISY ○CELL POWERED TYPE CHEMICAL HAZARD ○SITE PREP SUBCONTRACTOR RECOMMENDED ○REQUIRES PM

NOTE: (●) REPRESENTS POSITIVE FEATURE, (○) REPRESENTS NEGATIVE FEATURE

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Table 4-1. Features of AC Line Treatment Devices

ELECTRICAL REQUIREMENTS

SECTION V

INTRODUCTION

Reliable computer operation depends upon an adequate source of AC power that is stable and free of disturbances. A qualified electrician must connect this power to the computer system and ensure that the voltage at the computer input is within HP's tolerances and that fluctuations and disturbances are within operating ranges. In addition to a dedicated power line for the computer system, separate power is required for such items as lighting, air conditioning, etc.

Other factors that must be considered when planning and installing the electrical system include isolated grounding, lightning protection, and power line treatment devices. Also, electrical safety provisions must meet local code requirements.

DETERMINING POWER REQUIREMENTS

When determining power requirements for the computer site, the total current required for the system must be calculated. Future growth requirements should also be considered at this time.

After calculating the power requirements for the computer system, establish the power needs for lighting, air conditioning, auxiliary equipment, and other non-computer equipment. These items must be on a separate power line.

SERVICE VOLTAGE

The voltages available from your local power company determine which service voltages can be installed for the computer. Consult with your HP power/site preparation specialist about power requirements. An electrical contractor can then prepare the site.

Power Quality

Power supplied to your building by your power company may experience excessive sags, surges, transients, outages, or other conditions unacceptable for reliable computer operation. Therefore, a power quality survey should be conducted. The results of the survey should be analyzed to determine the need for line treatment devices. After the system is installed, a power line disturbance monitor should be connected to the dedicated system power to monitor the actual power conditions.

Voltage Limits

The line-to-line, steady-state voltage tolerances when the computer is operating must be maintained within plus ten percent to minus 10 percent of the nominal voltage, measured at the receptacle. The voltage limits and power fail thresholds are:

a. Overvoltage Limits: 208 VAC nominal = 229 VAC
380 VAC nominal = 418 VAC
415 VAC nominal = 457 VAC

b. Undervoltage Limits: 208 VAC nominal = 187 VAC
380 VAC nominal = 342 VAC
415 VAC nominal = 373 VAC

Frequency Limits

The line frequency must be maintained at 60 or 50 Hz (+/-5%), as measured at the input to the system.

Harmonic Content

At all sites, the maximum harmonic content of the computer system feeder must not exceed five percent as measured at the input to the system with the system running. Harmonic content is measured with a distortion analyzer.

Line-to-Line Imbalance

At the power distribution panel, from which individual circuits run to the computer and its peripherals, the current in any phase must not deviate by more than 18 percent from any other phase. This assures voltage uniformity to be within five percent between all phases in a multi-phase source.

Phase Angle Imbalance

The maximum phase angle imbalance between phases in a three-phase source should not deviate more than five percent from 120 degrees, as observed with an oscilloscope at the branch circuit panel.

POWER DISTRIBUTION

When the power and its quality has been observed, the power distribution system can be constructed. Figure 5-1 depicts the voltage configuration used with the HP 3000 Series 68 Computer. The configuration is shown for the distribution to the computer system components only. Power for convenience outlets, lighting, and other non-computer use should be on separately wired circuits.

Power Panels

The panel(s) should be in an unobstructed, well-lighted area in the computer room. The individual branch circuits on the panel(s) should be protected by suitable circuit breakers properly rated according to manufacturer's specifications and applicable codes. Each circuit breaker should be labeled to identify the branch circuit it controls. Breaker ratings will be determined by each load and local electrical code requirements.

Wiring

Wiring from the main service entry to the branch service panel, and from the branch circuit panel to receptacles or the peripheral power panel must be considered separately. Wiring from the main service entry to the branch circuit panel may involve the use of aluminum wire rather than the preferred copper wire. If this is the case, then the connectors at the branch circuit panel breakers MUST be composed of an aluminum-copper alloy, which are usually marked: AL/CU. If aluminum wire is secured to the panel with a copper connector, the aluminum wire will eventually shrink and result in loose connections. When this occurs, a voltage drop across the connection will be present. Heat will be dissipated, causing a potential fire hazard. Also, the voltage drop may be large enough to adversely affect the computer system.

Wiring between the branch circuit panel and receptacles or peripheral power panel MUST be copper. All receptacles, connectors, and wiring associated with the computer system are made of copper and, therefore, should not be attached to aluminum conductors or connectors.

As a rule-of-thumb, wire size should be increased one gauge for each 100 feet from source to load.

Receptacles and Connectors

When receptacles are used to connect system components to AC power, the receptacles must include an isolated ground connection that is insulated from the receptacle box. It is important to ensure that the separate receptacles include an isolated ground connection. When installing the receptacles, ensure that each receptacle has its own neutral. Using the same neutral for more than one circuit will cause heat problems which results in fire hazard and voltage loss. Figure 5-2 shows a typical receptacle that includes an isolated ground. Figure 5-3 is guide for isolated ground receptacles for various voltage ratings and includes the National Electrical Manufacturers Association (NEMA) identification number. The NEMA configurations apply specifically to North America. Use local equivalents where standards differ.

Peripheral power cords vary from country to country. While the connector to each peripheral is standard, the AC connector will not be standard. Those that cannot be ordered must be fabricated to meet your local requirements. Figure 5-4 shows available peripheral power cords.

Convenience Outlets

Devices other than computer system units should be connected to receptacles that are separate from the computer's power source. This is to prevent appliances such as vacuum cleaners from interfering with the computer units. These receptacles should be clearly marked to avoid the inadvertent connecting of computer peripherals to convenience outlets.

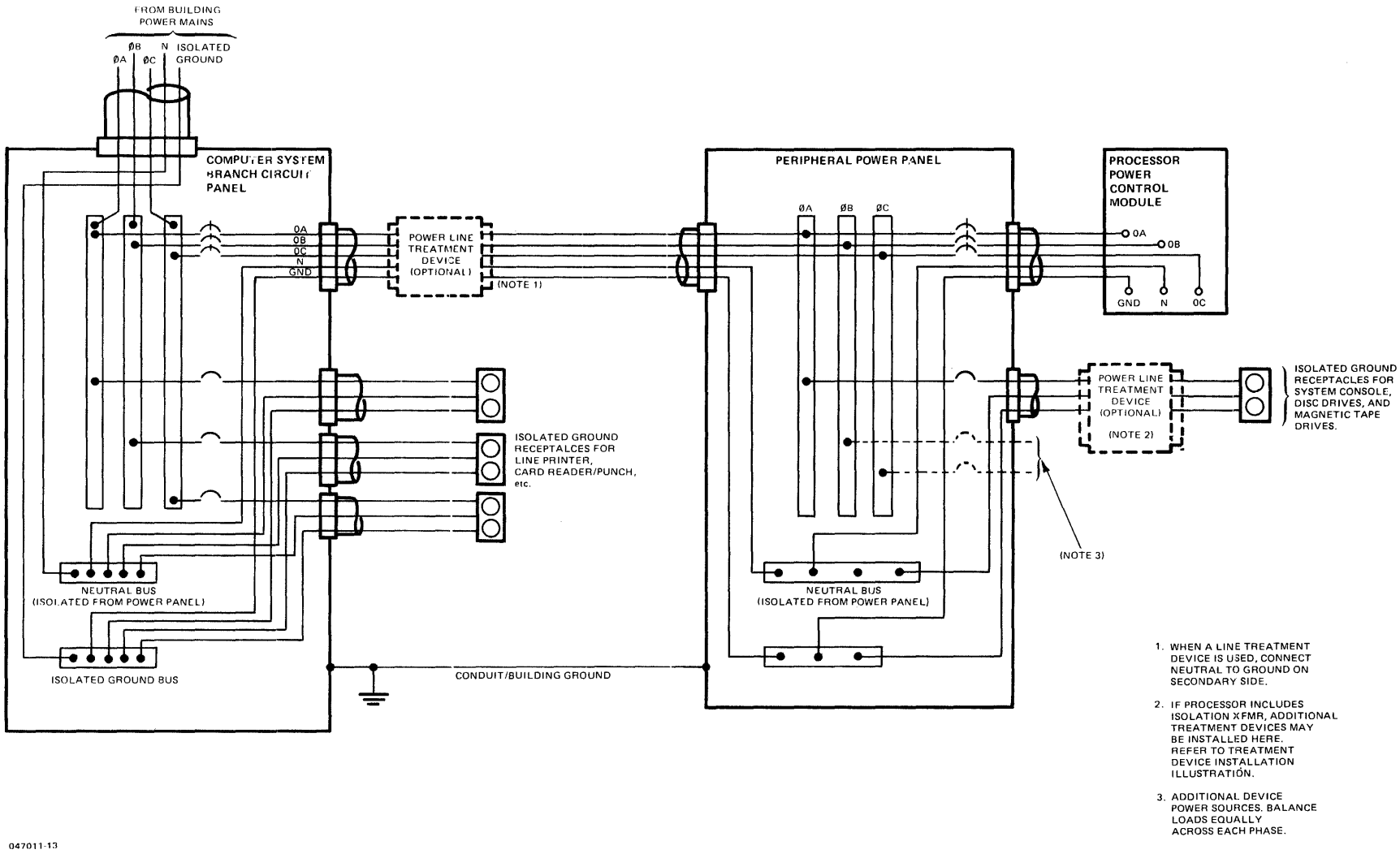


Figure 5-1. 208/380/415 VAC, Three-Phase Power

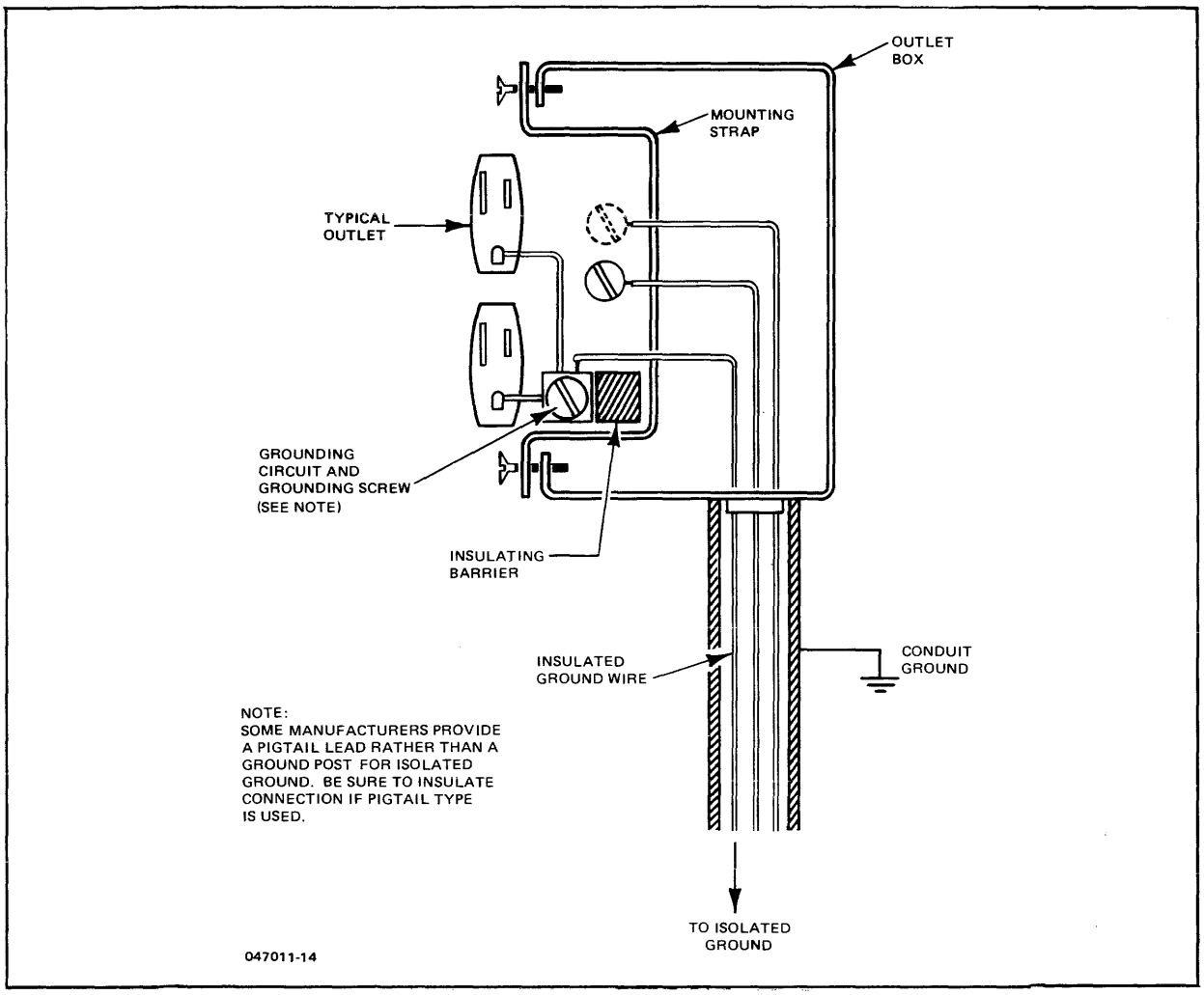
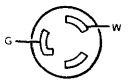
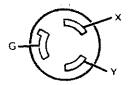
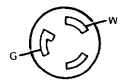
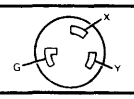
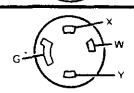
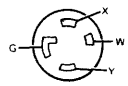
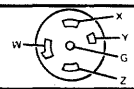
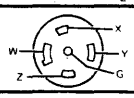
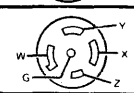
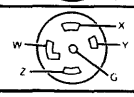


Figure 5-2. Typical Isolated Ground Receptacle

TWIST-LOCK

NEMA NO.	CONFIG.	RATING	DESCRIPTION	COLOR
L5-15R		15A 125V 15A 125V	2 Pole, 3 Wire, Duplex 2 Pole, 3 Wire, Single	Brown Orange
L6-15R		15A 250V	2 Pole, 3 Wire, Single	Orange
L7-15R		15A 277V	2 Pole, 3 Wire, Single	Brown
L5-20R		20A 125V	2 Pole, 3 Wire, Single	Black
L5-30R		30A 125V	2 Pole, 3 Wire, Single	Black
L14-20R		20A 125/250V	3 Pole, 4 Wire, Single	Black
L14-30R		30A 125/250V	3 Pole, 4 Wire, Single	Black
L21-20R		20A 3ϕ WYE 120/208V	4 Pole, 5 Wire, Single	Black
L22-20R		20A 3ϕ WYE 277/480V	4 Pole, 5 Wire, Single	Black
L23-20R		20A 3ϕ WYE 347/600V	4 Pole, 5 Wire, Single	Black
L21-30R		30A 3ϕ WYE 120/208V	4 Pole, 5 Wire, Single	Black

X = BLACK
Y = RED
Z = BLUE
W = WHITE
G = GREEN

STRAIGHT BLADE

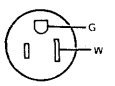
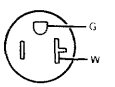
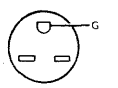
NEMA NO.	CONFIG.	RATING	DESCRIPTION	COLOR
5-15R		15A 125V	2 Pole, 3 Wire, Duplex 2 Pole, 3 Wire, Single 2 Pole, 3 Wire, Single	Orange Orange Orange
5-20R		20A 125V	2 Pole, 3 Wire, Duplex 2 Pole, 3 Wire, Duplex	Orange Brown
6-15R		15A 250V	2 Pole, 3 Wire, Single	Orange

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Figure 5-3. Selection Guide For Isolated Ground Receptacles

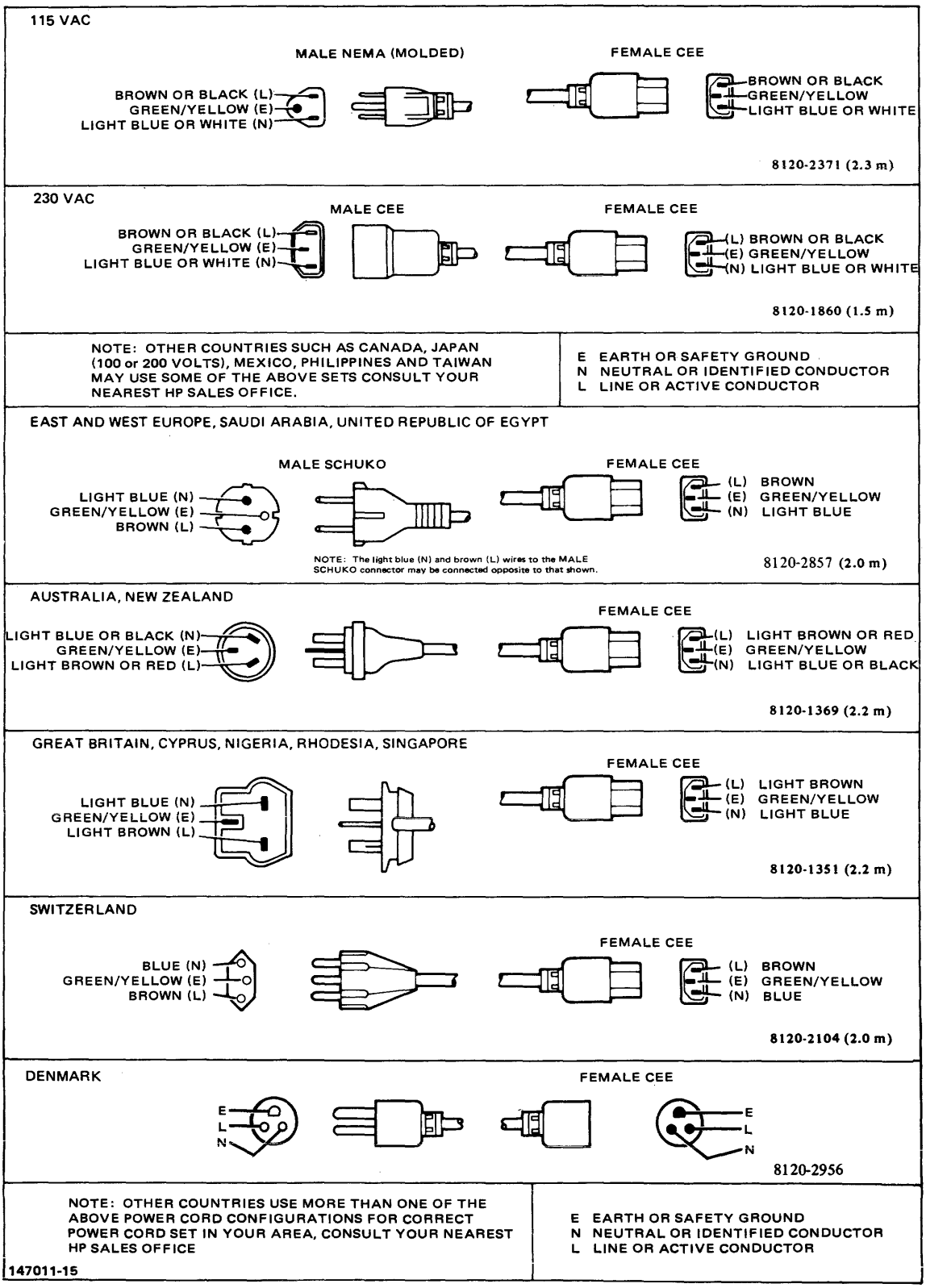


Figure 5-4. HP Peripheral Cord Sets

GROUNDING

The primary consideration for grounding is personnel safety. This is required by the National Electrical Code (in the U.S.A.) and most other local, regional, and national codes. In addition, a noise-free ground (earth reference) must be installed so a common reference point exists for all system components.

Safety Ground

Safety codes usually require safety conductors for electrical equipment. The codes require that each hot (live) wire and return (neutral) wire connecting a power source to equipment must be accompanied by a safety wire. The size of the safety wire must be the same size as the current-carrying wire. Safety codes also generally require that a safety ground conductor be connected to any metal surface a person can touch that could be energized by an electrical fault. This conductor, under normal operation, must not carry current; i.e., it must not be used as part of the equipment's hot-return electrical path. If it did, and if a live wire shorted to the metal, the metal could be charged with a hazardous voltage. Such shock hazards can be avoided by bonding a safety ground wire to the equipment chassis, thereby providing a path that would cause a circuit breaker to trip or fuse to open. A safety ground is built into each HP product; the path is completed when the unit is connected to a grounded receptacle or when a lug in the unit is connected to ground via a cord provided by the customer.

The safety ground should connect to the ground element at the main service entry (the panel where the power lines enter the building). The safety ground impedance from any piece of equipment to the main service entry must be less than one ohm.

Noise-Free Ground

Hewlett-Packard computers require noise-free grounds for proper operation. This ground is referred to as the isolated ground. In most cases, the safety ground is inadequate because ground medium may not be free from ground fault noise, RFI pickup, or may contain a steady current. Examples of unacceptable ground sources that are subject to noise are as follows:

- o Conduit
- o Roof building beams
- o Horizontal building beams
- o Sprinkler pipes (Connecting ground wires to sprinkler pipes violates most fire codes)
- o Water pipes (May have PVC sections, or PVC sections may be installed in future)
- o Raised floor support pipes
- o Gas pipes

These ground sources are subject to building noise from ground faults and pickup of RFI because of antenna action.

Acceptable ground sources may any be of the following: (Consult local electrical inspection authorities for acceptable sources in your area.)

- o Proper size wire connected to the building's main ground point.
- o Grounding electrode driven into the earth and bonded to the entrance ground point.
- o Vertical building beams in high rise structures.
- o Grounding nests or grid meshes bonded to the entrance ground.
- o Any approved service entrance ground.

The isolated ground wire must be properly bonded to the ground source. This precludes the use of clamps bolted to a pipe or ground stake, or any other connecting method that results in a loose connection. The bond should be welded, brazed, or soldered to minimize voltage drops at the ground connection. Any measurable resistance at a connection, plus the ground wire resistance may, if improperly installed, cause an unwanted potential to exist on the isolated ground.

When installing the isolated ground wire, the branch circuit panel should have an isolated ground bus, isolated from the power panel, from which the isolated ground is routed individually to each unit of the system. Where power panels are not available with integral isolated ground buses, a separate ground bus panel may have to be constructed. This separate bus panel then becomes the central distribution point for the dedicated ground.

Wire sizes must also be considered, since the distance from the ground element to the branch circuit panel may vary in distance from site to site. Refer to your local electrical inspection authority for applicable sizes.

POWER LINE TREATMENT DEVICES

If a power line treatment device is installed, it should be as indicated in figure 5-1. Treatment devices are connected with insulated couplers as shown in figure 5-5.

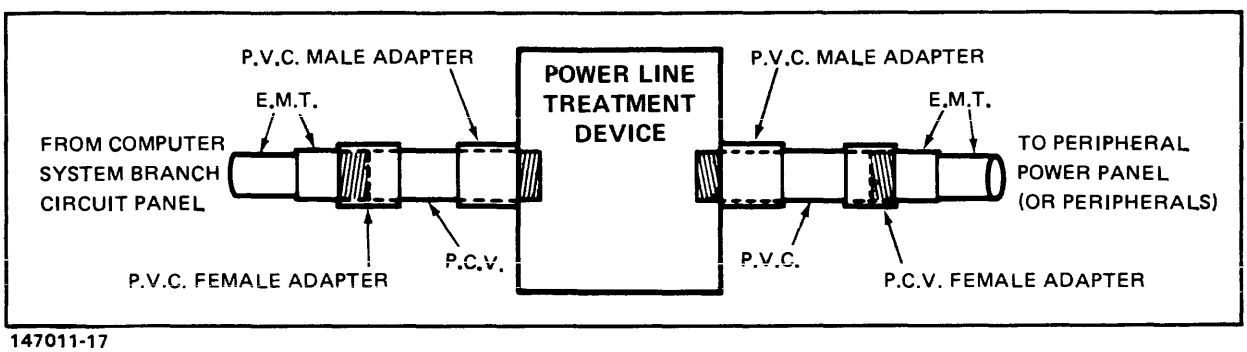


Figure 5-5. Power Line Treatment Device Installation

FACILITY MAINTENANCE

SECTION VI

INTRODUCTION

Proper facility maintenance is essential to reliable computer operation. There is no substitute for cleanliness, neatness, and properly-maintained power distribution and air conditioning systems. Cleanliness and neatness minimize dust and dirt accumulations. Periodic maintenance of the air conditioning system not only keeps the computer room at the proper temperature and humidity levels, but increases the useful life of the air conditioner itself.

To determine how often to perform the procedures described in this section, first ascertain the amount of traffic in the computer area. Next, consult the air conditioning manufacturer's recommended maintenance schedules. Also, ensure that your electrician checks the computer power regularly.

CLEANLINESS

Day-to-day operating practices will help keep the computer room clean and neat and maintain a pleasant working atmosphere. Establish procedures and ensure that your staff complies.

Pre-Installation Cleaning

Before installing the computer, ensure that the following steps have been taken:

- Windows in the computer area are sealed.
- Select paints for walls and ceilings that will not flake or powder.
- Use acoustical materials that do not attract and accumulate dust. Avoid sprayed-on acoustical ceilings and mineral-based dropped ceiling tiles; they tend to flake.
- Clean subfloor areas, including raceways and air-conditioning ducts and plenums, just before the computer system is installed.
- Place mats at computer room entrances to reduce the amount of dust tracked in from other areas.
- Avoid ordinary floor waxes and bright finishes which tend to build up and subsequently fragment into particles.
- Prepare a cleaning schedule.

Operating Practices

- o Prohibit smoking in the computer room and in the magnetic tape and disc storage areas.
- o Do not stack materials on top of cabinets, disc drives, or the computer. In addition to restricting the flow of air through equipment, a potential hazard to personnel can be created.
- o Keep magnetic tape and discs pack containers closed except when removing or replacing the contents.
- o Provide a coat rack outside the computer room for outer garments.
- o Minimize traffic in the computer area by restricting access to authorized personnel.

Cleaning Techniques

- o Use water sparingly. If a mop is used, it should be damp, not wet or dry. Antistatic lint-free dust cloths remove dust without stirring it up and without the electrical hazard water represents.

CAUTION

If magnetic tape and disc drives are installed, do not sweep area with a dry broom or mop.

- o Use a vacuum cleaner with a nozzle that is not electrically conductive. The cleaner should be tightly sealed, filtered, and watertight.

CAUTION

Do not connect vacuum cleaners or other floor treatment equipment to the line that carries power to the computer. This same caution applies to automatic coffee makers and any other appliances that make large current demands and/or generate electrical noise. Power line interference might otherwise result.

- o Do not use steel wool to clean computer floors; the metal fibers can cause electrical problems if drawn into the computer cabinets.
- o Particular attention should be given to areas that are not readily cleaned. General discoloration that does not yield to a fresh application of emulsion polish and machine polishing indicates that dirt is caught in an excessive polish buildup. Remove and replace the polish; if the discoloration is still present, the sealer is probably broken or cracked, allowing dirt into the surfacing material. The floor covering must be thoroughly cleaned and resealed.
- o Apply polish sparingly, and only to traffic routes where necessary. Machine-buff other areas. The polish should only fill in scratches, not build up to a thick coating.
- o Consult manufacturers of specific floor coverings regarding acceptable floor-cleaning procedures.

AIR CONDITIONING PREVENTIVE MAINTENANCE

Proper maintenance of the air conditioning system will prolong its life and assure the proper operating environment in the computer room. Since systems differ between manufacturer and design, preventive maintenance also differs from model to model. Consult the manufacturer of your system for its recommended maintenance schedule.

Filters may be used to prevent contaminants from entering the computer room. All filters have saturation points after which they are no longer effective. Consult your filter manufacturer for data on cleaning or replacement intervals. This is particularly important when filtering is required for corrosive contaminants; for example, when activated charcoal is employed to filter corrosives. When charcoal saturates, it emits quantities of gas, thereby defeating the purpose of filtering.

POWER LINE MAINTENANCE

Normally, the dedicated power to the computer system requires little attention. However, the power source should be checked at least semi-annually to eliminate fire hazards and voltage loss because of loose connections. Have your electrician perform the following checks and take remedial action when necessary.

NOTE

Fire safety codes, regulations, or ordinances vary in different areas. Consult local authorities.

- Inspect all power panels and receptacle boxes for debris, such as bits of wiring, insulation, or combustibles. Remove any accumulations.
- Inspect all power panels and receptacle boxes for accumulations of dust, cobwebs, and other forms of dirt. Remove any accumulations.
- Check all mechanical wiring connections. Loose connections are a source of voltage loss and may also be a potential fire hazard because of the heat that may be generated. Tighten all connections.
- Inspect conduit for damage. If cuts, dents, or abrasions are visible, check the wiring inside the conduit. Repair or replace any damaged conduit or wiring.
- Replace damaged receptacles, ensuring that the isolated ground lead is properly connected.
- Ensure that electrical phase balance is maintained as computer system expansion occurs.

PROCESSOR AND PERIPHERAL SPECIFICATIONS

APPENDIX A

Appendix A contains specifications for HP 3000 Series 64/68 Computers and peripheral equipment used with the systems. Included are specifications for heat, current, voltage, and weight. After determining your system configuration, refer to the specifications to determine air conditioning requirements, electrical requirements, etc.

NOTE

Heat dissipation values are calculated from actual power measurements. True power is measured with equipment that considers the phase angle between voltage and current, the nonlinearity of both, and the non-unity power factor. Attempts to calculate heat dissipation using only the product of volts times amperes will produce incorrect results.

SYSTEM PROCESSOR UNIT CHARACTERISTICS

ELECTRICAL CHARACTERISTICS

BTU/HR KCAL/HR	VOLTAGE(VAC) AND FREQUENCY	TOL. (+/−%)	MAXIMUM STEADY STATE CURRENT	SURGE CURRENT	PANEL CKT BKR
Two Bay Unit					
12,000 (3024)	208 at 60 Hz 3-phase	+10/−10	24A/phase	500A	30A
	380 at 50 Hz 3 phase	+10/−10	13A/phase	325A	20A
	415 at 50 Hz 3-phase	+10/−10	12A/phase	300A	20A
Three Bay Unit (Auxiliary I/O Bay)					
16,000 (4022)	same as above	same as above	same as above	same as above	same as above

PHYSICAL CHARACTERISTICS

HEIGHT	WIDTH	DEPTH	WEIGHT
Two Bay Unit			
48 in. (122 cm)	69 in. (176 cm)	26 in. (66 cm)	1150 Lb. (522 kg)
Three Bay Unit (Auxiliary I/O Bay)			
48 in. (122 cm)	105 in. (268 cm)	26 in. (66 cm)	1450 Lb. (658 kg)

ELECTRICAL CHARACTERISTICS -- DISC DRIVES

PRODUCT MODEL NUMBER	BTU/HR (KCAL/HR)	VOLTAGE (VAC) AND FREQUENCY	INPUT VOLTAGE RANGE (VAC)	MAXIMUM STEADY STATE CURRENT	SURGE CURRENT	MARKED ELECTRICAL RATINGS
HP 7920S (SLAVE)	1621 (409)	120 at 60 Hz 220 at 50 Hz	108-126 209-231	5.1A 3.0A	60A 60A	8A 4A
HP 7920M (MASTER)	2389 (602)	120 at 60 Hz 220 at 50 Hz	108-126 209-231	7.4A 4.3A	60A 60A	8A 4A
HP 7925S (SLAVE)	1160 (292)	120 at 60 Hz 220 at 50 Hz	108-126 209-231	4.4A 2.2A	60A 60A	8A 4A
HP 7925M (MASTER)	1928 (486)	120 at 60 Hz 220 at 50 Hz	108-126 209-231	6.7A 3.5A	60A 60A	8A 4A
HP 7933H/ 35H	5450 (1376)*	208 at 60 Hz 220 at 50 Hz	187.2-228.8 198-242	9.3A 9.0A	150A 150A	20A 20A
HP 9895A	295 (74)	120 at 60 Hz 220 at 50 Hz	108-126 209-231	2.1A 0.88A	50A 50A	3.0A 1.5A
HP 7911/12	2593 (654)	120 at 60 Hz 220 at 50 Hz	108-126 198-231	4.7A 2.6A	60A 60A	7A 4A
HP 7914P	2389 (597)	100 at 50 Hz 100 at 60 Hz 120 at 50 Hz 120 at 60 Hz 220 at 50 Hz 240 at 50 Hz	90-105 90-105 108-126 108-126 198-231 216-252	8.0A 8.0A 7.4A 7.0A 4.0A 3.7A	24A 24A 22A 21A 12A 11A	8.0A 8.0A 7.4A 7.0A 4.0A 3.7A

* Includes drive and accessory outlets.

ELECTRICAL CHARACTERISTICS -- MAGNETIC TAPE DRIVES

PRODUCT MODEL NUMBER	BTU/HR (KCAL/HR)	VOLTAGE (VAC) AND FREQUENCY	INPUT VOLTAGE RANGE (VAC)	MAXIMUM STEADY STATE CURRENT	SURGE CURRENT	MARKED ELECTRICAL RATINGS
HP 7970E	580 (154)	115 at 60 Hz 230 at 50 Hz	103.5–126.5 207–253	2.0A 1.7A	50A 50A	4.0A 2.5A
HP 7970E OPT 426	750 (198)	115 at 60 Hz 230 at 50 Hz	103.5–126.5 207–253	2.5A 1.4A	50A 50A	4.0A 2.5A
HP 7974A	205 (516)	115 at 60 Hz 230 at 50 Hz	99–125 198–242	4.6A 2.3A	15A 7.5A	4.5A 2.0A
HP 7976A	5100 (1285)	117 at 60 Hz 220 at 50 Hz	111.2–122.9 187–242	15.8A 8.2A		20A 10A

ELECTRICAL CHARACTERISTICS -- TERMINALS

PRODUCT MODEL NUMBER	BTU/HR (KCAL/HR)	MAXIMUM STEADY STATE CURRENT	VOLTAGE (VAC) AND FREQUENCY	INPUT VOLTAGE RANGE (VAC)	SURGE CURRENT	MARKED ELECTRICAL RATINGS
HP 2621A	140 (35)	0.43A 0.25A	120 at 60 Hz 220 at 50 Hz	90-126 198-231	10A 10A	0.8A 0.4A
HP 2621P	300 (75)	1.2A 0.6A	115 at 60 Hz 230 at 50 Hz	87-126 173-253	15A 15A	2.4A 1.2A
HP 2622A	255 (65)	0.65A 0.35A	110 at 60 Hz 220 at 50 Hz	99-115.5 198-231	3.2A 3.2A	2.0A 1.0A
HP 2622P	578 (146)	1.5A 0.75A	115 at 60 Hz 230 at 50 Hz	103.5-120.8 207-241.5	20A 20A	5.0A 2.5A
HP 2624A	408 (103)	1.2A 0.6A	110 at 60 Hz 220 at 50 Hz	99-115.5 19-231	6.2A 6.2A	2.0A 1.0A
HP 2624P	578 (146)	1.3A 0.7A	115 at 60 Hz 230 at 50 Hz	103.5-120.8 207-241.5	20A 20A	5.0A 2.5A
HP 2626A	1255 (65)	0.8A 0.4A	120 at 60 Hz 220 at 50 Hz	114-126 209-231	2.0A 2.0A	2.0A 1.0A
HP 2626P	408 (103)	1.7A 0.9A	115 at 60 Hz 230 at 50 Hz	109-120.8 218.5-241.5	20A 20A	5.0A 2.5A
HP 2635B	512 (142)	1.7A 1.0A	120 at 60 Hz 220 at 50 Hz	105-132 194-242	25A 25A	2.4A 1.2A
HP 2640A/B	290 (73)	1.1A 0.6A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195.253	15A 15A	4.0A 2.0A
HP 2641A	290 (73)	1.2A 0.6A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A
HP 2642A	510 (129)		115 at 50/60 Hz 230 at 50 Hz	111.6-126.5 195.5-253		
HP 2644A	290 (73)	1.2A 0.6A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A
HP 2645A	348 (88)	1.3A 0.7A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A
HP 2647A	560 (140)	2.2A 1.1A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A
HP 2647F	560 (140)	1.5A 0.8A	120 at 50/60 Hz 230 at 50 Hz	92.4-132 195-253	15A 15A	4.0A 2.0A
HP 2648A	440 (111)	1.7A 0.9A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A
HP 2649A	348 (88)	1.3A 0.7A	115 at 60 Hz 230 at 50 Hz	88.5-126.5 195-253	15A 15A	4.0A 2.0A

ELECTRICAL CHARACTERISTICS -- PRINTERS

PRODUCT MODEL NUMBER	BTU/HR (KCAL/HR)	VOLTAGE (VAC) AND FREQUENCY	INPUT VOLTAGE RANGE (VAC)	MAXIMUM STEADY STATE CURRENT	SURGE CURRENT	MARKED ELECTRICAL RATINGS
HP 2563A	853 (214)	120 at 60 Hz 220 at 50 Hz	108-126 198-231	5.0A 2.5A	25.0A 12.5A	400A
HP 2608A	2900 (730)	120 at 60 Hz 220 at 50 Hz	108-126 198-231	10.5A 5.3A	15A 15A	12.5A 6.25A
HP 2608S	2380 (595)	100 at 50/60 Hz 120 at 50/60 Hz 220 at 50/60 Hz 240 at 50/60 Hz	90-105 108-126 198-231 216-252	13.8A 11.5A 6.3A 5.7A	60A 50A 27A 20A	1375 WATTS MAX.
HP 2611A	2720 (680)	100 at 50/60 Hz 115 at 50/60 Hz 200 at 50/60 Hz 230 at 50/60 Hz	90-105 103.5-121 180-210 207-242	7.0A 6.0A 3.5A 3.0A	21.0A 18.0A 10.5A 9.0A	7.0A 6.0A 3.5A 3.0A
HP 2613A	1300 (328)	115 at 60 Hz 220 at 50 Hz	103.5-126.5 198-242	4.0A 2.5A	22.2A 22.2A	7.0A 3.5A
HP 2617A	2030 (512)	115 at 60 Hz 220 at 50 Hz	103.5-126.5 198-242	6.3A 2.5A	22.2A 22.2A	7.0A 3.5A
HP 2619A*	4340 (1090)	115 at 60 Hz 230 at 50 Hz	103.5-126.5 207-253	12.5A 6.3A	-- --	20A 10A
HP 2631B	512 (126)	120 at 60 Hz 220 at 50 Hz	105-132 194-242	1.7A 0.9A	25A 25A	2.4A 1.2A
HP 2680A	13,650	208 at 60 Hz 220 at 50 Hz	187.2-218 209-231	24A 22A	35A 35A	30A 30A
HP 2687A	3130 (789)	120 at 60 Hz 240 at 50 Hz	108-132 216-264	7.4A 3.8A	16A 8.0A	10.6A 5.5A
HP 2688A	3645 (919)	120 at 60 Hz 240 at 50 Hz	108-132 216-264	10.6A 5.5A	41A 20A	10.6A 5.5A

* 2619A requires a 20A, type 62 delay breaker.

ELECTRICAL CHARACTERISTICS -- READERS

PRODUCT MODEL NUMBER	BTU/HR (KCAL/HR)	VOLTAGE (VAC) AND FREQUENCY	INPUT VOLTAGE RANGE (VAC)	MAXIMUM STEADY STATE CURRENT	SURGE CURRENT	MARKED ELECTRICAL RATINGS
HP 2893A WITH OPT 333	1230 (310)	115 v at 60 Hz 230 v at 50 Hz	103.5–126.5 207–253	4.0A 2.0A	20.6A 20.6A	5.4A 2.7A
HP 7260A	471 (119)	115 v at 60 Hz 230 v at 50 Hz	103.5–126.5 207–253	1.2A 0.6A	-- --	1.2A 0.6A

PHYSICAL CHARACTERISTICS

PRODUCT MODEL NUMBER	DIMENSIONS (UNCRATED)						UNCRATED WEIGHT (NET)	
	HEIGHT		WIDTH		DEPTH			
	IN.	CM	IN.	CM	IN.	CM	LB	KG
HP 2563A	11.0	27.4	24.0	60.0	18.0	45.0	75	34
HP 2608A	38.5	97.4	26.0	65.8	22.0	55.6	215	97
HP 2608S	40.0	102.0	27.0	69.0	22.0	56.0	215	97
HP 2611A	42.75	108.6	36.5	92.7	26.0	66.0	528	240
HP 2613A	45.0	113.3	33.0	83.8	22.0	55.9	340	115
HP 2617A	45.0	113.3	33.0	83.8	26.0	66.0	390	168
HP 2619A	41.0	104.1	36.75	93.4	26.0	66.0	570	259
HP 2621A	18.0	45.7	14.5	36.8	23.0	58.4	35.5	16
HP 2621P	18.0	45.7	14.5	38.0	23.0	58.4	39.5	18
HP 2622A	17.3	44.0	15.0	38.0	26.2	66.5	37	17
HP 2622P	17.3	44.0	15.0	38.0	26.2	66.5	42	19
HP 2624A	17.3	44.0	15.0	38.0	26.2	66.5	37	17
HP 2624P	17.3	44.0	15.0	38.0	26.2	66.5	42	19
HP 2626A	17.3	44.0	15.0	38.0	26.2	66.5	37	17
HP 2626P	17.3	44.0	15.0	38.0	26.2	66.5	42	19
HP 2631B	36.75	93.4	25.0	63.5	18.5	47.0	51	24
HP 2635A/B	36.75	93.4	25.0	63.5	18.5	47.0	56	26
HP 2640B	13.5	34.3	17.5	44.5	25.5	64.8	44	20
HP 2641A	13.5	34.3	17.5	44.5	25.5	64.8	44	20
HP 2644A	13.5	34.3	17.5	44.5	25.5	64.8	50	23
HP 2645A	13.5	34.3	17.5	44.5	25.5	64.8	50	23
HP 2647A/F	13.5	34.3	17.5	44.5	25.5	64.8	50	23
HP 2648A	13.5	34.3	17.5	44.5	25.5	64.8	50	23
HP 2649E	13.5	34.3	17.5	44.5	25.5	64.8	50	23
HP 2680A	48.0	122.0	64.0	162.6	27.0	68.6	875	375
HP 2687A	11.0	28.0	26.0	66.0	20.0	50.0	150	68

PHYSICAL CHARACTERISTICS (CONT.)

PRODUCT MODEL NUMBER	DIMENSIONS (UNCRATED)						UNCRATED WEIGHT (NET)	
	HEIGHT		WIDTH		DEPTH			
	IN.	CM	IN.	CM	IN.	CM	LB	KG
HP 2688A	40.0	102.0	37.0	94.0	28.0	71.0	254	115.4
HP 2748B	7.0	17.8	17.0	43.2	16.0	40.6	42	19
HP 2893A	15.5	39.0	23.0	58.4	18.0	45.7	75	34
HP 2894A	40.0	102.0	42.0	107.0	27.0	69.0	260	118
HP 2895B	10.5	26.7	16.75	42.5	21.2	53.8	35	16
HP 7260A	--	--	--	--	--	--	54	25
HP 7906S	28.25	71.7	21.78	55.3	31.12	71.1	290	132
HP 7906M	28.25	71.7	21.78	55.3	31.12	71.1	326	148
HP 7911P 12P/14P	28.4	72.0	14.0	35.4	29.1	74.0	188	85
HP 7920S	32.5	82.5	21.5	54.6	31.0	78.7	299	135
HP 7920M	32.5	82.5	21.5	54.6	31.0	78.7	336	152
HP 7925S	32.5	82.5	21.5	54.6	31.0	78.7	304	138
HP 7925M	32.5	82.5	21.5	54.6	31.0	78.7	334	155
HP 7933H/ 35H	32.5	82.5	21.7	55.2	32.8	83.4	340	154
HP 7970E	47.5	118.9	27.0	68.6	31.0	78.5	--	--
HP 7974A	63.0	160.0	23.6	60.0	30.5	77.5	400	180
HP 7976A	62.38	158.5	24.5	62.3	35.63	90.5	560	254
HP 9895A	7.6	19.3	19.0	48.3	22.6	57.4	59	26.8

SYSTEM CABLES

APPENDIX B

Appendix B contains a list of system cabling. It should be used to plan how far apart various devices can be placed.

Most cables have a specified flammability rating. Determine where the cables will be installed (outdoors, in air plenums, cable troughs, raceways, etc.) and whether the cables are approved for use in those areas.

Some areas require that plastic-coated cables be in metal raceways. Check with your local electrical inspection officers.

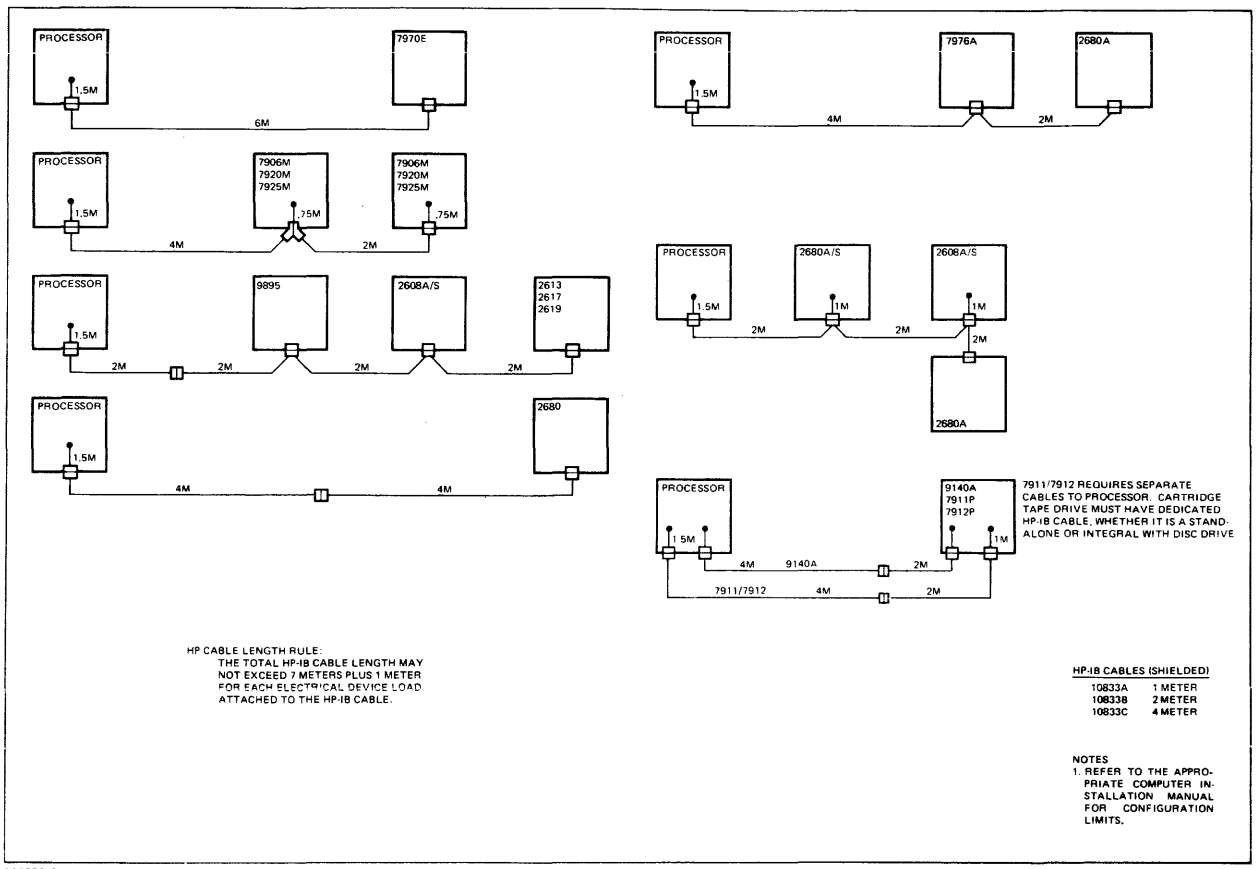
Care must be taken where data cables interconnect. Improper or noisy conductors, motors, fluorescent lights, etc., can cause radiated or magnetic coupling on the data lines. If that occurs, data can be lost or corrupted.

SIGNAL CABLES

MODEL NUMBER	EQUIPMENT	STANDARD LENGTH		MAXIMUM LENGTH	
		FEET	METERS	FEET	METERS
HP 2621P	PRINTING TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2631B	LINE PRINTER	*	*	500	152.4
HP 2635B	PRINTING TERMINAL	12.5	3.8	100	30.4
HP 2621A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2640A/B	CRT TERMINAL	5/15	1.5/4.5	100	30.4
HP 2641A	CRT TERMINAL	5/15	1.5/4.5	100	30.4
HP 2644A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2645A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2647A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2648A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4
HP 2649A	CRT TERMINAL	5/15/50	1.5/4.5/15.2	100	30.4

*See HP-IB cabling schemes for cable lengths.

TYPICAL HP-IB CABLING SCHEMES



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