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Interim Design Guidelines for Automated Offices

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Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Gaithersburg, Maryland 20899

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General Services Administration
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ABSTRACT

This report presents interim guidelines for design of offices using automated technologies. It is based upon findings obtained by an extensive literature search, a questionnaire survey of design firms, an office automation roundtable, and interviews with design and other office automation professionals. The guidelines should be considered tentative, since the information is based primarily on judgment, rather than on formal investigations or on broad consensus from the design community. Furthermore, many important design issues have not been dealt with, because they have not yet been appropriately considered, and/or it is unclear what the design implications of automation are - e.g. will overall space needs be greater or less? The introduction of automated systems into offices has changed the office setting as a place to work. Architects and other design professionals have responded to this technology by formulating a variety of design strategies. This report identifies design issues which merit consideration in automated offices, tentative criteria for environments and systems based on an overview of all resources used to develop this document, and typical approaches used accomplish design goals. Technological, ergonomic and organizational factors are considered from the standpoint of design implications.

Key words: acoustics; design criteria; electrical systems; ergonomics; lighting; noise; office automation; office design criteria; office furnishings; safety systems; workstation.

PREFACE

This report is the third of a series of documents prepared by NBS as part of a Memorandum of Understanding and Agreement between the National Bureau of Standards and the General Services Administration, Public Building Service, No. PBS-80-1, dated January 16, 1981. It was developed for a research project to determine the impact of office automation technologies on interior environments. The earlier reports are as follows:

1. The Automated Office - An Environment for Productive Work, or an Information Factor?: A Report on the State-of-the-Art, NBSIR 83-2784-1, November 1983.

2. The Automated Office - An Environment for Productive Work, or an Information Factor?: Executive Summary, NBSIR 83-2784-2, December 1983.

This interim guideline is intended to assist in developing functional, aesthetically pleasing, economical and humane environments for federal office buildings which house automated information technologies. It is meant to serve as an informational resource for personnel charged with the control, administration and maintenance of office environments with varying degrees of automation. The document is a compilation and evaluation of design practices, approaches, tentative criteria, and factors to be considered in the development of designs that are intended to serve individual and organizational needs. The information available on this topic is quite limited and should not be considered definitive since few formal studies have dealt with this subject area, and limited consensus exists among architects regarding appropriate practices. The report is intended to be updated as better information is obtained.

In developing the present publication, a number of basic assumptions were made. They provide the overall context for the following:

- Office automation is a continuing process, not a discrete event.
- The office environment will consist of electronic and paper-based tasks for the indefinitive future.
- Office work will continue to be performed in spaces and buildings designed for this purpose.
- The "typical office" is as meaningless a concept as the "average" worker, and the "prototype" organization.
- Energy conservation will be of continuing importance.
- Consideration of long-term costs are more important than first costs.
- Office design influences worker productivity; high quality environments are essential for automated offices.
- Better information is needed to formulate performance criteria for automated offices.

This report contains a variety of checklists and other information in summarized form for ready reference. Following is a listing of this material and their location in this report.

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1. INTRODUCTION

Office design has a major role to play in the work performance of the individual, and thereby in the functioning of an organization as a whole. While the physical setting of an office provides the direct support for conducting activities in a space, the environment also serves a catalytic function in that it can promote or inhibit discussions, meetings, and formal or informal interactions among people. Space characteristics, lighting, temperature levels, indoor air quality and other design features can have positive or negative influences on task performance and/or satisfaction of the worker (1).

Questionnaire surveys consistently have shown the work environment to be an important contributor to the satisfaction and morale of the office worker, thereby influencing productivity. The automation of office functions has further increased its significance for several reasons. The characteristics of the office workforce are rapidly changing, as is the nature of the jobs being performed. Technology has influenced the way that organizations are structured, and how decisions are made.

The fastest growing segment of the office population, and the key to increased productivity are knowledge workers- (profesionals and managers) who differ in many respects from their clerical counterparts. Knowledge workers are highly educated, have experienced high quality work environments and expect such settings. They also do not hesitate to express dissatisfaction with environmental distractions and intrusions on their privacy. Since their skills are readily tranferable from one organization to another, they are a highly mobile group. Under these circumstances, the work setting is important in recruiting and retaining qualified people, because other aspects of their jobs are often comparable in terms of salary and other features (2).

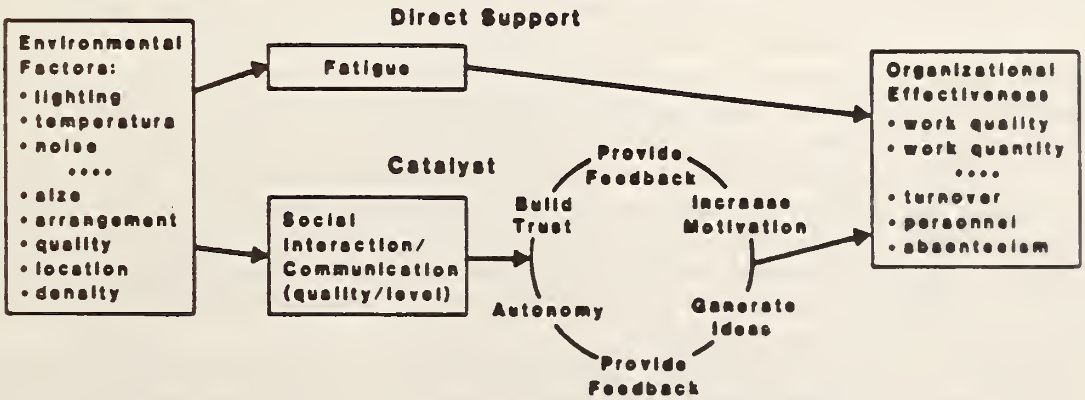


Figure 1. Environment as support and catalyst

The work performed by knowledge workers using automated equipment is mentally demanding and requires freedom from distractions such as glare, noise, and the activities of their colleagues. The tasks are often intrinsically difficult, as in the case of planning and problem solving. Personal interactions, which characterize many management functions, require auditory and visual privacy. The process required to perform VDT-based activities imposes a further burden on employees with limited training and/or skills in using keyboard devices or the specialized programming languages required to communicate with office automation devices such as microprocessors. Employees, often working at VDT terminals for eight hours a day, are quite sensitized to their surrounds, and require a respite from high technology, and an opportunity for social contact in pleasant settings.

Management style is an important determinant of the overall appearance and layout of the traditional office and particularly the automated one. Decisions concerning the balance between design uniformity and diversity, within an organization as a whole, among working groups, for the management hierarchy, and for individuals, all reflect the organizational culture. A centralized management approach is characterized by considerable uniformity and little room for personal expression by the individual. Decentralization provides the opportunities for working units and individuals to participate in the design of their environments, and encourage differentiation among groups and individuals. In this way, a sense of group cohesiveness can be expressed, as well as a means of countering the institutionalization of the office. In many instances, tradeoffs must be made between uniformity and the possibility of expressing diversity.

1.1 BACKGROUND

1.1.1 General

Productivity in the office has been virtually stagnant for almost a decade, at a time when white collar work has begun to dominate our economy. For example, by 1983, 53 percent of the workforce was engaged in information development and processing activities. The trend toward more office-based activities, the productivity figures, the information explosion, technological advances accompanied by decreased costs, have all combined to create an intense demand to automate office functions. As a result, millions of new devices and systems are now in offices, and countless others are being introduced daily at an ever increasing rate. Yet the experience with office automation has been mixed. While technology is seen by some observers as <u>the</u> answer to office productivity problems, considerable evidence exists that many office workers are less than satisfied with the quality of the environment in the automated office (3).

All too often, office automation has resulted from the piecemeal acquisition of new devices and systems which have been placed on available desks and other work surfaces in an environment designed to accommodate the processing of information in paper form. Systematic design planning has been a rarity. This process has resulted in a considerable number of complaints by workers about the unsuitability of their offices for performing VDT-based work. Noise and glare produced by inappropriate lighting systems, lead the list of expressed concerns, with the design of workstations and furnishings also receiving considerable attention. (Table 1 indicates major concerns expressed in a questionnaire survey (4)).

The increased popularity of open-office designs has contributed to the problems of office automation because many devices such as printers, produce considerable noise, thereby disturbing many people in the vicinity of the noise source. The fact that automation typically occurs incrementally in small steps, contributes to the design challenge. Changes are so gradual that there is little anticipation of the final result, and its environmental consequences. For example, the addition of a limited number of electronic devices add to the heat load of the building, but existing HVAC systems can usually cope with only minor increases in heat. However, at some point the presence of a large number of such systems seriously degrades the quality of the thermal environment, and may require a major HVAC retrofit for the work setting to be acceptable by users.

The first automated systems introduced into offices were word processors, designed to increase the efficiency of typing by converting information into an electronically accessible form; this forms the basis for all of the other systems. The results from the word processing experience pointed out both advantages and disadvantages of this approach. While there was some evidence of increased typing productivity, this was accompanied by a variety of complaints, which portended many of those later expressed about the automated office. Word processing activities were organized into a "pool" of workers performing a centralized function. A given typist had little or no contact with the author of the copy being worked on, and limited opportunity to carry through many jobs from beginning to end. This process, derived from the factory assembly-line system where work was analyzed, standardized, and simplified as a means of reducing the unit cost of products, resulted in complaints which echoed those of the production-line worker. Workers felt that they were being subordinated to machines and had little control over their jobs and little opportunity to interact cooperatively with colleagues. Finally, working eight hours a day at a VDT has been a source of concern because of the attention demands of such activities on workers (6).

If the assembly-line system for information processing is inappropriate for performing clerical functions such as word processing, it is even less applicable for automating the activities of knowledge workers. Their tasks are not readily amenable to analytic and standardized treatment, but instead are characterized by dealing with problems of ever-increasing complexity and a proliferation of information which must be assimilated and acted upon. Their work depends on using highly individualized knowledge and experience, limited and uncertain data in a rather unstructured informational environment. A manager, for example, is given a set of broad responsibilities and considerable freedom to formulate the means of carrying them out. The degree of autonomy associated with this work is one of its principal attractions, and plays a major role in the satisfaction derived in pursuing these careers. To the extent that they are required to adapt to work methods, technologies and environmental conditions selected by others, they are likely to be less productive, and less satisfied with the quality of their working life (7).

Table 1. Summary of Findings of Questionnaire Survey (5)

Issue	Bottom-Line Measures			
	Environment Satisfaction	Job Satisfaction	Job Performance (Self)	Job Performance (Supervisor)
FURNITURE				
Layout	X			
Comfort	X	X		
Furniture Quality	X		X	
AMBIENT CONDITIONS				
Temperature/Air Quality				
Lighting	X			
Noise		X		
PRIVACY				
Control Over Access	X			X
Intrusions/Distractions	X			
Speech Privacy	X			
Visual Access			X	
COMMUNICATIONS				
Ease of Communication	X	X		
Support for Communication	X			
FLEXIBILITY	X	X		

1.1.2 Technology and Design

Developments in telecommunications, computers, and office automation systems are changing the face of the office, and the manner in which office functions are performed. Information, which traditionally was developed, processed and stored in paper form, now is being processed electronically, while microfiche, magnetic and paper-based systems are all being employed as storage media. New systems are available to conduct activities in ways that were not possible before. For example, the advent of teleconferencing has provided an alternative to face-to-face meetings among geographically dispersed people in the same organization, or among different ones.

The informational resources available to the individual at a workstation are equivalent to those possessed only by large organizations not many years ago. This has made the workstation the focal point of the office, and the modular design unit, requiring considerable attention by designers. The linking of these workstations into networks is receiving considerable attention today. This approach enables individuals to share information and major hardware systems, such as high quality printers.

Since office and communications technologies are changing at such a rapid rate, it is virtually impossible to predict how they will evolve in the future. As a result, a major design challenge is to provide sufficient flexibility for changes to be made, at a minimum cost and limited disruption or ongoing activities. Among the systems meriting attention are:

- Network connections to all required systems and services.
- "Clean" vs. utility power.
- Power and localized cooling to accommodate heat loads from electrical equipment.
- Mechanical, electrical distribution, lighting, and communications systems.
- Workstation design - to accommodate a range of tasks, and individuals.
- Standardization of components for workstations - work surfaces, task lighting, panels, furniture.
- Changes in space use.
- Air supply and return.
- Floor plenum system for air and electrical distribution
- Storage of informational media - paper, disks.

At the macro level of design, available systems can be automated and pre-wired into new buildings to accommodate operational, service, energy conservation, fire safety, communication, and other systems. However, just because the technology exists to automate functions doesn't mean that this is the most effective approach, from the standpoints of the organization or the individual. Automation is typically based upon uniform requirements, while individuals and activities often differ from one another in important ways, and thereby have distinctive needs.

The design approach to the automated office today is directed toward meeting the needs of the average office worker performing typical tasks in a characteristic organization. This depiction of the automated office is both widespread and meaningless. There is no such thing as a typical:

- Person
- Organization
- Task
- Office
- Office Automation System
- Workstation
- Office Procedure(s)

Organizations and individuals have unique characteristics which merit attention in design, and it is the function of the design process to develop the information required to respond to the particular of requirements of both of them.

1.1.3 Organizations and Design

Architects have an important contribution to make in furthering organizational and group cohesiveness. Microcomputer-based workstations have enabled many jobs to be performed autonomously, thereby isolating the individual from a working group and from the organization as a whole. Design elements such as furnishings and panels can serve to distinguish one group from another one, and the layout of workstation groupings can be integrated to further organizational functions. Common spaces can provide the opportunity for members of diverse groups to exchange ideas, thereby furthering the sense of organizational identity. Above all, there is a need to provide a high quality environment for the staff.

Table 2 suggests several features which might contribute to "high quality" design.

- Humane and pleasant setting to offset technological emphasis.
- Places for visual relief, inside and outside.
- Spaces arranged to make locations and circulation patterns comprehensible.
- Places for casual interchange of ideas and unplanned social contact.
- Centers of interest to serve as guideposts and informal meeting places, e.g. works of art, planters.
- Quiet, restful areas, with expanded recreational and physical exercise spaces.
- Workstations grouped in functional clusters.
- Personalization and individual control of workspace furnishings and environmental systems.
- Attractively designed public areas.
- Privacy - visual and auditory.

Table 2. Checklist - Design Considerations for 'High Quality' Offices (Criteria)

Organizational issues are closely linked to technological, ergonomic, and design factors. Technological changes in office systems have been too rapid for them to be properly assimilated into most organizations. This has resulted in a gap between what is technically feasible, and what is needed to further organizational objectives.

1.1.4 Ergonomics and Design

Automated technology is neutral with respect to its influences on the quality of the workplace. It can be used as a means of standardizing and controlling job characteristics and environmental features, thereby minimizing the autonomy of the individual worker and the freedom to make on-the-job decisions. Many of the problems with the early automation word processing have been attributed to this approach. On the other hand, automation offers the potential for the individual worker to exercise considerable control over job functions and environmental systems, thereby enhancing the quality and quantity of work performed.

Individual control can take many forms:

- Environment - lighting, heating
- Information
- Work Procedures
- Task Decisions
- Workspace
- Social Settings
- Furniture - selection, modification
- Personalization of Space
- Planning of Individual Work

1.1.5 Planning

Productivity in offices results from the appropriate integration of people, tools, and places. This integration should be accomplished by proper planning, including organizational representatives from human resources, technology, information processing, and design - who often find themselves in competition with one another in productivity improvement programs. The planning should be under the direction of top management and include extensive involvement by end-users at all stages of the process (8). The automation of office functions is a continuous process, not a discrete event, and must be directed to organizational effectiveness and not the introduction of new technologies because of their advertised effectiveness. An essential element in such planning is the preparation and training of the staff to ensure that automation is viewed as a tool to assist work activities, not a threat to jobs, or a means to subjugate people to technology. It is self-evident that the greatest single determinant of office productivity is the performance of the workforce, and technology as well as design should contribute positively to the office work setting (9).

2. PLANNING AND PROGRAMMING THE AUTOMATED OFFICE

2.1 FUNCTION

To promote the orderly transition of office work from primarily paper-based activities to electronic systems while maintaining (or improving) the overall quality of the workplace. This goal can be accomplished by acquiring detailed information concerning organizational, individual and technological requirements and then devising appropriate design solutions. The planning should be accomplished by the close cooperation of a multi-desciplinary design team with the client (10).

Designers and office automation experts are in general agreement that detailed planning is an essential prerequisite for the automation of office activities. The piecemeal acquisition equipment has resulted in many complaints by office workers in the past, because of such factors as the inappropriateness of furniture and environmental systems (e.g. lighting) for performing VDT-based activities (11).

2.2 CRITERIA

- Planning should be under the auspices and commitment of top management.
- End-users should be an important source of information.
- Flexibility should be a major consideration.
- The integration of information and communication systems is important.
- The analysis of present and proposed office activities as they meet organizational objectives should precede any decision about automated equipment and systems.
- Long-term costs should be considered - especially those associated with the salaries of workers.

2.3 INFORMATION DEVELOPMENT

Following (tables 3 and 4) are two methods which can be used to develop planning information:

Table 3. Analytic Approach for Relating Technology Issues to Design (Rubin and Murray (12))

	PRESENT OFFICE	AUTOMATED OFFICE	POSSIBLE DESIGN IMPACT
INFORMATION/MANAGEMENT SYSTEMS			
Record Storage & Management	Paper files	Limited paper, Electronic files	- Less space for file cabinets, changed layout - Added electronics, added cooling load
Internal mail generation & Distribution	Paper	Electronic	- Smaller mail room, more electronics
Document distribution	Typed copy	Optical Character Recognition devices (Hard copy readied for electronic distribution)	- Need for physical separation of system (Noisy), special acoustic design
Document preparation	Separated functions; Manual typing, artwork, graphics	Centralized and electronic	- Large work station for preparing documents, less space needs for visual arts
Organization of activities	Specialized and decentralized	Work stations - clerical, managerial, professional	- Change in adjacency locations - e.g., management-secretarial - More electronics and capability to access information from various sources (wiring, cooling)
Expansion of capabilities	Space set aside	More power, wiring to accomodate future needs	- Added capacity for electronics power; plan for "local" cooling
Planning activities for organizational needs	Minimal necessary	Detailed planning of systems essential, building, mgmt, communication, info.	- Much greater need for detailed architectural programming activity
POWER SYSTEMS			
Emergency Power	None	Batteries, Generator - Support for electrical equipment during outage	- Additional space, special venting systems, fuel storage, special flooring for acid, fuel runoff; fire protection, security
Wire Distribution Techniques	Conduits Under floor systems In-wall outlets	Flat wire cables under carpet Raised floors	- New floor systems - carpets - Increased size of floor/ceiling systems - Changed power loading factors-less load per local circuit, more runs - Changed needs for wire closet space - Special protection for cables
OFFICE TECHNOLOGY BASED ACTIVITIES			
Typing	Electronic typewriter	WP system	Glare free lighting, additional workspace
Communication-individual	Telephone, mail, memos	Electronic mail	CRT terminal, wiring
Filing	Paper files, individual	Centralized data base	Specialized computer facility - raised floor, clean, emergency power, less paper storage space
Facsimile production	Hands-on duplicating	Duplication at a distance - FAX machine	Specialized facility to accomodate a variety of devices, acoustic treatment, cooling
Reading	Paper copy	CRT's, microfiche	Special lighting, additional desktop area for more equipment

Table 4. Checklist for Office Automation Design (13)

	Yes	Not applicable	Not Aware	No
1. Are private offices available for personnel who conduct professional or supervisory counceling or confidential discussions on a regular basis?	☐	☐	☐	☐
2. Have conference spaces been provided for those times when employees need to work together?	☐	☐	☐	☐
3. In circumstances where several employees share equipment, are those employees co-located?	☐	☐	☐	☐
4. Are the employees separated from noisy equipment such as CPUs, copiers, etc?	☐	☐	☐	☐
5. Have office locations been chosen with regard to expected interactions?	☐	☐	☐	☐
6. Are partitions used to screen traffic?	☐	☐	☐	☐
7. Are all commonly used facilities centrally located?	☐	☐	☐	☐
8. Are frequently interacting functions located on the same floor?	☐	☐	☐	☐
9. Are the pathways to and from offices straight? (That is, are confusing spirals, curves, or dead-ends avoided)?	☐	☐	☐	☐
10. Where an open office concept has been used, is some amount of pathway continuity present?	☐	☐	☐	☐
11. Are the dimensions of all private offices at least 7.5 x 7.5 ft (2.3 m x 2.3 m)?	☐	☐	☐	☐
12. Are the private offices designated so no one faces a window while working?	☐	☐	☐	☐
13. Does each private office have a good source of illumination?	☐	☐	☐	☐
14. Does each office have independent control of its ventilating system?	☐	☐	☐	☐
15. Is there adequate space at the workstation for the equipment and data (printouts, microfiche, manuals, etc.) that the user needs?	☐	☐	☐	☐
16. Is the work area adjustable so that it can accommodate comfortably the 5th to the 95th percentile of the adult population?	☐	☐	☐	☐
17. If the CRTs, the microfiche readers, etc., are not at the immediate workstation, are they as close as possible to that station?	☐	☐	☐	☐
18. Is the workstation adjustable so that the home typing keys are 2 inches (55 mm) below the elbow height?	☐	☐	☐	☐
19. Are all employees trained to adjust their furniture, or is adjustment provided as requested?	☐	☐	☐	☐
20. Are office noise levels below 45 dB(A), 37 dB PSIL-4, or 38 dB PSIL?	☐	☐	☐	☐

2.4 PLANNING APPROACHES - PROGRAMMING

The information developed during the planning phase will serve as the basis of the architectural program. Following (table 5 and figures 2, 3 and 4) are approaches that have been used to develop and organize programming activities, including post occupancy evaluation (POE).

Essential Programming Information (14)

- Objectives and Philosophy. A clear statement of goals is the first step. These are based on the history and background of the organization and its attitudes and expectations towards its client and staff.

- Functional Relationships. An analysis of the interactions and transactions of individuals and organizational units is needed to understand traffic flow, communication, information flow and access. It is also necessary to determine the appropriate placement of support services such as word processing, mail reproduction, data storage and communication, etc., with relation to the location of administrative and organizational units. The proper location of conference and meeting rooms, libraries, internal waiting areas, lunchrooms, lounges, all merit particular attention.

- Facility Spatial Requirements. Spatial needs for individual and organizational units are based upon a complex of interfacing factors such as ergonomics, communication requirements, status, and needs for privacy.

- Development of the Program and Program Criteria. The program should be written in performance language, describing the functional requirements of a system for example, not the hardware specifications.

- Post Occupancy Evaluation. To prepare for future evaluations, a log of projects should be kept and preserved, including all plans, the program, decisions and changes made. Evaluation should be made on the basis of general staff satisfaction, staff use of space and facilities, environmental and communications systems, task performance, and the value and use of staff amenities.

Table 5. Introduction of automation into offices - critical factors:

1. Collect your facts, so that your method of installing equipment can be supported with numbers.

2. Start early to announce and explain the new systems, answer questions, share your plans, and generate enthusiasm.

3. Share information with both the management staff and the support staff-preferably, the same information.

4. Take it slowly. Allow time to pilot-test a few systems. Allow time for people to get used to the new idea. Again, communicate test results as they come in. The slow, careful approach always works best.

5. Notice whether, and what "grapevine" information is leaking out, and try to make the informal network positive and working <u>for</u> you.

6. Collect information as systems are installed, to assess effectiveness and pinpoint problem areas. Share the results with all involved.

7. Admit and face up to problems; find solutions to them immediately (call in experts if needed) so that the spirit and support are maintained.

8. Think of ways to generate enthusiasm and motivate the user groups, from the inception of the plan through to the refresher training and the documentation of the system procedures. Involve managers and support staff together.

9. Know when to turn each operation over to its manager (with documented procedures and with available assistance when needed).

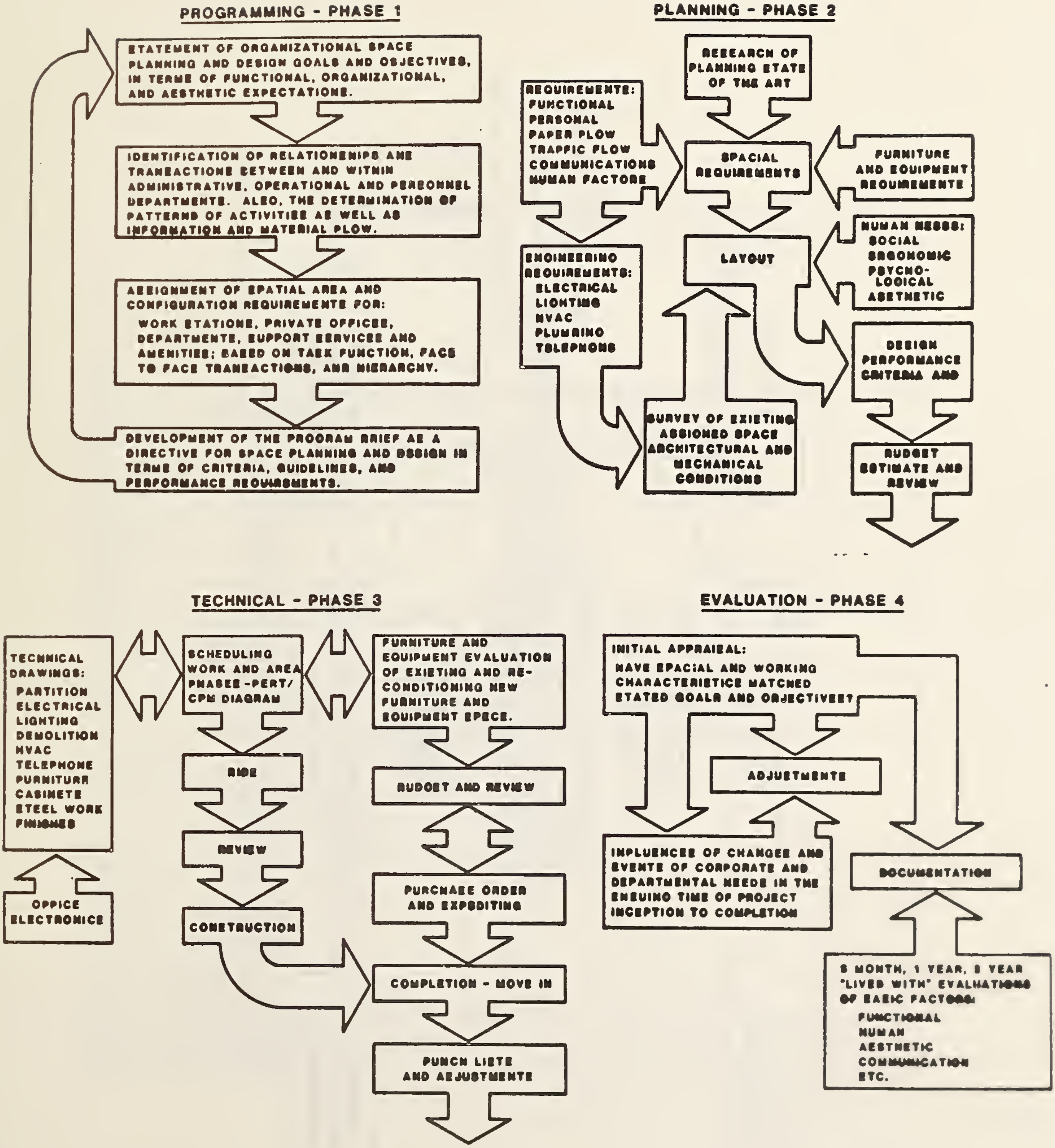


Figure 2. Office design process (14)

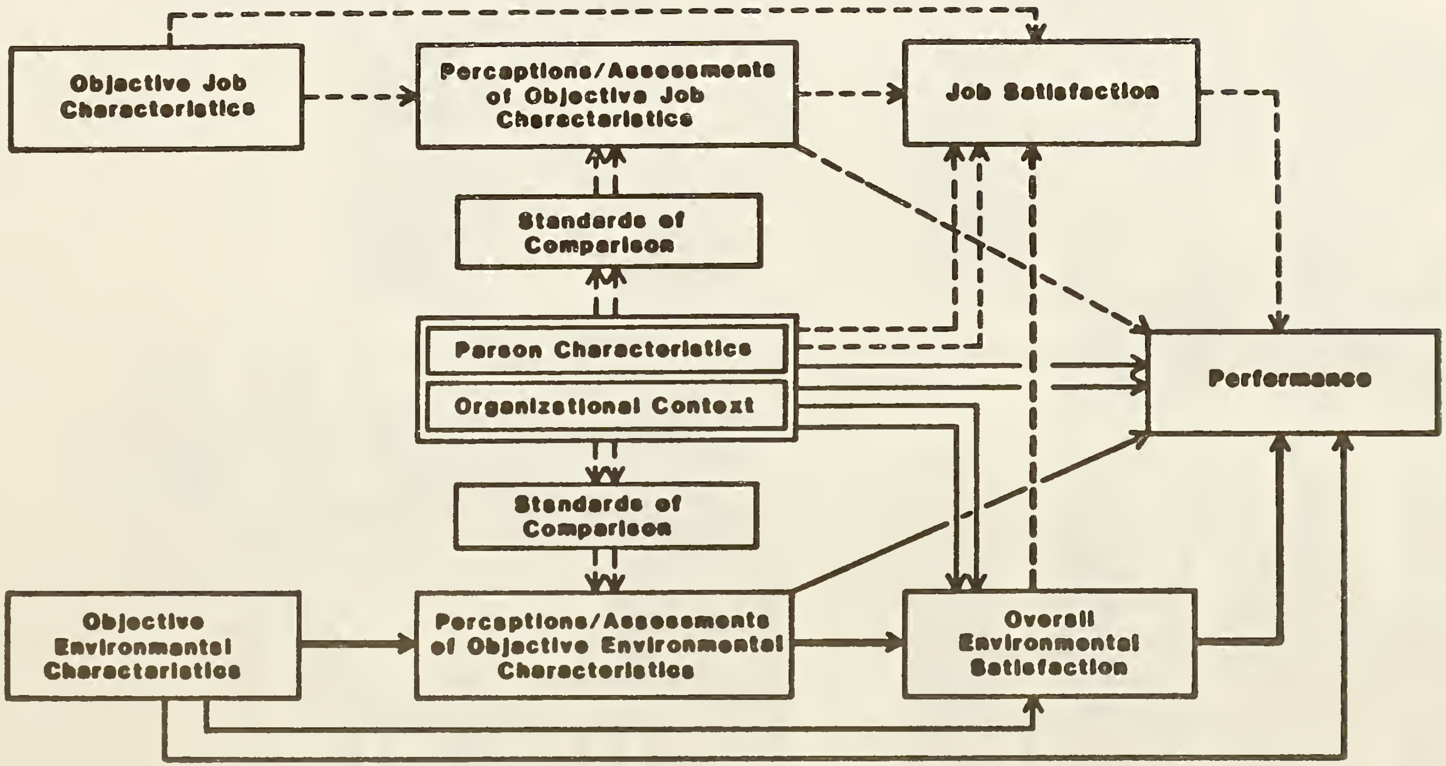


Figure 3. Conceptual model for evaluating work environments (15)

	OCCUPANT REQUIREMENT					FACILITY RATING					COMMENTS
	IMPORTANT				UNIMPORTANT	SATISFACTORY				UNSATISFACTORY	
PRIVACY - Auditory and Visual											
SOCIABILITY - Accomodate Conversations											
FORMALITY - Restricted Activities											
CHOICE - Control of Environment											
COMFORT - Appropriate Environmental Features											
IMAGERY - Space Depicts Purpose											
EFFICIENCY - Easy to Arrange Workspace											
ACTIVITY - Selection of Furnishings, Colors											
FLEXIBILITY - Ability to Modify											
TASK PERFORMANCE - Space Accomodates Job											
TERRITORIALITY - Personalization											
LACK OF CROWDING - Not Overoccupied											

Figure 4. Checklist for Facility Evaluation (16)

3. WORKSTATION SYSTEMS

3.1 FUNCTION

The workstation is the basic operating unit of the automated office, where information and communication technologies are merged into a powerful system used by the individual office worker. While initially confined to secretarial and data processing tasks, it is being used increasingly for managerial activities.

The workstation is the place where organizational, design, and personal factors are integrated. Since it is the domain of the individual, it must be designed to meet a variety of requirements which differ from person to person -- physical, sensory, and cognitive. This can be accomplished by providing suitable flexibility for the furnishings and equipment associated with the workstation. For example, the selection and placement of equipment and furnishings requires a consideration of factors such as physical comfort, how the body moves, individual preferences and requirements. As office workers spend more and more time at workstations, it becomes increasingly important for them to have access to the tools and materials needed for their jobs, without causing undue stress or discomfort. The size of components, clearances between them, and allowances for free movement of the body, are all integral to the proper fit of the person to the workstation. Figures 5 and 6 and table 6 are examples of recommended designs and dimensions of workstation components.

3.2 CRITERIA

The workstation should have:

- Sufficient flexibility to accommodate the range of tasks performed and the individuals performing them.

- Sufficient vertical and horizontal surfaces for materials and equipment use and storage.

- Power and communications capabilities consistent with performing required activities.

- Ready access to work materials.

- Layout of workstation to facilitate performing activities.

- Individual controls for equipment and selected environmental features, e.g., task lighting, thermal comfort conditions.

- Capability to personalize workspace.

- Easily reached controls; easily read displays.

- Sufficient space to facilitate movement, e.g., legs should have enough room to move freely.

Table 6. Recommended Workstation Dimensions for VDTs (mm) (74)

Source	Work Surface Height	Work Surface Width	Work Surface Depth	Knee Room Height	Knee Room Width	Knee Room Depth
Canadian CIEM (Gorrell, 1980)						
Groupe de Recherche sur les Ecrans Visuelisation (Rey and Meyer, 1977)						
German DIN Standard 66234 (Deutsche Institute fur Normung e.v, 1982)	650-750; ≤ 720 if fixed	> 1200	900	≥ 660; 690 preferred	≥ 1200	
German Safety Standards (Zenthralstelle dur Unfallverhutung und Arbeitsmedizin, 1980)	680-760; 720 if fixed	≥ 1200; 1600 preferred	50-100 in front of keys	≥ 650; 690 preferred	580	600
Snyder and Maddox (1978)						
Swedish National Board of Occupational Safety and Health (1979)						
Technical University of Berlin (Cakir et al. 1978)	650-750; 720 if fixed		690	690		
University of London (Reading, 1978)						
MIL STD 1472B (U.S. Department of Defense, 1974)[a]	740-790	≥ 760	≥ 640	≥ 640	≥ 510	≥ 460
Video Display Terminals (Cakir et al. 1980)	≤ 720				800	700

[a] See MIL STD 1472C (U.S. Department of Defense, 1981) for additional information.

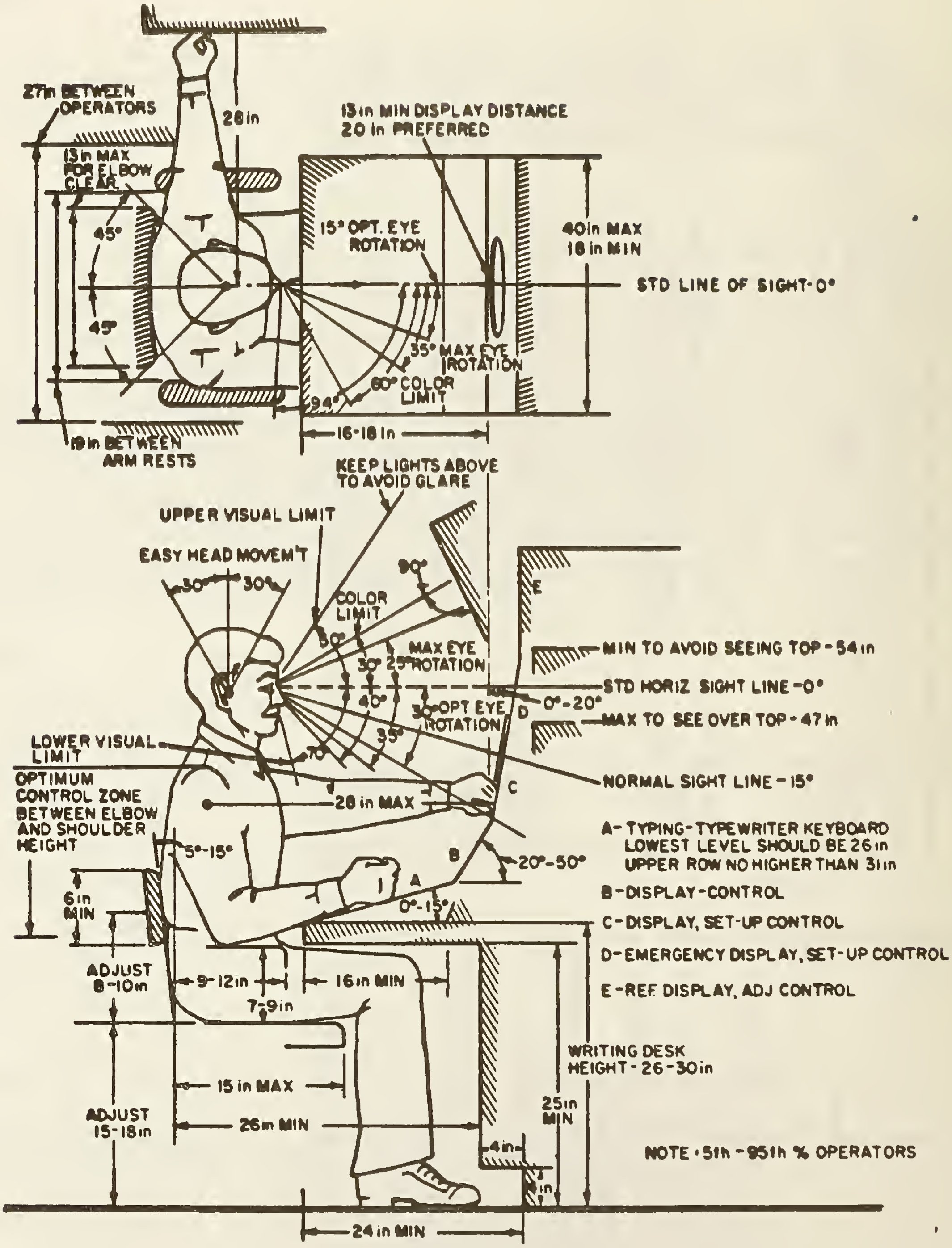


Figure 5. Suggested parameters for mockup of a seated operator console (17)

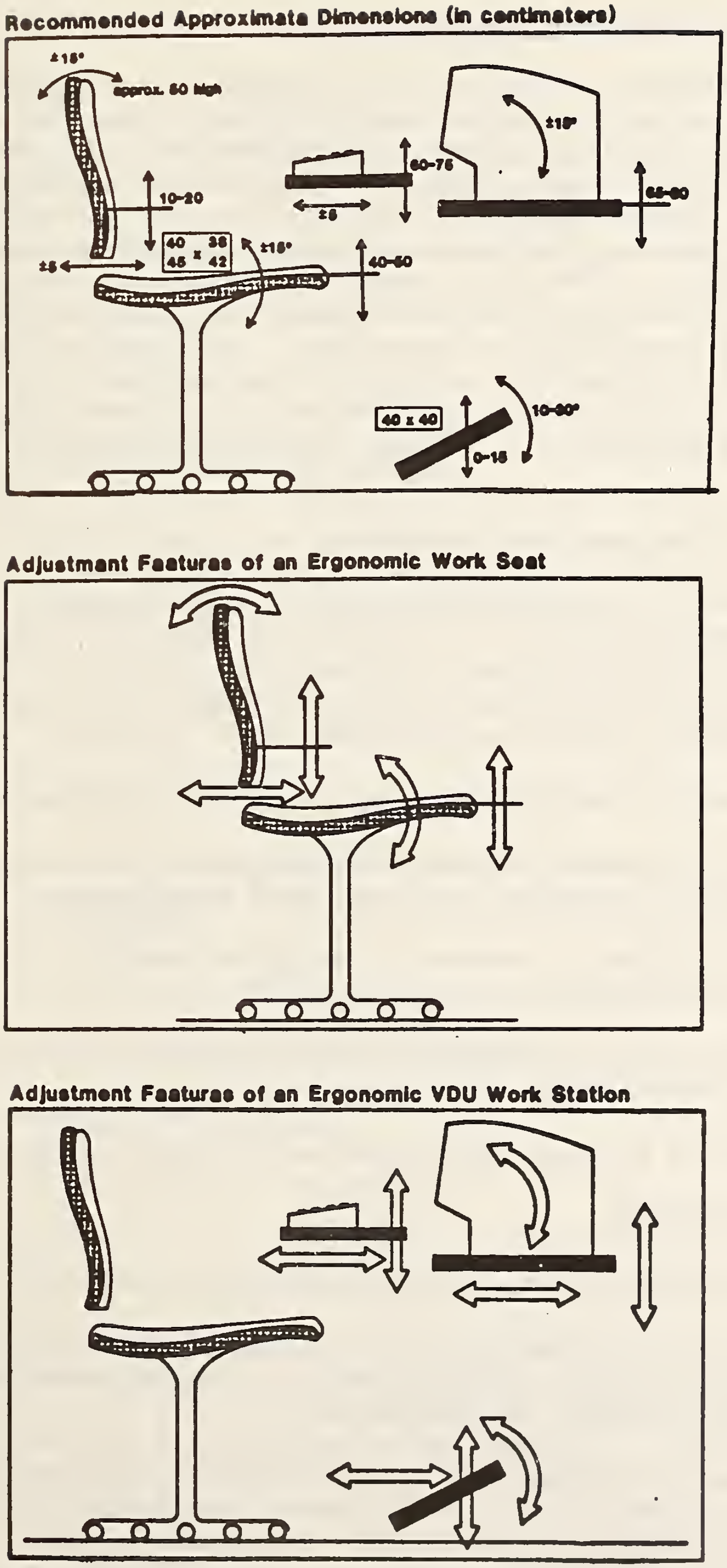


Figure 6. Workstation and seat design (19)

3.3 FURNISHINGS - FLEXIBILITY REQUIREMENTS

The concept of the average person has been discarded by equipment manufacturers and designers. It is now recognized that individuals come in a wide variety of sizes and shapes, and have different preferences for equipment and furnishings. Just as the design emphasis for the office is on the need for flexibility, a similar requirement exists for furniture to be adjustable. The seat, keyboard, display, and foot support are interacting system components in the design of a workstation. The chair should be supported on four legs (or a pedestal with a five caster base) and should have an adjustable seat pan; the backrest height should also be adjustable. The angles of the seat pan and the backrest should be adjustable relative to one another. The backrest should also be adjustable front and back, with respect to the seat pan. The footrest may also need to be adjustable in height, angulation, and front and back distance (18).

3.3.1 Checklist -- Workstation Flexibility

- Changes should be accommodated with minimum disruption to staff or ongoing activities.
- Adjustments should be easy to make; not requiring a high degree of skill or special tools.
- Systems should be simple and made of standardized components.
- Dimensions and heights of work surfaces should be adjustable and/or cover a range of activity and individual requirements.
- New configurations of components should be possible to accommodate changing requirements.
- Furnishings should accommodate individual differences, e.g., left and right handed people.
- Seating should be adjustable; firm back and neck support are important.

3.4 ENVIRONMENTAL CONTEXT

3.4.1 Checklist for Workstations Environment/Design Components

- Can components be adjusted to fit individual differences in physical height, size, and work habits? Can the same products be used in a right and left handed configuration?
- Does the hardware allow adaptability? Can the system be moved, shifted, moved on a carpeted floor, and adjusted readily with minimum expertise and simple tools?
- Can the equipment be used in angular configurations?

- Does the system permit optimum use of vertical space?
- Do acoustical panels perform their intended function?
- Does the product provide a method to control, modify, and conceal electrical and communications systems?
- Can the product serve a range of visual privacy needs?
- What controls does the worker have over the mini-environment?
- Is the product durable, safe, and easy to maintain?
- Is the product a standard one, likely to be available if additional components are needed in the future?
- Do components relate visually to one another and the rest of the system?
- Is a "family" of products available, if variety is to be an important design feature, e.g., different but compatible colors?

3.4.2 Checklist Workstation Environment/Design

- Acoustic privacy.
- Freedom from auditory and visual distractions.
- Glare-free lighting.
- Physical separation of unrelated activities.
- Ease of power and communication changes and additions.
- Nondisruptive traffic patterns.
- Clearly defined personal boundaries.

3.4.3 System Panels

3.4.3.1 Function

The systems panel plays a major role in open-office design. It is used for acoustical and visual privacy, the articulation of the office layout and as a means of facilitating the distribution of wire systems. It is a basic element used in implementing changes in the office environment.

Panel heights vary from 30 inches for clerical workstations, to 80 inches, where acoustical and visual privacy requirements predominate, such as in executive workstations. With lower partition heights, improved commumication is accomplished at the expense of privacy. Higher partitions helps acoustical performance, but might create difficulties for the HVAC and lighting systems.

Panels are constructed with metal or wood frames, with or without exposed or integrated support posts. Connector systems vary widely. The composition of the panel material is fairly standardized. Non-acoustical panels are often made of hardboard or honeycomb cores sandwiched between layers of laminate, wood veneer or metal. Acoustical panels often have a hardboard core with layers of fiberglass or other sound absorbant material on both sides, under a layer of acoustically transparent fabric.

3.4.3.2 Criteria

The following are desirable features of panel systems:

- Acoustical performance consistent with required activities.
- Facilitate wiring distribution.
- Readily disassembled and reconfigured with unskilled labor.
- Sufficiently durable to be reused repeatedly.
- Components standardized to ensure availability of replacement and expansion requirements.
- Appropriate range of sizes, colors, etc. to meet organizational demand for alternative configurations and specific needs, e.g. privacy, groupings of organizational units by "color coding".
- Adequate stability and impact resistance.

3.4.3.3 Checklist for Panel Components

- Can components be adjusted to fit individual differences in physical height, size and work habits? Can the same products be used in a right and left handed configuration?
- Does the hardware allow adaptability? Can the system be moved, shifted, moved on a carpeted floor and adjusted readily with minimum expertise and simple tools?
- Can the equipment be used in angular configurations?
- Does the system permit optimum use of vertical space?
- Do acoustical panels perform their intended function?
- Does the product provide a method to control, modify, and conceal electrical and communications systems?

- Can the product serve a range of visual privacy needs?

- What controls does the worker have over the mini-environment?

- Is the product durable, safe and easy to maintain?

- Is the product a standardized one, likely to be available if additional components are needed in the future?

- Do components relate visually to one another and the rest of the system?

- Is a "family" of products available, if variety is to be an important design feature, e.g. diffferent but compatible colors?

- Are there light and/or sound leaks between connected panels?

- Do the panels have slotted rails along their face edges for hanging storage and worksurface components?

The following table describes minimal federal performance requirements for panels:

ATTRIBUTE	TESTS	MINIMAL FEDERAL PERFORMANCE REQUIREMENTS
FLAMMABILITY		
FLAME SPREAD	ASTM E-84	FLAME SPREAD<25 UNSPRINKLERED FLAME SPREAD<200 SPRINKLERED
SMOKE	NBS 708	SPECIFIC OPTICAL DENSITY<150
POTENTIAL HEAT	BASED ON ASTM PROCEEDINGS VOL. 61 1961, PP 1337-47	<40,000 BTU
ACOUSTICS		
AIRBORNE SOUND	PBS-C1 (SUBJECTIVE)	SPP<60 IN OPEN PLAN AREAS SPP<70 IN ROOMS WITHOUT DOORS
	PBS-C2 (OBJECTIVE TEST)	NIC + (NC<40)<60 IN OPEN PLAN
IMPACT SOUND	FOOTFALL TEST 1B1-1 1-1965	MASK VERTICAL FOOTFALL SOUNDS W/NC<40
STABILITY		
RESIST HORIZONTAL LOAD	ASTM 72-74	RESIST LOAD OF 50 LB SUPPORT 40 LB PER LINEAR FT OF SHELVING
RESIST TIPPING		
RESIST IMPACT	ASTM 72-74	RESIST 30-LB IMPACT HORIZONTAL FORCE OF 100 LB APPLIED 5" ABOVE FLOOR
DURABILITY		
ABRASION	ASTM 72-74	RESIST ABRASION
COLORFASTNESS	FADEOMETER	NO COLOR CHANGE AFTER 50 HOURS AT 150°F
CHEMICAL RESISTANCE	FTM 141 A METHOD 6081	RESIST STAINING AND DAMAGE

SOURCE: Specifications for Commercial Interiors, by S.C. Reznikoff, New York, WHITNEY LIBRARY OF DESIGN, 1979.

Table 16. Panel Requirements - Federal Standards

3.4.3.4 Interactions with Other Systems

3.4.3.4.1 Wiring

The system panel plays a particularly important role with respect to electrical distribution systems in the open-planned office. Three basic approaches are employed in wire distribution:

- The panel with a raceway that accomodates electrical wires and communication cables.

- The panel which can be equipped with an optional manufacturer-supplied power pack, with panel-to-panel connectors, and hooks up to the building's electrical grid.

- The prewired panel, already assembled and plugged into the electrical grid - the most expensive option.

3.4.3.4.2 Simple Raceway

This system is assembled before the panels are; it adds a few inches to the height of the total panel system. Among the specific issues to be considered in using this approach are:

- How accessible are the wires and cables?

- How durable are the base plates and covers that conceal the wires?

- Are there separate channels for electrical and communication wiring?

- Does the panel accept power feeds from the floor and/or ceiling? How accessible are these entries?

- Does the panel have optional convenience outlet strips?

3.4.3.4.3 Power Pack

The availability of power where needed is of major concern for all of the wiring systems. Among the factors to be considered are:

- Can the wiring system be retrofitted to non-electrified panels in the system?

- Are there integrated convenience outlets at work surface heights?

- If the system has integrated ambient lighting, can the lighting circuit be turned off while the task lighting and convenience lighting remain live?

- Does the system have pass-through panels for areas not requiring electrified outlets?

- How many outlets are permitted in each circuit?

3.5 VDT/KEYBOARD SYSTEMS

The primary working tools at the electronic workstation are the VDT and the associated keyboard. The system should be selected on the basis of ease of use and adapatability to individual requirements, e.g., its ergonomic features.

3.5.1 Checklist -- VDT/Keyboard

- The keyboard should be detachable from the VDT for individual convenience and/or preference.
- The VDT screen should be readily adjustable -- the capability to tilt, move vertically, swivel toward or away from the operator.
- The keyboard should enable the operator to keep hands and elbows in comfortable positions.
- Work surfaces should be located at preferred height and distance for the individual for ease of manipulation, support or forearms, palm and wrist, and convenience for seeing the task.

3.6 POSSIBLE PROBLEM AREA -- VDT SCREEN GLARE

A major complaint by VDT operators has been the difficulty in reading material on the screen because of the glare. The lighting and design issues related to this problem are covered in another part of this report (Chap. 5). A study by the National Academy of Sciences (18) suggests another approach to enhance the quality of the visual image on the VDT screen, the use of filters. It describes four systems available for this purpose.

3.6.1 Potential Solution - Filters (18)

- Circular polarizer with antireflective coating. It is used to reduce both specular and diffuse reflections. The outside surface is coated with several layers of optically transparent materials to form an anti-reflective coating to reduce specular reflections from the surface of the filter. The remainder of the filter package is a polarizer to eliminate reflections from the underlying VDT screen.
- Neutral density filter. This is the simplest filter, consisting of a neutrally tinted plastic allowing a small percentage of the light falling on it to be visible. It is effective in reducing diffuse reflection of light from ambient sources.
- Notch or color filter. It allows transmission of a high percentage of lights from certain wavelengths (usually green), and absorption at other wavelengths. It is designed to be "tuned" to the color of the VDT screen, permitting the desired light to penetrate, while absorbing the undesirable ambient light.
- Directional filter. It employs geometrical means to prevent ambient light from reaching the screen, thereby preventing reflections from reaching the user.

4. ACOUSTICS ENVIRONMENTAL SYSTEMS

4.1 FUNCTION

To provide an acoustical environment appropriate for the activities being performed in automated offices.

The auditory needs of workers depend upon the characteristics of the work being performed. For example, many managerial and professional functions have rather stringent acoustical demands and are performed by people accustomed to a quiet workplace. A manager is often required to conduct private conversations with staff members and visitors. Professionals spend considerable time performing and planning creative thinking and report writing activities, which are susceptible to distraction from noise intrusions. On the other hand, many office tasks require using office machines and systems that are inherently noisy, such as copiers and most printers. One design challenge is to physically separate and/or otherwise isolate activities with conflicting acoustical properties.

4.2 BACKGROUND

Survey findings have consistently demonstrated that the acoustical features of the office are extremely important to most employees, especially for those working in open-space design offices. These same studies indicate that major sources of complaints have been the presence of intrusive noises that disrupt ongoing activities, and the lack of acoustical privacy.

The acoustical properties of spaces are influenced by such factors as the thickness and density of enclosing structures, the porosity of wall and floor covers, insulation, drapes and furnishings. Sound is affected by room shape, volume, and the characteristics of the interior surfaces.

4.3 CRITERIA

A proper acoustical environment consists of:

- Adequate acoustical privacy; consistent with the activity performed.
- Freedom from intrusive noise sources.
- Freedom from distracting vibrations.
- Ability to conduct conversations at normal speech levels.
- Isolation of major noise sources from general working environment.
- Special acoustical treatment for sensitive activities/spaces, e.g. conference, audio-visual rooms.

Tables 5 and 6 provide recommendations for acoustical performance of selected office activities.

Table 5. Types of Offices Applicable to Articulation Index Ranges (21)

I	00.00-0.05	Confidential Privacy. Speech cannot be followed with understanding.	a) Closed offices with STC of 40-45. b) Open plan, or office landscape environment.
II	0.05-0.20	Normal Privacy. Speech may be understood with careful listening attention but should not interfere with the ability to concentrate on other work.	a) Closed offices with STC of 35-40. b) Open-plan environmental.
III	0.20-	Marginal Privacy. Provides a relatively quiet office environment when privacy is not of supreme importance.	Open-plan environment
IV	0.35-0.50	Fair communication, no privacy typical, relatively noisy environment. Does not promote maximum productivity.	
V	0.50-	Good to excellent communication, no privacy.	Not normally an office feature. Usually found only in conference rooms and auditoriums.

Table 6. Speech Interference Levels (SIL) and Noise Criteria (NC) Recommended for Rooms (22)

Type of room	Maximum permissible level (measured in vacant rooms) SIL	NC
Secretarial offices, typing	60	50–55
Coliseum for sports only (amplification)	55	50
Small private office	45	30–35
Conference room for 20	35	30
Movie theater	35	30
Conference room for 50	30	20–30
Theaters for drama, 500 seats (no amplification)	30	20–25
Homes, sleeping areas	30	20–25
Assembly halls (no amplification)	30	
Schoolrooms	30	25
Concert halls (no amplification)	25	15–20

Source: SIL data from Beranek and Newman as modified by Peterson and Gross to reflect current practice of using octave bands with centers at 500, 1000, and 2000 Hz; NC data from Beranek.

4.4 OVERVIEW OF BASIC ISSUES

Before discussing design approaches to achieve adequate acoustical performance several basic issues and concepts will be mentioned. Table 7 indicates background sound levels of familiar activities and places.

Apparent Loudness	Examples	Decibels
DEAFENING	Jet aircraft	140
	Threshold of feeling	130
VERY LOUD	Elevated train Thunder	120
	Subway train	110
	Nearby riveter	
	Noisy industrial plant	100
	Office with tab machines Loud street noise	90
	Noisy office Vacuum cleaner	80
LOUD	Average street noise	70
	Average office Congested department store	60
MODERATE	Moderate restaurant clatter Average 2-person conversation	50
	School classroom Private office	40
FAINT	Bedroom	30
	Rustling leaves	20
VERY FAINT	Normal breathing	10
	Threshold of audibility	0

Table 7. Familiar Background Sound Levels

4.4.1 Privacy

Two kinds of privacy have been identified. Normal privacy is a condition where speech from adjacent locations can be understood if one listened intently, but the speech is not loud enough to cause a disturbance. Confidential privacy would preclude the understanding of phrases and/or sentences in adjoining locations.

The preferred method of assessing speech privacy is the Articulation Index (AI). The AI is a measure of the percentage of sentences that can be understood from a person speaking in a normal conversational tone. The index is based upon the signal-tc-noise differences in decibels, weighted in terms of the relative contribution of each one-third octave band, to speech intelligibility. As the speech level drops toward the noise level, the AI value approaches zero; as the speech level arises above the noise, the AI nears 1.0. (See following figure.)

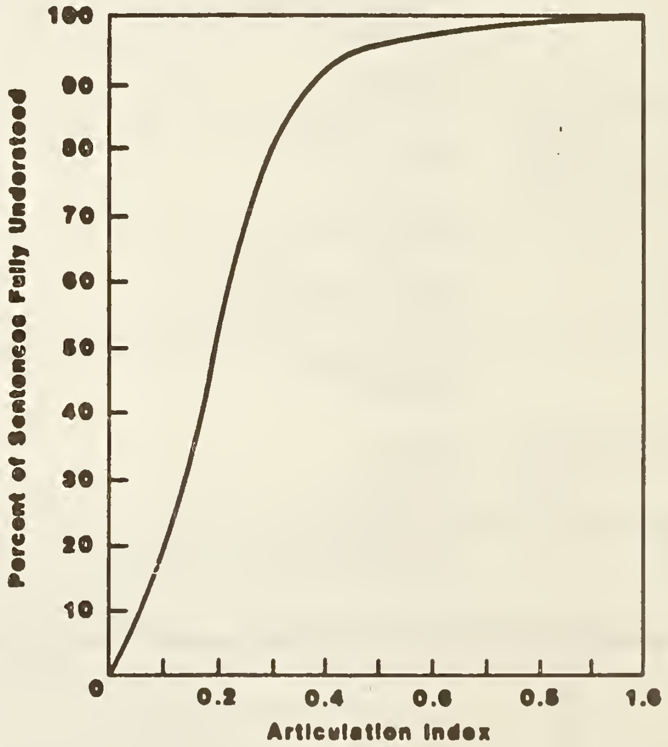


Figure 6. Approximate relation between AI and speech intelligibility (21)

Another means of evaluating environmental noise, is the Speech Interference Level (SIL). These levels constitute the arithmetic average of the sound pressure levels of noise in the three octave bands centered on the frequencies of 500, 1000 and 2000 hertz, and are based upon complaints of office workers in conducting speech communication. Table 8 demonstrates the relationship between sound level and distance in conducting conversations.

4.4.2 Sound

It is a form of energy produced by minute pressure fluctuations in the air, generated by vibrating surfaces and aerodynamic turbulence. Most solid objects have the potential for producing sound, as does the air, when it interacts with structures which change its path, e.g. HVAC ducts. Sound waves are transmitted directly and indirectly. In direct sound, waves are neither deflected by reflective surfaces, nor absorbed by porous ones. The sound pressure levels of direct sound decreases proportionally with increased distance from the sound source. Indirect sound occurs when the sound from the source is reflected from hard surfaces such as walls, ceilings or floors. Furnishings, equipment and room features such as light fixtures, can also create sound reflections.

4.4.3 Sound Transmission

There are two types of sound transmission: airborne and structure-borne. Airborne sound originates and is transmitted directly to the person, e.g. conversation, machine noise. Structure-borne sound is produced when an object impacts against a structural element of a building, e.g. footsteps. The sound energy is transmitted in proportion to the mass and rigidity of the structure. A major acoustical problem in many buildings is the presence of flanking (indirect) paths, which permit sound to travel throughout many areas of a building. Interior elements such as HVAC ducts, continuous walls between floors, uncaulked junctures of ceilings and partitions can all produce such sound paths.

Speech-Interference Levels that Barely Permit Reliable Conversation

Distance between talker and listener (ft)	Speech-Interference level (dB)			
	Normal	Raised	Very Loud	Shouting
0.5	71	77	83	89
1.0	65	71	77	83
2.0	59	65	71	77
3.0	55	61	67	73
4.0	53	59	65	71
5.0	51	57	63	69
6.0	49	55	61	67
12.0	43	49	55	61

Table 8. Conversations and Speech Interference Levels (SIL)

4.4.4 Noise Criteria (NC) Curves

These curves were also developed from "complaint data" obtained in questionnaire surveys. They are intended to specify the maximum noise levels which can be present in an environment without elciting too many complaints, which were considered to be an indicator of the ability to perform assigned work. The survey responses are then correlated with physical acoustical measurements to specify the acoustical properties of spaces required to perform given activities. Figure 8 illustrates the NC curves.

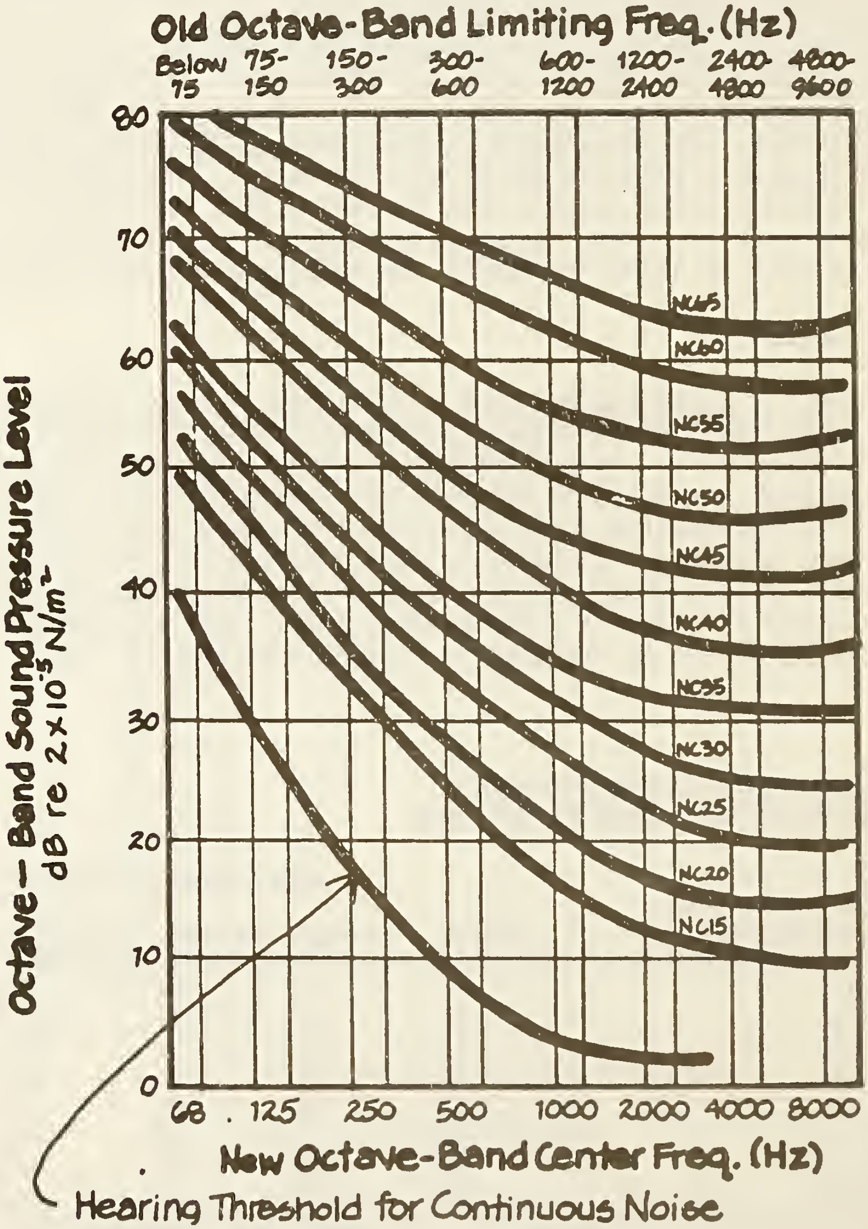


Figure 8. Noise Criteria (NC) Curves

4.5 POSSIBLE PROBLEM AREAS

The solutions being employed to cope with several of the design problems posed by office automation have important implications for acoustical design. For example:

- As a means of providing flexibility in the electrical distribution system, new and expanded utility chases are placed above a lowered ceiling or beneath a raised floor. These chases can provide excellent passages for noise, and flanking paths for conversations meant to be private.

- Supplementary air conditioning units are sometimes placed above lowered ceilings, introducing still another undesirable noise source into the office.

- Elevated lightweight floors provide excellent sound and vibration radiating diaphragms (i.e. sounding boards) for equipment, machinery and footsteps noises.

- The mechanization of office tasks has resulted in a proliferation of noisy equipment such as copiers and printers.

- The continuing trend toward open-office planning has exposed the office workforce to more noise.

- The automation of the activities of the knowledge workers (managers and professionals) has exposed noise sensitive tasks such as planning to noise intrusions; these workers have been more prone to complain about environmental conditions than clerical workers.

4.6 TYPICAL APPROACHES

4.6.1 Barriers

Sound barriers are used to reduce or eliminate noise by reflecting it or resisting its transmission. The mass of the material used as a barrier determines its effectiveness, the greater the mass, the better the performance. The performance of a wall, for example, is measured in decibels (dB), and the measurement is referred to as the sound transmission loss (STL). The sound transmission loss class (STC) is a rating scheme using a single number to rate its performance. Typical fixed barrier materials in buildings are sheet rock, gypsum board, concrete, brick or wood, while partitions are used in open-office settings as moveable barriers.

4.6.2 Isolation of Surfaces

This is a means of preventing vibrations from one space being transmitted to an adjoining one. One method of achieving this result is the placement of rubber, compressed fiberglass or springs between surfaces. The isolation of a surface receiving impact, such as a floor or ceiling, from the structure, will restrict the transmission of sound.

4.6.3 Sound Absorption

The surface treatment of a space is often considered to be the single most important determinant of the acoustical properties of a space. Sound absorption is accomplished by using porous materials to dissipate or absorb acoustical energy, e.g. fiberglass, cloth. The sound absorption coefficient is a measure of the sound absorbed by a surface; hard materials such as concrete and steel have low values, while carpeting has a relatively high value (the scale ranges from 0 to 1.0). Materials used for sound absorption purposes have a low mass, and therefore are not effective in preventing the sound from being transmitted to adjoining spaces.

4.6.4 Vibration Damping

This approach is used to prevent a material or object from resonating to a primary source, thereby acting as a secondary noise source, e.g. an air conditioning unit mounted in a window frame. Windows, walls, and machine components are potential problem areas. Rubber or vinyl is typically laminated to the surface of the noise producing element to avoid this problem.

4.6.5 Isolation of Noise Source

An effective means of controlling unwanted sound is to isolate and/or "sound treat" the source of noise. For example, place duplicating and printing equipment in a location remote from activities requiring quiet, and provide acoustical treatment to the room.

4.6.6 Masking Sound

Background noise is frequently used in open-space designs as a means of securing speech privacy. This "white noise" is generally introduced by means of ceiling speakers. This approach is not recommended because unwanted sound (noise) is not an optimum design solution.

4.7 CHECKLIST ACOUSTICAL DESIGN (23)

NOISE CONTROL

- The outer shell of the building should provide adequate protection from outdoor noise sources; control of fenestration is particularly important.

- HVAC and plumbing equipment should be selected, installed and operated to minimize noise; ancillary equipment should not be noisy.

- Automated equipment should be as quiet as feasible; vibration isolation from floor and furnishings should be considered.

- Sound absorption properties of ceilings, floors, and panels are a major design concern.

ACOUSTICAL PRIVACY

- Spaces for confidential meetings should be available in open offices.
- Adequate separation is required between workstations to ensure proper acoustical comfort.
- Partitions should be selected and placed in accordance with noise reduction needs.
- Flanking paths should be avoided between private spaces and the general workfloor; special attention should be given to lowered ceilings, raised floors, and utility chases.
- Consider using natural sound from HVAC to substitute for masking noise.

VIBRATION CONTROL

- Plumbing, HVAC and other mechanical equipment should be vibration isolated.
- Noisy automation equipment should be vibration isolated.
- Raised floors should be designed with high vibration damping features.
- Emergency power generators should be located, installed and used in a manner that avoids vibration and noise problems.

SPACE DESIGN

- Individuals and working groups should be clustered in accordance with acoustical requirements, e.g. privacy, freedom from noise intrusions.
- Noise producing equipment should be grouped and separated from general office activities when feasible.
- Panels and screens should be used to intercept horizontal sound paths.
- Ceilings with a high percentage of light fixture area can result in noise reflection problems.

4.8 ACOUSTICAL DESIGN PROCESS

A system has been developed which employs a computer program for the acoustical design of open-plan offices; it is called OPLAN. It is intended to provide an estimate of the degree of speech privacy anticipated for a given workstation. The program takes into account all paths by which sound travels from one location to another. Data are collected on the following: "anticipated speech effort, source/receiver distance, screen locations and dimensions, materials, background noise levels, and the degree of privacy required." Figure 9 summarizes the approach developed.

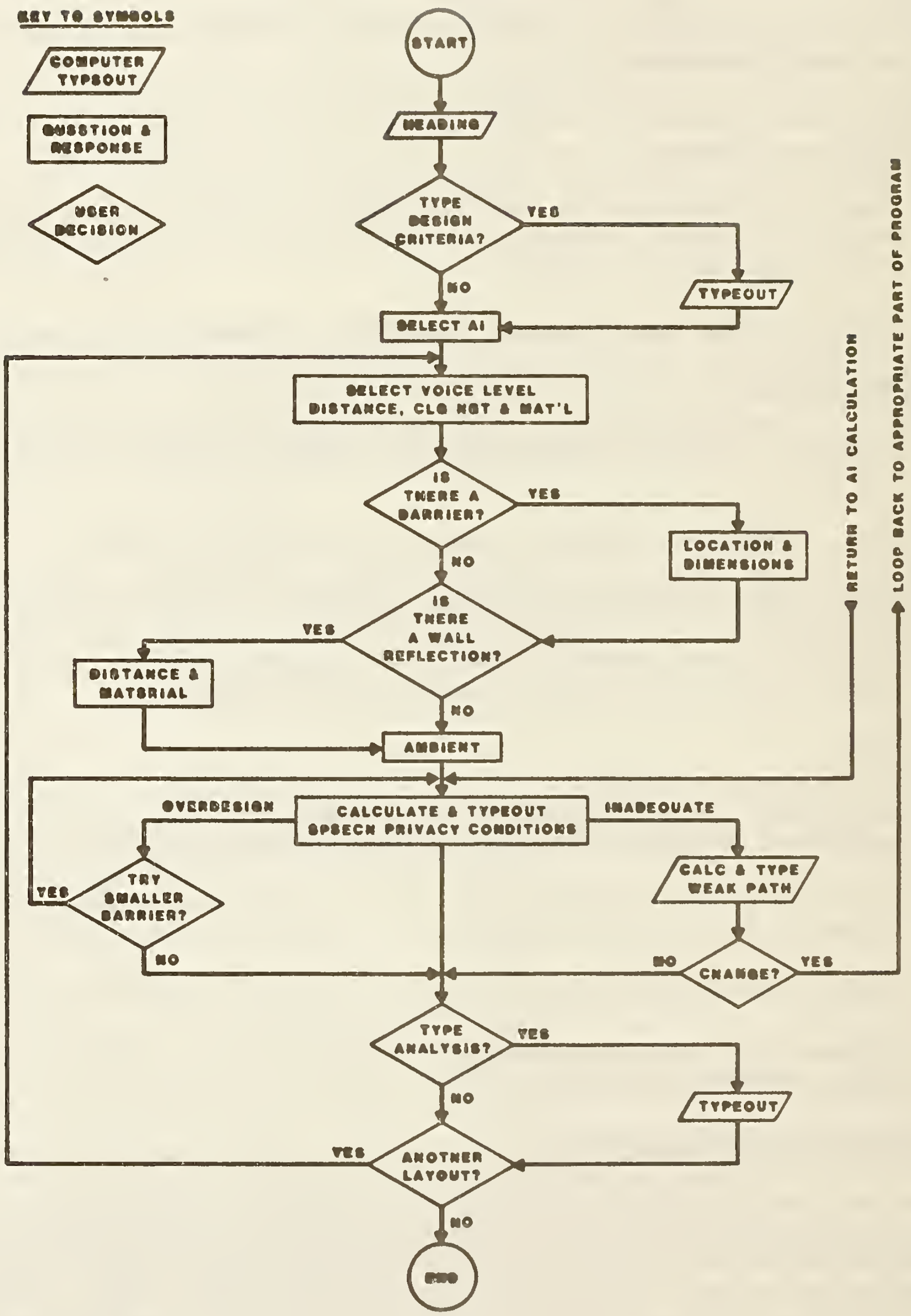


Figure 9. Simplified block diagram of OPLAN program (24)

5. LIGHTING SYSTEMS

5.1 FUNCTIONS

The primary purpose of lighting is to facilitate the performance of visual office tasks. It also serves other pragmatic and aesthetic purposes. It provides directional and locational information and is an integral component of security and safety systems. Finally, lighting can be used to create an environment which has variety, visual interest and pleasing contrasts, thereby offsetting the institutional appearance of offices.

Since most office tasks are predominantly visual ones, it is not surprising that lighting conditions are prominently mentioned in all surveys of office workers (25). The advent of the VDT in offices has further increased the importance of office lighting because most existing lighting systems are designed for desktop paper-based activities, with different visual requirements than VDT activities. To complicate matters further, for the forseeable future most workstations will have to accommodate a combination of both types of these activities.

Effective lighting requires a consideration of the entire environment. A balance of contrasts is needed to prevent visual discomfort and fatigue. The light generated by the VDT, the task area adjacent to the screen, the keyboard area and the surround lighting is also important. Visual problems can occur when the eye must continually adjust to markedly different lighting characteristics, and a variety of contrasts associated with a given activity such as reading paper copy while monitoring a VDT screen.

5.2 BACKGROUND

The quality and quantity of light are both critical features in the design of the automated office. Proper lighting also depends upon a consideration of the acitivities being performed, the people doing the work, and organizational requirements. It must take into account traditional building elements such as ceiling heights, wall and floor materials and treatments, room area, adjacent spaces, columns and various equipment and systems. Factors such integration of lighting with other systems, and flexibility are of special importance in the automated office. Since lighting systems are a major energy user in offices, this feature also merits detailed attention - uniform lighting levels to accommodate the most visually demanding task are no longer considered to be an acceptable approach to lighting design.

5.3 CRITERIA

- Lighting should reinforce the architectural intent of the building, e.g. connection with the outside and between spaces; provide a sense of intimacy and the delineation of activity spaces.
- The quality and quantity of lighting should support the visual needs of those performing VDT and/or paper-based tasks.
- Lighting levels should be consistent with activities performed.
- Color rendition should be aesthetically acceptable, and appropriate for the activities performed.
- Lighting should not produce glare.
- Extreme brightness contrasts should be avoided.
- Individual control of task and area lighting should be available.
- Lighting systems should provide flexibility appropriate for organizational needs and plans for expansion.
- Lighting systems should not be wasteful of energy.
- Lighting systems should be properly integrated with other building systems - e.g. ceiling, wiring, automation, safety.
- Lighting should provide proper margins for safety and security activities.
- Lighting systems should be designed for ready maintenance.
- Daylight should be appropriately integrated into the overall lighting system.

Lighting Recommendations - Illuminating Engineering Society (IES) (26)

Type of Activity	Illuminance Category	Ranges of Illuminances: Lux	Ranges of Illuminances: Footcandles	Reference Work-Plane
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working space where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

Table 9. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors (IES)

5.4 OVERVIEW OF BASIC ISSUES

Office lighting is achieved by a combination of natural and artificial lighting. Daylight is a varied, changing source of color and intensity, influenced by atmospheric conditions such as cloud cover and pollution, the position of the sun (e.g. time of day, and the reflection of building materials, trees and grass) (27).

5.4.1 Artificial Light Sources

The most common sources are incandescent and tungsten halogen lamps; gaseous discharge lamps such as fluorescent, and high intensity discharge (HID) lamps.

5.4.1.1 Incandescent Lamps

Light is produced when a wire of tungsten filament is heated to intense brightness by the flow of electric current. Although all spectrum colors are present, the light tends to be strong in the red, orange and yellow wavelengths. Colors in the "warm" spectral range are therefore strenghthened when illuminated by incandescent sources, while "cool" colors such as blue and green are weakened. The efficiency of these lamps is low -i.e. the amount of light produced by a given amount of energy. Efficiency is directly related to filament temperature and, for incandescent lamps, the most efficient ones have the shortest lives. Figure 10 below depicts several types of incandescent lamps.

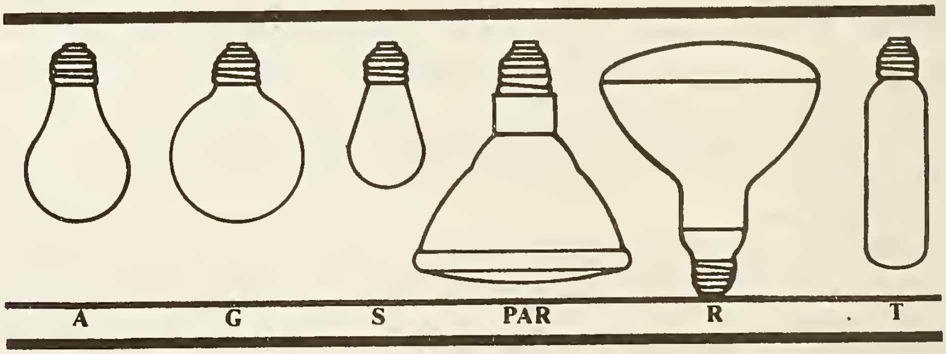


Figure 10. Common Types of Incandescent Lamps

A- General service lamp, G- Decorative lamp, S- Decorative lamp, PAR- Lamp used for directional purposes, e.g. downlight, used with reflective or baffled fixtures in recessed, surface or track lighting. R- A type of PAR downlight with a wide beam spread. T- A tungsten-halogen lamp, designed for long life and high intensity output; used for general lighting in medium-to-high ceiling areas.

5.4.1.2 Fluorescent Lamps

Fluorescent lighting occurs when a phospher powder lining along the inner tube wall of the lamp, fluoresces or glows. The powder is activated by ultraviolet radiation emitted from low pressure mercury vapor in the tube. They are higher in efficiency than incandescent lamps and produce much less heat. Furthermore they last from 20 to 25 times longer than incandescents, and therefore require less maintenance. Lamp performance can be overestimated if measured immediately after installation, because they produce more light during the first 100 hours of operation. The lamps should therefore be "seasoned" for this length of time before occupancy. This procedure has an added advantage of identifying faulty ballasts and lamps because when these components are defective, early problems with them are likely. The particular color rendition properties of fluorescent lamps depend upon the particular coatings and gases used in their designs.

5.4.1.3 High Intensity Discharge (HID) Lamps

They produce light through the gaseous discharge or vaporization of atoms of metallic elements contained in arc tubes. Vaporization causes the atoms to emit large amounts of electromagnetic energy within the visible range. An arc of electricity generates heat and pressure much higher than in the ordinary fluorescent lamp. Mercury, sodium and metal halide lamps are characterized by wide light distribution, wattage efficiency and low energy consumption and maintenance costs. Color rendering properties are often not as good as those of incandescent and fluorescent sources.

5.4.2 Ballasts

A ballast is needed to operate fluorescent and HID lamps. It is used to limit the flow of current through the lamp. Without it, the current will increase to a level which will quickly destroy the lamp. The ballast provides a voltage that is sufficiently high to start and maintain the arc discharge in the lamps. Special ballasts are now available which conserve energy and permit the dimming of the lamps. Ballast hum can be a distracting side effect of HID and fluorescent lamps.

5.4.3 Fixtures

For incandescent housings, they are sometimes moveable (e.g. table, pole track or floor lamp), or fixed (recessed, surface-mounted, ceiling hung). The quality of light and its distribution depend on the type of bulb used, the diameter of the fixture aperture, the interior shape and surface finish of the fixture, the distance of the lamp from the aperture, and the distance of the fixture from the surface to be illuminated. Interior fixture surfaces are often coated with a color and/or a special finish to produce given lighting effects.

Offices today are predominantly lighted by fluorescent lighting systems. Housings for these systems are ceiling recessed, surface-mounted, or ceiling-hung pendant. The quantity of light produced is primarily dependent on the number and wattage of lamps used in each fixture. The quality of lighting is

Lamp Name	Sunlight Simulating and Colour Matching Fluorescent	Cool White Fluorescent	Deluxe Cool White Fluorescent	Warm White Fluorescent	Deluxe Warm White Fluorescent	Incandescent	Deluxe Mercury	Phosphor Coated Metal Halide	High Pressure Sodium	Low Pressure Sodium
Approx. Correlated Colour Temp.(K)	5000- 5500	4400	4000	3100	3000	3000	3400	3500	2200	–
Lamp Colour Appearance	Bluish- White	White	White	Yellowish- White	Yellowish- White	Yellowish- White	Purplish- White	Purplish- White	Yellowish	Strong Orange
Colours Strengthened	All Nearly Equal	Orange Yellow Blue	All Nearly Equal	Orange Yellow	Red, Green Orange Yellow	Red Orange Yellow	Red Yellow Blue	Red Yellow Blue	Yellow Orange Green	Yellow Orange
Colours Greyed	None Appreciably	Red	None Appreciably	Red Green Blue	Blue	Blue	Green	Green	Red Blue	All Except Yellow and Orange go Brown-Black
Approx. Initial Luminous Efficacy (lm/W)	55-72	80	55-72	80	55-72	20	55	85	120	180
Approx. Rated Life (Hours)	(a) 12 000- 20 000	(a) 12 000- 20 000	(a) 12 000- 20 000	(a) 12 000- 20 000	(a) 12 000- 20 000	(b) 750-2500	(c) 16 000- 24 000	(c) 7500-20 000	(c) 24 000	(d) 18 000
Remarks	Very good colour rendering. Light appears cold at low illuminances.	Acceptable for most applications where colour rendering not important. Light appears cold et low illuminances.	Use where good colour rendering important. Light appears cold et low illuminances.	Acceptable for most applications where colour rendering not important. Light appears warm.	Colour rendering not quite good enough where colour rendering important. Light appears warm.	Good colour rendering.	Similar to remarks for cool white fluorescent lamp.	Similar to remarks for cool white fluorescent lamp.	Similar to remarks for warm white fluorescent lamp, but lamp with poorer colour rendering.	Poor colour rendering makes use unlikely for school interiors, but may be used for exteriors.

Notes:
- (a) According to type, 3 hours per switching.
- (b) According to type.
- (c) According to type, 10 hours per switching.
- (d) 5 hours per switching.

Table 10. Lamp Selection Guide (28)

largely influenced by the lens and/or louver system employed to distribute the light. A major determinant of lighting quality is the "glare producing" potential of a given system. This is discussed below.

5.4.4 Lighting Fixture Rating Schemes

5.4.4.1 Visual Comfort Probability (VCP)

This is a rating of the likelihood that people using a given system would not be bothered by direct glare from a given fixture design. For example, a VCP of 70 means that 70% of those workers seated in the worst location in a space would not be bothered by direct glare from a lighting system composed of the type of fixture whose VCP is under evaluation.

5.4.4.2 Coefficient of Utilization (CU)

This is a measure of the efficiency of a fixture in a specified space, i.e. the percentage of the light produced by a lamp which ultimately reaches the work area. For example, a fixture with a rating of .70 delivers 70 percent of the lamp's output to the work plane.

The VCP and CU of any given fixture depend upon such factors as room configuration, reflectivity of surfaces, distance from the floor, and the spacing between fixtures.

5.5 POSSIBLE PROBLEM AREAS

- Lighting systems at workstation should accommodate VDT and paper-based tasks.
- The line-of-sight of the VDT screen is near the horizontal, resulting in a greater likelihood of glare from a fixture in direct view.
- Reflected glare can occur from reflections on the surface of the VDT, from windows, fixtures, people, and other VDT's.
- Extreme visual contrasts in the visual field, created from VDT, the workspace, general surrounds, windows, etc.
- The placement of fixtures may be inappropriate for the tasks being performed - e.g. shadows, glare.
- Indirect HID lighting can produce "hot spots" on the ceiling.
- Color rendition of HID sources can result in aesthetic problems, especially if the materials and furnishings aren't carefully selected with regard to their color characteristics.
- Color stability and uniformity are sometimes a problem with HID sources.
- Highly reflective materials can be sources of reflected glare.

- Black and white "colors" can contribute to undesirable visual contrasts in the work setting.

- Dirt and dust on fixtures and lamps can substantially reduce light output; scheduled maintenance is important.

5.6 TYPICAL APPROACHES USED IN LIGHTING DESIGN

5.6.1 Types of Illumination

Three general approaches are available for providing office lighting - general (ambient), direct, and indirect. Ambient lighting refers to a uniform pattern of lighting throughout a space. This approach is being supplanted in many offices by task/ambient systems which are upon a relatively low level for movement and circulation purposes (i.e. less demanding visual tasks) and direct lighting on the task to be performed. Direct lighting has the advantage of efficiently using the available light to accomplish a given purpose, but glare and veiling reflections must be avoided. Indirect lighting uses wall and/or ceiling surfaces to reflect light into the workspace, e.g. for ambient lighting, architectural definition.

5.6.1.1 Ambient (General) Lighting

Ceiling fluorescent systems are usually employed for this purpose. The first consideration is to avoid any lamp reflection on the face of the VDT. This can

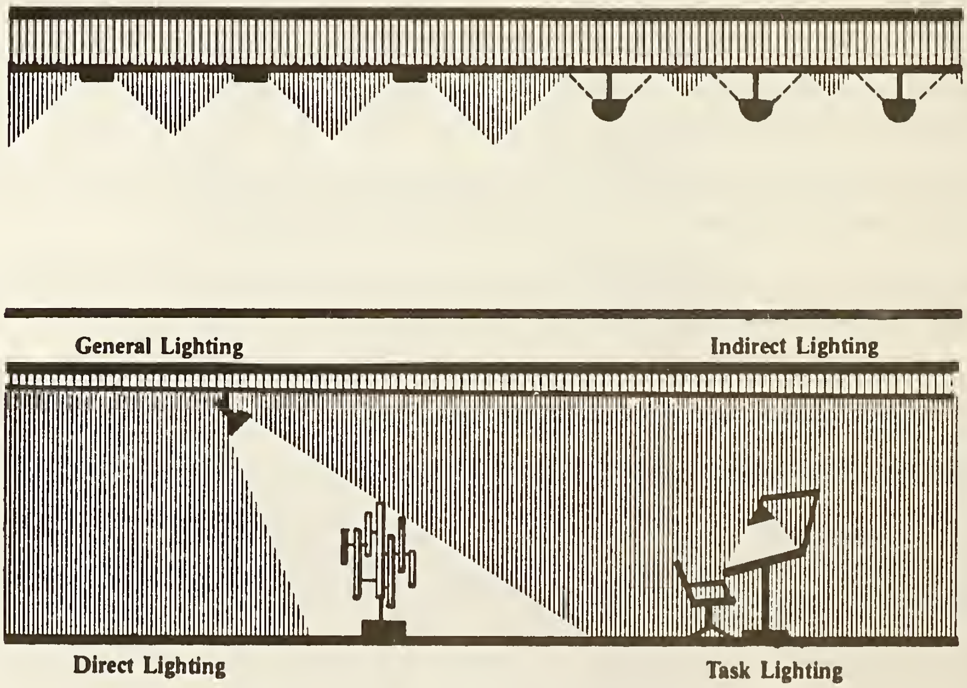


Figure 11. Types of Illumination

be accomplished by using a specular parabolic wedge louver; it has a typical cutoff of 45°, with any images from the lamp being reflected below the viewing angle.

5.6.1.2 Task Lighting

Lighting is directed to a specific surface or area to provide illumination for visual tasks. Typically, light sources are placed on top of a desk, hung from a panel, placed above a worksurface, or under an overhead bookcase.

5.6.1.3 Task/Ambient Lighting

This system is one which combines general and task lighting. In this approach the task lighting is placed as above (5.6.1.2) while the ambient illumination can be ceiling mounted, on top of bookcases, attached to the top of panels, or housed on top of a kiosk.

5.6.1.4 Indirect Lighting

The light is mounted beneath the ceiling, placed in a free-standing or partition mounted kiosk, with the light being directed toward the ceiling, which serves as a reflector. The luminaire should be designed to direct light rays laterally to provide the greatest spread of lighting.

5.6.1.4.1 Checklist for Evaluating Task/Ambient Systems (29)

1. Lighting should be evenly distributed over the task area.

2. Veiling reflections should be minimized.

3. A proper brightness relationship between task and surround is essential. (No more than 3:1 in the immediate seeing zone, no more than 10:1 in the total zone.)

4. Luminaires should be glare free. The light source should not be visible.

5. Ballast noise should be minimized by the use of a properly mounted, high quality ballast.

6. The ballast and housing should not radiate excessive heat.

7. Fixtures should be easy to clean and maintain. Replacement of lamps and ballasts should be easy.

8. Fixture should be properly mounted to prevent vibration.

9. Upward light distribution should minimize shadows, while avoiding "hot spots" on the ceiling.

10. Downlights should light the back part of a workstation uniformly.

5.6.2. Controls

Lighting controls provide the operator with the means to adjust the lighting to suit the activity to be performed. They also serve an important energy-saving function. Local lighting controls can activate a small number of fixtures which permit the lights to be readily turned off when not needed. Dimmers also provide the opportunity to adjust the lighting conditions as visual requirements change.

A variety of automated control systems are now available; they frequently are dependent on a combination of manual and automated features. For example, time switches are employed in areas that are often not used. In some configurations, lighting is activated manually and deactivated after a given time interval, unless manual intervention occurs first. Some centralized lighting controls can send signals to fixtures over existing circuitry, while others use radio frequencies or require new wiring.

Another system is manually activated and then deactivated after a given time period, when people are no longer detected in a space. The controls work on the principles of motion detection (ultrasonics), body heat (passive infra-red), noise in the human activity range (acoustics), or the interruption of beams given off and returned by a detector (active infrared). Carbon dioxide (CO_2) is also used as an occupant sensor.

Window lighting should be controlled by curtains and blinds which can also serve to filter and direct sunlight at reasonable cost. Vertical blinds can be turned and pivoted to redirect sunlight. A fabric finish is preferable to a hard one because it diffuses the light thereby reducing glare. There are also mylar and plastic filters and screens which can be positioned in front of windows like a sunshade.

5.6.3 Maintenance

Lamps should be replaced before they fail because the light output declines with use. Replacing lamps early therefore maintains a greater average light output of the entire system. Another advantage of relamping before failure is that it tends to lengthen the life of the ballasts, which fail prematurely with the failure of lamps. Group relamping is best accomplished by changing all of the lamps at the same time. When personnel, equipment and lamps are assembled simultaneously, a lamp change can be made in few minutes for many lamps. In contrast, replacement of a single lamp when it fails can take as long as 30 minutes. A further savings can be made if fixtures are cleaned when group relamping is scheduled. A periodic cleaning schedule for fixtures and lamps is a requirement if designed lighting levels are to be maintained over the lifetime of the building. Dust and dirt accumulations can severely limit the efficiency of lighting systems (30).

5.7 ENVIRONMENTAL CONTEXT

When a person is operating a VDT, he or she looks not only on the work materials, but peripherally at the work surface, distant furniture and walls, windows and the general office area. Sharp contrasts in color and reflective surfaces should be avoided because they may result in visual distractions and/or difficulty in performing required tasks.

Brightnesses within the office space should be controlled. Walls and other surfaces should be diffuse and have a light reflectance value of less than 50 percent. Carpeting colors should be muted rather than saturated in color. Desks and work surfaces should be matte, or low-glare non-reflective. The tops of tables and desks should be made of non-specularly reflective material. Neutral color tones are preferred for all furnishings.

5.7.1 Checklist for Glare Control (31)

Direct and reflected glare can be limited by means of one or more of the following methods:

- Drapes, shades, and/or blinds over windows should be closed or directionally adjusted, especially during sunlight conditions.
- Terminals should be properly positioned with respect to windows and lighting fixtures, e.g. screens facing away from bright sources.
- Direct lighting fixtures may need to be recessed; baffles or special covers are used to direct light source downward.
- Indirect lighting fixtures should have appropriate lens/louver systems to minimize glare potential.
- Specular surfaces on furnishings and equipment should be avoided.

6. ENVIRONMENTAL CONDITIONING SYSTEMS

6.1 FUNCTION

HVAC systems provide for human comfort and the well-being of office occupants and help maintain the proper environment for the operation of support systems to operate effectively by regulating (32):

- the temperature of the air
- the temperature of surrounding surface
- the relative humidity and motion of the air
- the quality of the air - e.g. freedom from unwanted odors and particulate matter

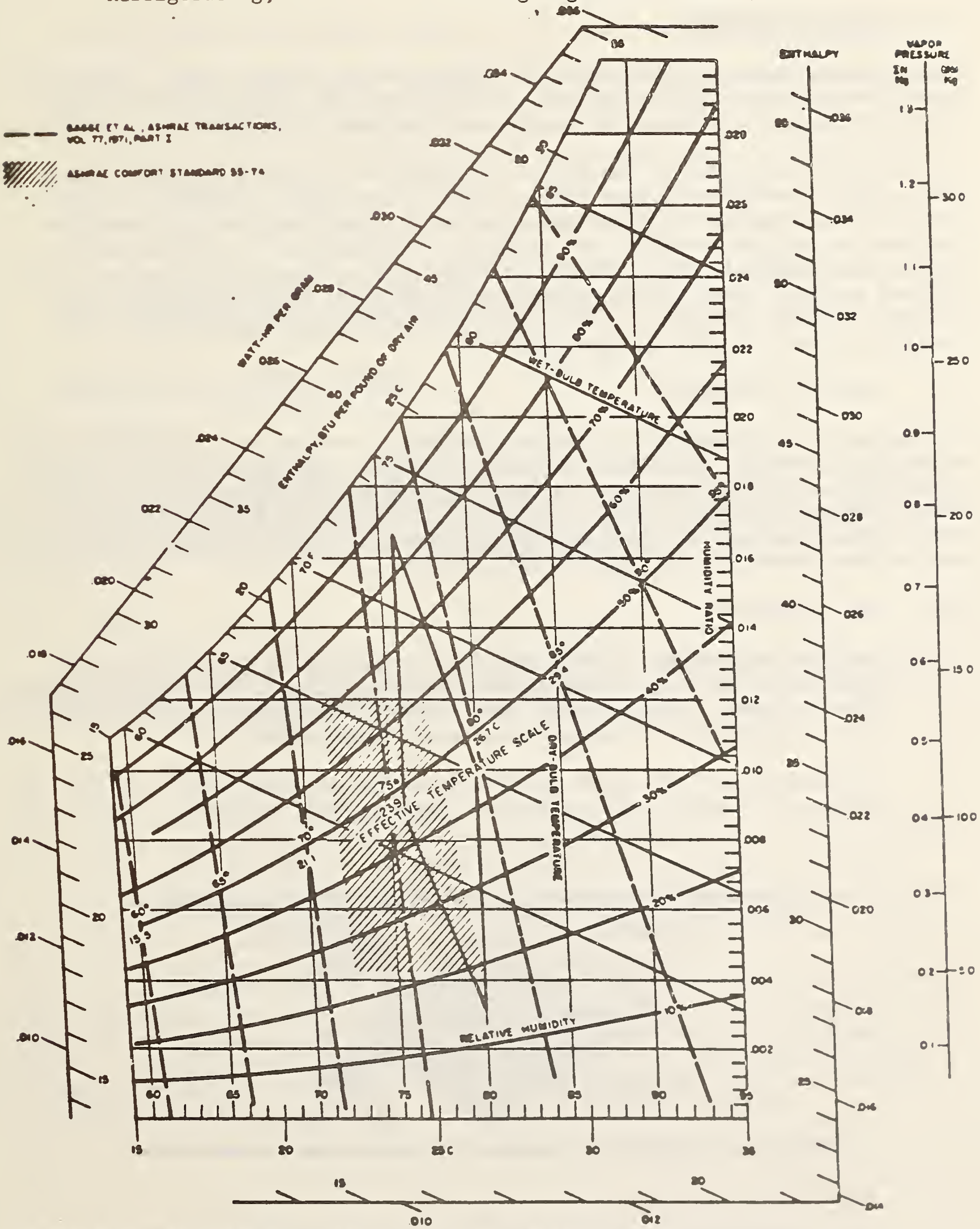
6.2 CRITERIA (33)

- Air temperatures must accommodate equipment and people.
- Flexible air supply and return systems should be designed mechanically and architecturally to facilitate change and/or expansion.
- Humidity control must accommodate the needs of people and equipment.
- Thermal comfort conditions should be in accordance with ASHRAE recommendations.
- Energy usage is of major importance.
- Control systems should enable area zoning to accommodate equipment and activities.
- Static electricity should be minimized.
- Air distribution system should permit change in workstation locations without loss of thermal comfort.
- Do not exceed maximum humidity conditions; wet equipment, corrosion.

6.3 OFFICE AUTOMATION DESIGN IMPLICATIONS

The automated office has more electronic devices and systems than the traditional one. This technology produces considerable heat which substantially increases the cooling load of the building resulting in equipment outages and occupant complaints. Many of these devices are humidity sensitive and proper humidity control is essential for the proper operation of equipment, and for minimizing the detrimental effects of static electricity on the office staff as well as on the electrical equipment. A combination of tight building designs to save energy, and the use of chemicals in many office activities, e.g. ink for duplicating machines, tends to degrade the quality of the air in many office buildings.

Thermal Comfort Recommendations - American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) (34)



* The envelope applies for lightly clothed, sedentary individuals in spaces with low air movement, where the MRT equals air temperature.

Figure 12. New effective temperature scale (ET*) (ASHRAE)

6.4 TYPICAL APPROACHES

Meeting environmental requirements in offices is not an easy task. Conditions in a given space served by the same central system may vary markedly, depending on the location and grouping of people and electronic equipment.

The conventional system of ceiling air distribution consists of a main trunk and a grid of auxiliary feeder ducts, which can be either flexible or rigid. Adequate clearance is needed between the ceiling and the structure above the ductwork as well as access to the mechanical equipment in the plenum space. Supply and return air grills in the ceilings must conform to the module of the ceiling system. Newer and proposed systems employ floor distribution, some delivery through workstation units with local control, others achieve local control by local "modifying" systems.

6.4.1 Existing Buildings

For spaces having clusters of computer equipment, modular ceiling mounted HVAC units can be used to supplement the central system. Localized controls should be available for this equipment so that they can be turned off when not being used. The use of heat-recovery systems from clustered workspaces should be considered. Packaged air conditioning and humidity control systems can be used to supplement the central building system.

6.4.2 New Construction

- Variable air volume systems should be considered to maintain desired temperature levels; if air movement is insufficient, fan-powered should also be used. (Some problems have occurred with regard to air motion and ventilation in occupied spaces with these systems.)

- Thermostats must be carefully positioned in the open space; not near the return air supply, and at a height representative of office activities.

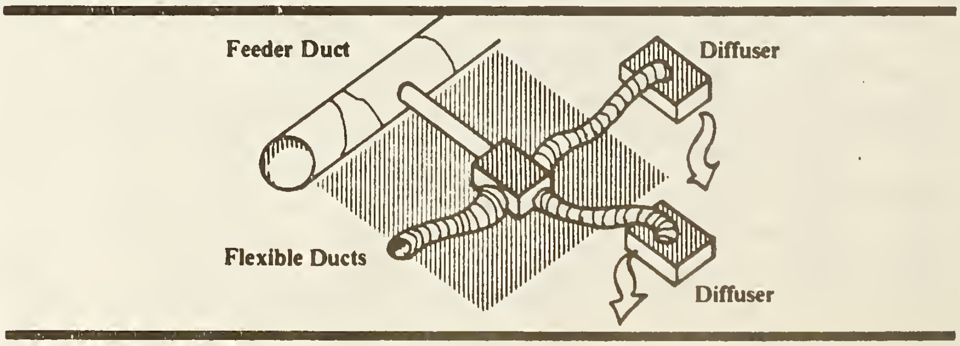


Figure 13. Conventional ceiling air distribution

- Consider the use of floor plenums for HVAC/electrical distribution.

- Zoning can be accomplished by means of individual HVAC systems. Localized areas of the building are likely to be subject to concentrated heat loads.

- Portions of the building might have to be occupied on a 24 hour per day basis and merit separate treatment.

- Localized air conditioning units should be used for computer rooms.

- Ceiling-mounted modular cooling systems which operate independently of the central system are available, but the cost of installation and the difficulty in moving them are shortcomings.

6.5 INTERACTION WITH OTHER SYSTEMS

6.5.1 Lighting

Heat removal and air handling lighting fixtures extract heat before it enters a space, thereby reducing the overall heating load. However, furniture-integrated lighting systems emit their heat directly into the air. Lighting and HVAC system design should be integrated to optimize lighting efficacy and useful heat generation.

6.5.2 Acoustics

Air distribution systems can be designed to produce a relatively uniform sound, thereby sometimes eliminating the need for the introduction of white noise into the office as an aid to privacy.

6.5.3 Indoor Air Quality

Energy conserving design, characterized by unopenable windows, increased insulation, tighter buildings and reduced ventilation, has resulted in a concern for the air quality in buildings. The reduced outdoor air supply has increased the potential for accumulating noxious agents in the air of offices, e.g. smoke. New construction materials and chemicals used in office systems such as duplicating machines are also potential sources of air contaminants. These conditions have resulted in complaints by office workers concerning the quality of the indoor air environment. The discomfort of office workers might be attributable to the synergistic effect of environmental contaminants and environmental conditions. This issue, and an approach for effective control is suggested in table 11. Proper ventilation is a key to the control of indoor air quality. Air supply and return should be designed so that local contaminants and odors can be removed locally, instead of diluting them into the room air.

Table 11. Control Measures for Indoor Air Pollutants; Responsibilities (35)

Control Measure Description	Pollutant	Example
Ventilation: dilution of indoor air with fresh outdoor air or recirculated filtered air, using mechanical or natural methods to promote localized, zonal, or general ventilation	Radon and radon progeny; combustion by-products; tobacco smoke; biological agents (particles)	Local exhaust of gas stove emissions; air-to-air heat exchangers; building ventilation codes
Source removal or substitution: removal of indoor emission sources of substitution of less hazardous materials or products	Organic substances; asbestiform minerals; tobacco smoke	Restrictions on smoking in public places; removal of asbestos
Some modification: reduction of emission rates through changes in design or processes; containment of emissions by barriers or sealants	Radon and radon progeny; organic substances; asbestiform minerals; combustion by-products	Plastic barriers to reduce radon levels; containment of asbestos; design of buildings without basements to avoid radon; catalytic oxidation of CO to CO_2 in kerosene burners
Air cleaning: purification of indoor air by gas adsorbers, air filters, and electrostatic precipitators	Particulate matter; combustion by-products; biological agents (particles)	Residential air cleaners to control tobacco smoke or wood smoke; ultraviolet irradiation to decontaminate ventilation air; formaldehyde sorbant filters
Behavioral adjustments: reduction in human exposure through modification of behavior patterns; facilitated by consumer education, product labeling, building design, warning devices, and legal liability	Organic substances; combustion by-products; tobacco smoke	Smoke-free zones; architectural design of interior space; certification of formaldehyde concentrations for home products

Responsibilities for Healthful Indoor Environments

Individuals

Maintain and properly use products and appliances
Exercise direct discretionary control of ventilation in most residential and some occupational circumstances

Building Owners or Managers

Operate and maintain a balanced ventilation system in compliance with building ventilation codes
Use zone ventilation or local exhaust for indoor contaminant sources
Properly use cleaning solvents, paints, varnishes, herbicides, insecticides, furnishings, and insulation

Architects, Developers, Contractors

Adopt protection of indoor air quality as a design objective
Design ventilation systems to comply with new ASHRAE standard 62-1981
Provide for separation of occupants and indoor pollutant sources
Elimination or containment of potential sources

6.6 ENVIRONMENTAL CONTEXT

6.6.1 Interior Design

- Window coverings, wall fabrics, floor coverings and adjustment of air flow patterns all influence the thermal comfort of a space. The proper placement and adjustment of diffusers and radiators also contribute to environmental satisfaction.

- Window exposures can also contribute to the thermal environment in significant ways. For example, in the winter months, southern exposure can contribute to the heat needed, and northern exposure, if shaded, will prevent undesirable heat loss.

- Functions that require similar environmental conditions can be grouped together, focusing mechanical demands appropriately.

6.6.2 Design Process Issues

Better planning and coordination is needed for implementing office automation systems. Improved coordination is required among the user, the A/E, and the consultants involved in designing the office systems. Among the issues that require detailed architectural programming attention are:

- Means of achieving flexible air distribution.

- Determining tradeoffs among automation, energy conservation, and thermal comfort requirements.

- Responsiveness to a strategic automation plan by the building user.

- Integrating HVAC effectively with other building systems.

- Providing control systems which are responsive to particular needs of equipment and people, e.g. the older worker often requires warmer temperatures than the younger one; requirements differ in accordance with the physical demands of tasks.

6.6.3 Potential Problem Area - Static Electricity (45)

Electrostatic discharge can be a major problem in an automated office. Static electricity occurs in two ways, induction charging and contact charging. In induction charging, electrical fields radiate from the surfaces of materials such as styrofoam and cloth. For example, a shirtsleeve can generate enough of a charge to destroy the read only memory (ROM) of a computer. In contact charging, two materials make contact with one another and then separate. This action causes one material to strip electrons from the other. This is what occurs when one walks across a carpet and is shocked when touching a doorknob. The size of a particular charge depends on the speed, degree of friction, and the characteristics of the materials coming into contact with each other. The higher the electron density of the material, the greater its charge. While voltages of 3,000 are sometimes sufficient to distrub computer circuits, it is not until voltages are in the 10,000 to 15,000 range that people become aware of unpleasant or painful sensations.

6.6.3.1 Common Sources of Static Electricity

- Waxed, painted or varnished surfaces
- Vinyl tile flooring
- Polystyrene (Styrofoam)
- Finished wood or plastic covered desks, chairs
- Electrostatic copiers
- Insufficient humidification

ACTIVITY	VOLTAGE 10-20%	65-90% Humidities
• Walking on carpet	35,000	1,500
• Walking on vinyl floor	12,000	250
• Picking up polyethelene bag	20,000	1,200
• Sliding on foam padded chair	18,000	1,500

ENDANGERED COMPONENTS	
• Precision voltage regulator circuits	(1-1,000 v)
• Transistor logic devices	(1,000 - 4,000 v)
• Silicon power transistors	(4,000 - 15,000 v)
• Small signal diodes	" "

Table 18. Static Electricity Issues

6.6.3.2 Possible Approaches to Overcome Problem

- Power grounding.

- Humidity control. Humidity in the 40 - 60 percent range is recommended by manufactures of office automation equipment.

- Carpeting materials should be carefully selected for low static electricity properties.

- Chairs and movable furnishings should have metal, conducting rubber or plastic wheels.

- Conductive anti-static floor mats can be used to bleed static charges to ground, through a wire. The mat must be kept free of dirt and wax; operators must wear conductive footwear.

- Anti-static agents can be sprayed directly on carpet or tile. These agents increase the rate at which air ions recombine with surface charges by maintaining a thin moisture layer over the area applied.

- An ionizer can be used; it emits both positive and negative electrons which combine with opposite charges on the surfaces of non-conductive materials such as cloth and plastics.

7. ELECTRICAL POWER SYSTEMS (36)

7.1 FUNCTION

To provide an electrical environment for the safe, reliable operation of office automation equipment and other electrical systems in federal office buildings. It is the most critical system for office automation.

The electrical environment for computers includes their power sources, grounding and electrical interfaces with communications lines, air conditioning, and life-safety systems. It also includes lighting and other electrically operated equipment. The electrical environment in which office equipment operates must also be considered, since electrical disturbances propogate through conductors, pipes, metal ducts and conductive structural members, or by radiation as radio waves. External sources of electrical fluctuations range from lighting to electrical loads which generate electrical noise when operated or switched on and off. Internal sources of electrical changes can be caused by the office automation equipment itself.

No equipment is immune to electrical disturbances but sensitivity to such changes varies from device to device and from one type of disturbance to another. Disturbances of high energy content can result in catastrophic failure of impairment of circuit components. Smaller disruptions may not damage components but may disturb the logic signals and cause intermittent errors in data or control functions.

Significant improvements in logic design and the integration of circuits ironically has made office systems more susceptible to disruption by electronic noise, because these circuits need less power than many of their predecessors, and the quality of commercial power hasn't kept pace with these requirements. The faster response times of newer, high performance logic circuits makes tham susceptible to fast noise pulses which have always existed, but which failed to disturb the older, slower logic circuits. This implies that electrical environments which were suitable for older generation office machines may need to be improved to accommodate some of the newer systems. Power and electrical system requirements should therefore be carefully reviewed prior to installing new systems.

7.2 CRITERIA

- A power source is needed that is relatively free of major fluctuations.

- The means to reduce or eliminate sources of electrical disturbances is needed.

- Circuits should be designed to reduce the coupling of electrical noise and transients from all sources into low power level circuits.

- The office equipment selected should not be readily disturbed by power abnormalities.

- Software and operating procedures should be available to readily detect, correct and recover from errors and power outages.

- Additional capacity is needed in electrical bus risers to handle future needs, e.g. to main and distribution panels.

- Power panels are required for station-to-station distribution.

- Use power distribution modules for isolation.

- Segregate power usage ("clean" vs. "dirty" power), e.g. coffee maker should not be on same circuit as an OA device.

- The use of uninterruptable power systems should be considered for critical operations.

- Proper grounding is essential for safety and operational purposes, e.g. lighting protection.

7.3 POSSIBLE PROBLEM AREAS

Power surges and spikes are major sources of difficulty in the electrical environment of an office. A power surge is an increase of voltage levels from 10 to 20 percent (or more) above normal, usually lasting from one half cycle to several seconds. A surge can be induced by static discharges, lightning, or inductive switching produced by the starting or stopping of a major electrical motor on another circuit, e.g. an elevator or air conditioner motor. A third, less frequent cause for a surge is when power is restored after an outage. Surges do not generally affect the performance of traditional motor driven machines, but computers and microprocessors have critical threshold operating voltages, and power fluctuations can seriously impair their performance. Spikes, which are sudden but brief disturbances reaching thousands of volts with frequencies reaching to the megaherz level, are also a danger to the operations of electronic office equipment.

7.4 POSSIBLE APPROACHES (36)

7.4.1 Emergency Standby Power

This power is normally off and does not start manually or automatically) until the public utility power fails. The power is provided by a bank of batteries and/or diesel generators, which can be started within ten to thirty seconds, if their condition for rapid starting has been continuously maintained. However, this length of interruption would shut down electronic office equipment not served by an uninterruptable power system. Power surges should be controlled when this source is activated.

7.4.2 Uninterruptable Power Systems (UPS)

They have become a virtual necessity for powering electronic systems where the application serves a critical need, e.g. a life safety system. These systems, unlike the emergency standby power systems, are always in operation (except for planned maintenance, or outages). UPS systems are typically supplied with sufficient battery capacity to carry a data processing load for periods ranging from five minutes or less, to several hours. The success of a UPS system is dependent on its ability to permit operations to continue without interruption; requiring power switching to be performed in less than one haf cycle and without substantial transient noise during the switching. A variety of approaches can be used to provide no-break power; for details see reference (35).

Condition	% Probability	Causes	Effect	Treatment
Line voltages too high or low	11-12%	Neighboring increases in demand, loading down supply.	Improper equipment operation. Possible damage if sustained. Overheating.	Constant Voltage Regulator (CVR)
Severe power drops or outages of short duration (20 milieseconds [thousandths] to a few seconds)	.5-1%	Electrical storms, power equipment fault. Addition of heavy equipment to load.	Total disruption of computer operations. Damage to equipment when power is restored abruptly.	Uninterruptible Power Sources. Reserve supply equipment, inverters, Motor Generators.
Power surges and sags of short durations (typically a few milliseconds or a single power cycle)	40-47%	Abruptly adding or removing loads to the power line by users. Faulty or arcing switches.	False computer output, misregistration of logic circuits, possible hardware damage.	Surge suppression devices or isolation transformers, optionally with surge suppression devices.
High voltage impulses of extremely short duration (a few microseconds to a short nanosecond)	35-40%	Inductive load switching, contact arcs, start/stop equipment operation, static discharge, electrical storms.	Premature component failure, misregistration of logic circuitry, equipment down time.	Surge suppression devices.
High frequency RFI /EMI	N/A	Other computers, radio and communication devices, small motors, and commutators.	Little effect on digital equipment.	Low pass filters.

Table 12. Basic cause, effect and treatment of power-line problems, and the approximate cost of devices to remedy each situation

7.5 CHECKLIST FOR MINIMIZING ELECTRICAL DISTURBANCES (36)

- Use separate feeders and branch circuits for office automation (OA) systems so that no sudden common voltage drop will be created by noncomputer equipment sharing the same circuits ("clean" power).

- Large motors which drive air conditioning compressors, which are regularly started and stopped should not be powered from the same feeders or isolating transformers which supply the OA power.

- The operation of OA equipment from high impedence power sources such as diesel or gas turbine driven engines can result in large transient voltage variations; low internal impedance and/or larger kVA sizes can minimize this risk.

- Avoid apparatus with regulators susceptible to overheating or to oscillatory interaction with loads containing their own regulators.

- The input power to OA equipment should be filtered to ensure proper performance.

7.6 ENVIRONMENTAL CONTEXT

7.6.1 Specialized Space Needs

UPS systems and barriers should be in protected utility areas. Batteries represent potential shock hazards, danger from acid spills, flash heat and sparks from high-energy short circuits, or even explosions. They should be installed in dedicated battery rooms with controlled access. Temperature should be maintained at between 70° to 80°F, to ensure long life and capacity. The UPS hardware should be placed close to the batteries to avoid unnecessary loss in the dc bus and excessive electrical noise as well as a possible shock hazard. Typically, the UPS is placed in a basement utility room or utility corridor area where the equipment can be properly ventilated and kept at the appropriate temperatures. The space should be secured and locked to prevent unauthorized entry. Appropriate warning signs should be strategically located. A shower is needed if batteries are of the lead-acid type. Finally, rooms should be shielded from potential sources of electromagnetic and/or radio interference.

8. POWER AND COMMUNICATIONS WIRING SYSTEMS

8.1 FUNCTION

To provide power and communications services wherever needed to facilitate organizational performance in offices. To provide the flexibility required to cope with changing requirements.

8.2 BACKGROUND

Wiring systems in offices have remained basically the same for many years, but within the past decade this situation has undergone profound changes. Office automation, telecommunication, and other technologies, energy conservation requirements, and the increasing use of open-plan designs have all fostered the design and application of new systems to delivery power and communications to work areas. The central role being assumed by individual workstations in automated offices has accelerated the demand for improvements which have ranged in complexity and sophistication from "intelligent buildings" to flat conductor cable.

8.3 CRITERIA

- Optimized flexibility is needed to accommodate future changes; tradeoffs made between frequency of changes, initial and long-term costs.
- Wiring and communications systems should be integrated when feasible, e.g. information and energy management; proper shielding is required also.
- Systems should be aesthetically acceptable.
- Wiring changes should not cause major disruptions in ongoing activities.
- Dedicated circuits should be considered for maintaining critical operations such as security, safety, and highly critical information services.
- When laying cable, future needs for communications and office automation systems should be considered.
- Complete wiring diagrams should be available, and updated to reflect all changes.
- Cabling should be identified at every location where it enters or exits a room.

8.4 TYPICAL APPROACHES

Many designers consider wire management to be the most important factor in effectively coping with the needs of the automated office. Equipment types, densities, and locations are all likely to change frequently within the useful lifetime of a building, so power and communications systems must be designed to move and adapt. The options for distributing power, lighting, electronics and communications services consist of five basic approaches, often used in combination:

1. Raised access floor.
2. Flat cable distribution.
3. Integrated floor ducts.
4. Floor distribution and poke-through.
5. Ceiling distribution and power poles or flex conductors.
6. Modular removable connectors.
7. Ceiling and workstation distribution.

Providing power and communications requires a wire or fiber conductor within a conduit (e.g. sheath, raceway, raised floor) connected to a terminal within a room and/or above the ceiling. The degree of flexibility provided varies from system to system, as do the initial and long term costs. However, power and communications signal lines should have sufficient separation to prevent interference, e.g. magnetic coupling.

The major features of the open office system has led to the popularity of the underfloor system for electrical distribution and communication. The replacement of permanent walls with partitions and dividers and the movement of desks away from exterior walls have had the effect of decreasing the potential use of walls for power distribution purposes. The work support system exists underfloor in one of five different horizontal planes. It can run along the underside of the slab (as in a poke-through system), within the body of the slab (in a concrete underfloor system), just under the top surface of the slab (fill and finish), or above the structural slab and below the walking surface (raised or access floor). All underfloor systems result in a penetration of the actual floor surface. The penetration can be as simple as raising a hatch lid, or as complicated as drilling through the concrete slab. The location and appearance of the service fitting is an important design consideration, as is the appearance of the floor after relocation. Some designs treat service fittings as a necessary functioning element which should be clearly exposed and detailed, while others attempt to conceal the service fittings.

8.4.1 Poke-Through System

In this system the floor slab is cored in order to pull electrical wiring from the floor below. The resulting holes must be fire-treated. The conduit runs from its connection to the service fittings of the slab to the currently spaced junction box. A sleeve may be preset during construction or after. After the hole is drilled, a sleeve is forced into place and the service fittings are then installed from above. The system does not require an underfloor raceway.

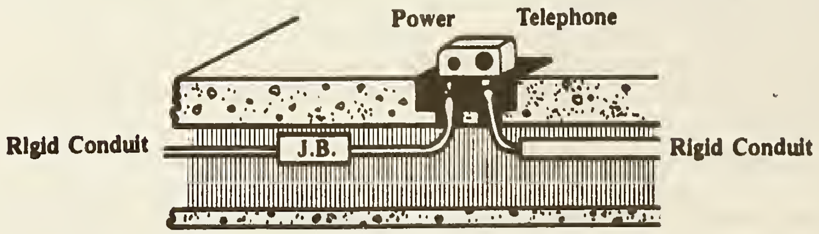


Figure 14. Poke-Through System

8.4.2 Electrical Cellular Deck

It consists of closely-spaced cellular raceways that connect at regular intervals to a main and header duct. A matrix of preset service fittings is spaced just below the surface floor in a trench. The required service is obtained by punching a hole through a thin panel and bringing the appropriate cables through the opening. Physically, the wiring must penetrate the floor, and in the case of carpet tiles, the carpet might have to be cut out or peeled back.

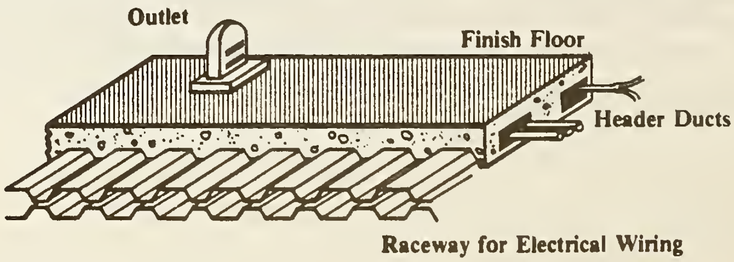


Figure 15. Cellular Floor System

8.4.3 Underfloor Duct System

It consists of ducts spaced at regular intervals, between five to eight feet on centers, connecting to a main or header duct. This system has preset access points which allow for minimal floor slab disruption, thus eliminating the need for fire safety precautions.

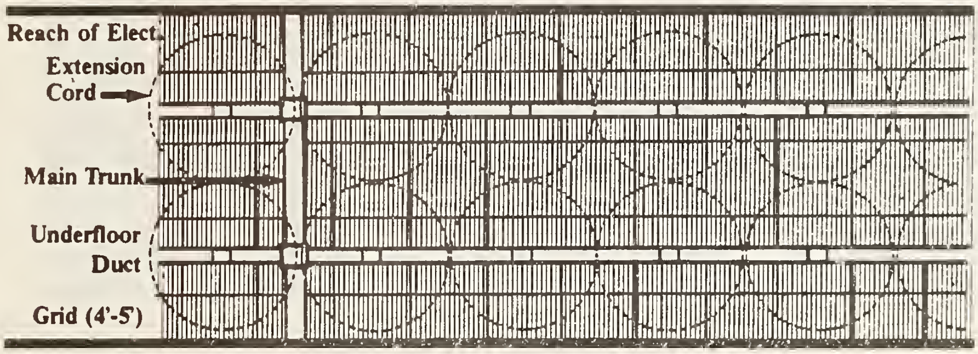


Figure 16. Underfloor Duct System

8.4.4 Raised Access Flooring

Total access flooring is a system of interconnecting floor panels that are raised sufficiently above the structural slab to allow for installation of electrical, mechanical, and air distribution systems. This approach is frequently used for the design of major computer facilities. Cabling may have to be plenum-rated if underfloor area is a plenum.

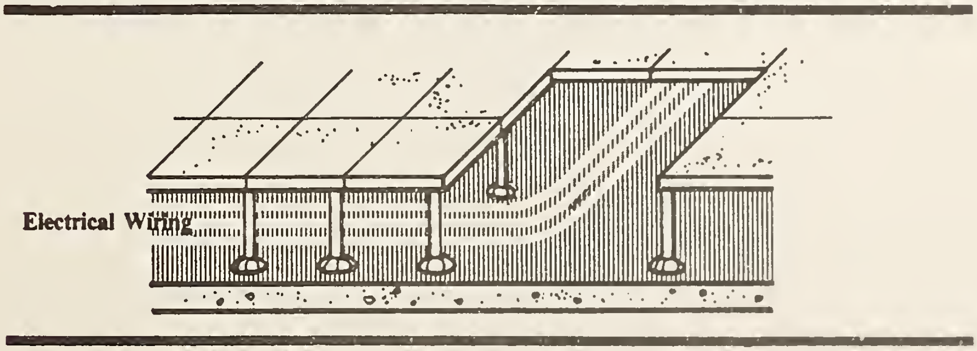


Figure 17. Access Flooring

8.4.5 Ceiling-Based Systems/Power Poles

These systems offer an alternative to underfloor systems. Power poles are used as a direct means of distribution by means of vertical poles or flexible hoses located at workstations.

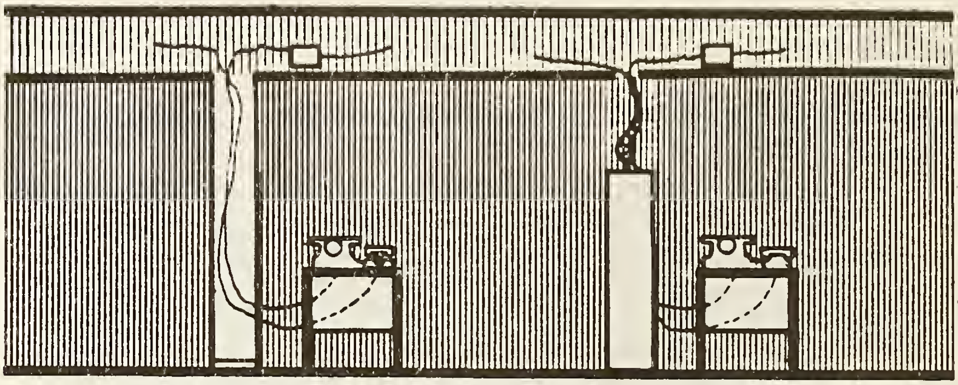


Figure 18. Power Pole

8.4.6 Flat Conductor Cable

This is a rather new approach which is receiving considerable attention today. It offers an option for wiring design in buildings where underfloor ducting cannot be used and conduit combined with exposed ceilings is not desired. Flat cable delivers power and communications services to floor pedestals (power outlets) that serve electric appliances and telephones. Experience has shown that these pedestals should not be placed until workstations have been assembled and last minute adjustments have been made in their location and orientation. (Good coaxial flat conductor cables might be difficult to find.)

Cables can be mounted directly on the floor (with a protective metal shield) under existing carpet tiles. Locational changes and/or new systems are installed by raising carpet tiles in the desired path, and redirecting existing flat cable runs or by tapping into a run. Connections between flat and round cables are made at transition boxes, usually located in walls or columns (37).

8.4.6.1 Flat Conductor Cable Checklist

- Expect to see cable-caused ridges in the carpet tile initially; the problem is often a temporary one.

- The cable cover should not be reused; it will be distorted when pulled up, causing an uneven carpet tile.

- Consider keeping excess material for replacement purposes.

- Plan beyond the pedestal itself:

  - Determine the kinds of wire management needed between the pedestal and the using appliance.

  - Determine the number of outlets needed for each particular workstation.

- Close coordination is required among the following systems: electrical, communications, floor (carpet tiles), and workstations.

- Use undercarpet telephone cable where appropriate.

- Breaks in the wire are difficult to locate.

8.4.7 Workstation Distribution

This consists of pre-wired interconnecting panels in which the need for individual wiring is eliminated. Many furniture systems have power in raceways, but power must be clustered at some point from floor, wall or column; planning of clusters for future expansion is important. (Also see section 13.1).

8.5 TRADEOFFS AMONG ALTERNATIVE WIRING SYSTEMS

SYSTEM	POSITIVE	NEGATIVE
POKE-THROUGH	°Low first cost °No raceway	°Expensive to make changes °Disruptive of activities °Fire safety precaution needed
ELECTRICAL CELLULAR DECK	°Relative flexible °Easy to make changes	°Expensive °Service fittings sometimes protrude; unsightly, tripping hazard
UNDERFLOOR DUCT	°Accessible °No fire safety problem	°Expensive °Difficulty planning for needed flexibility
RAISED ACCESS FLOOR	°Integration of electrical, communications, HVAC °Flexible	°Expensive to install °When frequent changes made, disruptive, hazardous °Many spaces need conventional floors - ramps, stairs needed
CEILING-BASED SYSTEMS	°Easty to integrate with furniture systems °Flexible	°High first cost °Careful planning needed - intrusive
FLAT CONDUCTOR CABLE	°Short installation time °Structural integrity of the floor system kept °Changes can be made readily °Can be used under carpets	°Cable must be shielded from punctures °Careful installation needed to avoid unsightly cable ridges

8.6 ADDITIONAL DESIGN CONSIDERATIONS

8.6.1 Retrofits

Providing adequate methods for concealing and running cables from mainframe computers to peripheral equipment is often difficult in existing facilities. Standard solutions include running cables up inside walls and over ceilings, flat conductor cable systems, power poles, or raised flooring systems.

8.6.2 Upgrading of Cabling Systems

The ability to substitute new technologies for old ones depends on the ability to remove the obsolete systems because of the limited capacity of horizontal and riser space. Cable runs should therefore be visible and accessible over their entire run, and must meet fire safety requirements.

8.7 ENVIRONMENTAL CONTEXT

- Hung ceilings with greater than average depth below the structural member, for coaxial cable, fiber optics, and future air conditioning ductwork. This can sometimes result in aesthetic problems because of ceiling tiles being repositioned incorrectly or chipped from repeated access for maintenance and/or changes.

- Floor to ceiling utility chases can be placed on a regular module. It is readily accessible, but reduces flexibility and limits room dimension and total space arrangement options available.

- Movable walls, floors and/or ceilings are available, with vertical and horizontal chases to accommodate future wiring needs.

- Plug-in cables can be used to connect above ceiling runways to power poles; these systems have traditionally been used for the ready installation of lighting fixtures. For enclosed offices, the plug-in cables can be nested in floor/ceiling assemblies.

- Underfloor soft wiring systems are available with plug-in boxes and harnesses of various lengths to connect with pre-slotted outlets in raised floors.

8.8 CHECKLIST WIRING SYSTEM DESIGN

- With cellular flooring and underfloor ducts, system flexibility is governed by the spacing of electrical cells, but flexibility can be augmented by undercarpet systems.

- Service areas must be designed with sufficient space for distribution boxes and panels to accommodate changes and planned expansion.

- Expansion space is needed in the building core for installing additional bus risers for communications and power.

- Extra sleeves are required for future power and communication cables.

- Additional riser space might be needed on each floor for office automation systems and networking, including mainframe and minicomputer linkages.

- Ceiling heights of rooms must be sufficient to accommodate raised floors; plenums must be deep enough to accommodate present and future needs when these approaches are used.

- Sufficient capacity is needed for feed conduit, vertical risers, telephone closets, and conduit to individual tenants.

- Specific needs of building users should be considered.

- Plenum space needs plenum rated cable approved by local fire regulation agency.

9. COMMUNICATION SYSTEMS

9.1 FUNCTION

It provides the means to transmit information in the form of voice and data, within an office, and to the "outside world."

9.2 BACKGROUND

Several types of communications and/or computer applications are likely in an office. It is anticipated that all workstations will contain a terminal and at least one telephone. The computer service may be provided by dedicated hard-wired connections to desktop terminals, or by using the same wires that serve the telephone, possibly in a local area network configuration. Other possible workstation services are electronic and/or voice mail, electronic filing, and facsimile transmission. The telecommunication system can have a major impact on the level of service provided to office personnel. This system will have important implications for the design of the building and its systems, e.g. cable distribution, wiring closets, riser systems, main telephone room and service entrance. The need to plan for likely future expansion of these services is another requirement.

9.3 CRITERIA

- Voice and data information should be readily transmitted at an acceptable rate of speed.
- Error rates of systems should conform to organizational requirements.
- Systems should have sufficient flexibility to facilitate future changes and/or expansion.
- System features, e.g. capacity, flexibility should meet needs of office activities.
- Sufficient power is needed to meet emergency conditions.
- Systems should have the capability to handle analog and digital information.
- Adequate protection is needed from electromagnetic interference.
- Systems should provide the means to integrate building support (e.g. energy management) and operational data.
- Systems should be designed to facilitate maintenance.
- There should be a single organization responsible for system operation, and problem reporting.
- A diagnostic capability is needed to locate problem - what and where.
- Voice and data communications channels should be separated, unless digitized.

9.4 TYPICAL APPROACHES

The telephone lines or cables cross the property line at the telephone service entrance, where they also enter the building. These lines interconnect with the building cable system at the main telephone terminal equipment room, the "heart" of the building's communication system. (In multi-storied buildings, more than one main terminal room may be needed.) From the main terminal room(s), riser systems are used to distribute the lines to each floor of the building. The particular riser system design used depends on the type and layout of the building and the particular systems being installed. There are two basic types of systems - closed shaft and open shaft. The closed system consists of vertically aligned closets on each floor, connected by pipe sleeves, slots, or conduit through floors. In the open shaft design, the riser cables pass from floor to floor, without being enclosed in closets. Coordination with local exchange company early in the planning process is essential.

9.4.1 Checklist of Network Features (38)

NETWORK APPLICATIONS	NETWORK CHARACTERISTICS 1 Bi-Directionality	2 Freedom from Error	3 Efficiency Despite Burstiness	4 Low Cost Per Bit	5 Connectivity	6 Information Rate	7 Security	8 Privacy	9 Authentication	10 Reliability	11 Full-Duplex	12 Priority	13 Speech Capability	14 Picture Capability	15 Insensitivity to Distance	16 Shortness of Delay	17 Uniformity of Delay	18 Broadcast Capability	19 Mobility	SPACE FOR ADDITIONAL CHARACTERISTICS								SUBJECTIVE RATING OF IMPORTANCE OF APPLICATION
BASIC																												
Transmission																												
Storage																												
Processing																												
Information																												
COMMUNICATION																												
Mail, Messages																												
Duologue																												
Teleconferencing																												
Speech																												
Encrypted Speech																												
Still Pictures																												
Moving Pictures																												
NEOPAPERWORK																												
Telework																												
Augmentation																												
Task Management																												
MANAGEMENT																												
M.I.S.																												
Modeling																												

Figure 19. Network Applications and Features

The framework for defining a communications network is based on a highly layered series of protocols developed by the International Standards Organization (ISO), called the Open System Interconnection (OSI) protocols . . The OSI architecture defines seven layers of communications:

"1. The Physical layer. This defines the electrical and mechanical interfaces to the network. The physical layer specifies the particular signaling means (baseband vs RF for example), the modulation technique adopted, station identification addresses, etc.

2. The Data-Link Level. This is where the actual packet formats are established, along with the particular access control mechanism used to regulate use of the physical network. Data are encapsulated in packets that contain physical addressing information, error detection, etc.

3. The Network Layer. This level determines how to get a message from one network to another one, since many paths may exist. It may use several intermediate steps to get information to its ultimate destination.

4. The Transport Layer. This provides another level of connections between network entities. It manages the connections and segments messages into smaller pieces that the network can support. It may also be involved in error and flow control.

5. The Session Layer. This is used to set up and break communications paths across the network and manage the exchange of data. It is responsible for multiplexing and demultiplexing messages, managing the sequencing and priority of these messages, and providing the needed buffers.

6. The Presentation Layer. It is primarily responsible for making data available to the Application layer in a meaningful fashion. It takes care of protocol conversion, data unpacking, translation, or encryption.

7. The Application Layer. It provides for the identification of users and services, and is responsible for initiation and reliability of data transfers, as well as general network access, flow control and recovery. Utility programs may perform network file-transfers, terminal to network support, etc."

9.4.2 Checklist - Design for Communications Systems

- Telephone Service Entrance
  - Size is determined by the number of lines needed, present and future.

- Main Telephone Terminal Room
  - Location should be close to the center of the riser cable distribution network.
  - It should be convenient to the service entrance.
  - Environmental conditions should be appropriate for the equipment being supported.
  - The size should be sufficient to house existing equipment, accommodate necessary activities and planned expansion.
  - If a non-sealed battery powered or battery backup for non-sealed PBX is installed, separate space should be available for the batteries.

- Wiring Closets
  - Walk-in and shallow types are both used.
  - They should be at least three feet deep unless they open into a circulation area.
  - Access is needed without disrupting normal office operations.
  - Adequate power is required.
  - Environmental conditions should be appropriate for the equipment being supported.
  - Closets for data systems should contain patch panels to cross connect data devices.
  - Sufficient easy access to risers is needed.
  - They should be separated and/or shielded from sources of electromagnetic interference.
  - Lighting should be from incandescent sources.

- Cabling
  - It must be housed in conduits where required, and riser ducts separate from power conductors.
  - It should be separated and/or shielded from sources of electromagnetic interference.

- Networking (See following section)
  - Internal systems should be linked with external ones, e.g. telephone, microwave, satellite.

9.5 TELECOMMUNICATIONS ACCESSORIES (39)

9.5.1 Functions

There are self-contained, plug-compatible devices for word processors, small computers, terminals, and other types of office automation equipment. Once connected they provide direct and automatic access to one or more domestic and international networks.

9.5.2 Criteria

Desirable features are as follows:

- Capability to support multiple private and public networks.

- Access to a text editor.

- Call dialing, connect, disconnect, and reentry features.

- Capability to address commonly called locations.

- Communications port options allowing for selection of one, two, or all business networks.

- Compatibility with dissimilar types of equipment through standard accessory ports.

9.5.3 Checklist of System Requirements

- Appropriate protocols, speed conversions and signaling must be perfectly matched with those of the networks being accessed.

- A national maintenance capability should exist.

- An integral battery back-up system to protect the memory from momentary power outages.

- User-friendly programming features, with instructions in jargon free language.

- Multiple user capability, connecting dissimilar systems.

- Low power requirements.

- The system should be modular, expandable and capable of upgrading

- Capability to perform simultaneous operations - e.g. receiving and sending messages, information status, etc.

- Good record of customer service, preferably through local dealers and users.

10. LOCAL AREA NETWORKS

10.1 FUNCTION

A local area network (LAN) is an electronic communication linkage which may not require public communications facilities to operate. It is typically used by an organization within a building or among a small set of buildings, to facilitate communications and information processing. The LAN is designed to provide the "highway" to optimize network traffic and often trouble shooting capabilities for linking different machines, languages, and operating techniques into a coherent system. Such networks can provide the capabilities of advanced technologies to every worker at every location. They can also provide the means of coordinating diverse activities consistent with overall organizational objectives, e.g. management information systems, security and safety requirements, energy management, and centralized data bases (40).

10.2 CRITERIA

Two types of criteria are important for LAN, those associated with system performance, and those which address design issues.

10.2.1 System Performance

Table 14. Requirements for a LAN (40)

- Relatively high data rates (typically 1 to 10 or higher megabits per second).
- Geographic distance spanning at 1 kilometer or more (typically within a building or a small set of buildings).
- Ability to support at least several hundred independent devices.
- Simplicity, or the ability to provide the simplest possible mechanisms that have the required functionality and performance.
- Good error characteristics, good reliability, and minimal dependence upon any centralized components or control.
- Efficient use of shared resources, particularly the communications network itself.
- Stability under high load.
- Fair access to the system by all devices.
- Easy installation of a small system, with gradual growth as the system evolves.
- Ability to optimize and report status of system elements.
- Ease of re-configuration and maintenance.
- High reliability of devices on network.
- Low cost.
- Easy maintainability.

10.2.2 Design Issues

- LANS should be able to operate under typical environmental conditions of the buildings in which they are located, with normal exposure to dust, humidity and temperature change.

- Equipment may be required to operate within given electrical constraints, e.g. power, voltage, phase, and/or frequency characteristics.

- Sufficient space is needed to accommodate specialized equipment and cabling requirements.

- Sufficient flexibility is needed to readily accommodate planned and unplanned changes and additions with minimal disruption to ongoing activities.

10.3 TYPICAL APPROACHES

10.3.1 Network Configurations

Most local networks are designed to accommodate several hundred stations (nodes), separated from one another by various distances, sometimes as much as a mile. Each node operates as a device (terminal, computer port, printer, etc.) and a communication system, enabling data from diverse organizational elements to be used by an individual working on a given problem or office function. Three types of configurations exemplify the structure of most networks. Table 15 indicates some important positive and negative features of each approach.

10.3.1.1 The Star

This is the oldest arrangement, with a multiplexing device serving at the head of the network. Devices connect directly to the hub by coaxial cable, or a voice/data telephone, or by using some type of modem.

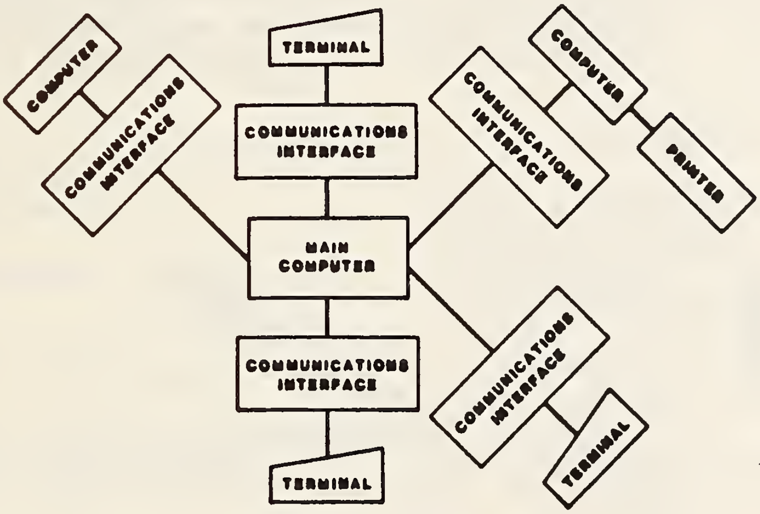


Figure 20. Star network topology

10.3.1.2 The Ring

This configuration eliminates the need for a central hub switcher. A signal repeater is located at each node of the network, enabling signals to travel great distances.

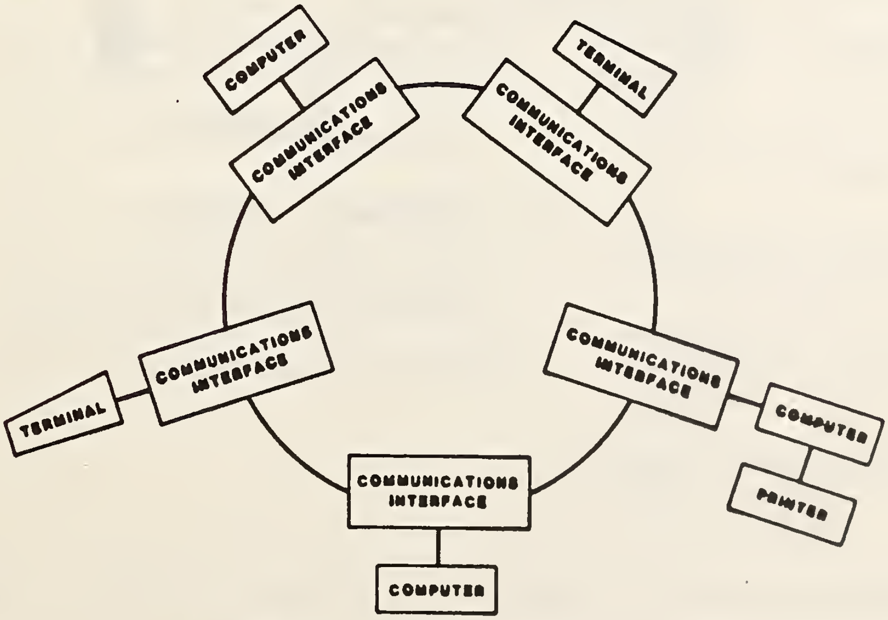


Figure 21. Ring network topology

10.3.1.3 <u>A Bus Network</u>

This is the most common form of network, consisting of a length of coaxial cable (bus), to which microcomputer stations are attached by means of simple cable taps. There is no centralized control hub and signals from one station move along the bus in both directions to all stations tapped into the cable.

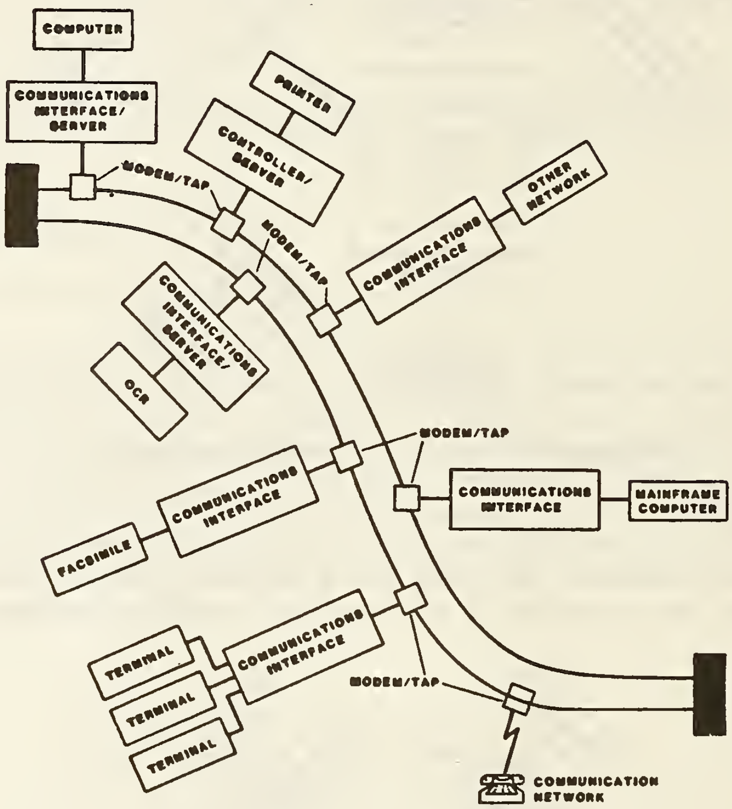


Figure 22. Bus network topology

10.3.1.4 Tradeoffs Among Alternative Configurations of LAN

	POSITIVE FEATURES	NEGATIVE FEATURES
STAR	° Multiple access possible ° Memory may reside in both central and peripheral locations ° Ideal for continuous monitoring of individual and full system performance ° Accommodates fiber optics	° Central processing unit (CPU) malfunction affects entire system ° CPU operational limitations influence system capability ° High load operation calls for careful planned access strategy ° Polling of station is required
RING	° High overall performance ° Each terminal communicates with every other terminal ° Supports distributed decision making ° Repeaters boost signal for large terminal separation distances ° Fault detection and diagnosis from any terminal	° Relatively easy to access (security problems) ° Bandwidth of ring limits data transmission capability ° On-line access control strategy is needed ° If one node goes down, the system cannot operate; redundancy and logic interface unit needed to overcome problem
BUS	° Every terminal communicates with every other terminal ° Control may be decentralized ° Widely used with good results ° Few maintenance problems, use of common bus for data linking ° Easy to add peripheral equipment	° A broken bus cripples all down-line communication ° Relatively easy to access (security problems) ° Bus bandwidth limits data transmission capability ° Strategy needed to control user access; tailored software necessary ° Cannot cheaply accommodate optical cables

Table 15. Positive and Negative Features of LAN Configurations

10.4 ELECTRICAL/COMMUNICATIONS LINKAGES

Four network types are available - twisted pair, baseband, fiber optics. Considerations for their selection depend upon a number of factors:

- The capacity required
- The distances between proposed stations
- The importance of data speed
- The requirements to interfere with other systems
- Acceptable error rates
- Proposed expansion requirements
- Maintenance requirements and constraints
- Cost considerations - first and long-term
- Availability

10.4.1 Twisted Pair

This is the oldest technology and consists of two or more wires connecting devices to one another, sometimes employing a PBX for central switching.

10.4.2 Baseband

Communications are placed on one channel of a coaxial cable or a TWX cable. It doesn't require the dedicated wires associated with twisted pairs. It can connect computers, word processors and other office automation devices on a single floor or limited area.

10.4.3 Broadband

Information is carried up to distances of more than 40 miles by several hundred channels on a cable television type of coaxial cable. The channel bandwidth can accommodate voice, video and data channels at high transmission speeds.

10.4.4 Fiber Optics

Uses light beams traveling through glass threads. Each fiber can carry many channels, and many channels can be packed into a relatively slender cable. The bandwidth is considerable, as is the capacity to accommodate network system terminals.

10.4.5 Tradeoffs Among Alternative Linkages of LAN (42)

	POSITIVE FEATURES	NEGATIVE FEATURES
TWISTED PAIR	° System compatibility through the telephone system	° Limited capacity ° Slow transmission speed ° Lack of shielding make it susceptible to interference ° Large ducts needed for dedicated wires ° Trouble-shooting difficult because of large number of wires ° Connecting with other networks requires interfaces ° Requires ducting, conduit or fireproof coating to meet building code requirements
BASEBAND	° High speed of data transmission ° Relatively trouble free	° Limited range; repeaters needed for more than one mile ° Cable must be "pulled through" the building in most instances ° Connecting with other networks requires interfaces ° Requires ducting, conduit or fireproof coating to meet building code requirements ° Taps must be made at specified points to make connections
BROADBAND	° High speeds of data transmission ° Doesn't require conduit or protective ductwork when using special cable ° Can be fastened directly to walls or ceilings; must be done with care	° Relatively expensive
FIBER OPTICS	° High speeds of transmission ° Bandwidth is very high ° Secure	° Limited to point-to-point applications today ° Maintenance is difficult; splicing tiny and similar cables ° Technology is relatively new; limited operational data available

Table 16. Positive and Negative Features of Wiring Systems

10.5 ENVIRONMENTAL CONTEXT

10.5.1 Space Considerations. Among the considerations are:

- Room for the interconnection of units colocated with support units.
- Available wall and floor space for taps/transceivers.
- Areas within or outside of walls, ceilings, and floors for cabling, and repeaters/amplifiers.
- Dedicated rooms or floor space for network control units placed centrally or distributed appropriately.
- Floor loading.
- Adequate space for working on equipment; maintenance and service support.
- Availability of proper power.

11. LIFE SAFETY SYSTEMS

11.1 FUNCTION

To prevent life and property from harm or loss caused by accidents and natural or man-made events.

Life safety systems include fire protection equipment and systems such as sensors and alarms, extinguishing systems, exit lights, control of emergency exits, emergency lighting, control of fire dampers, smoke exhaust and ventilating fans, and some aspects of site security.

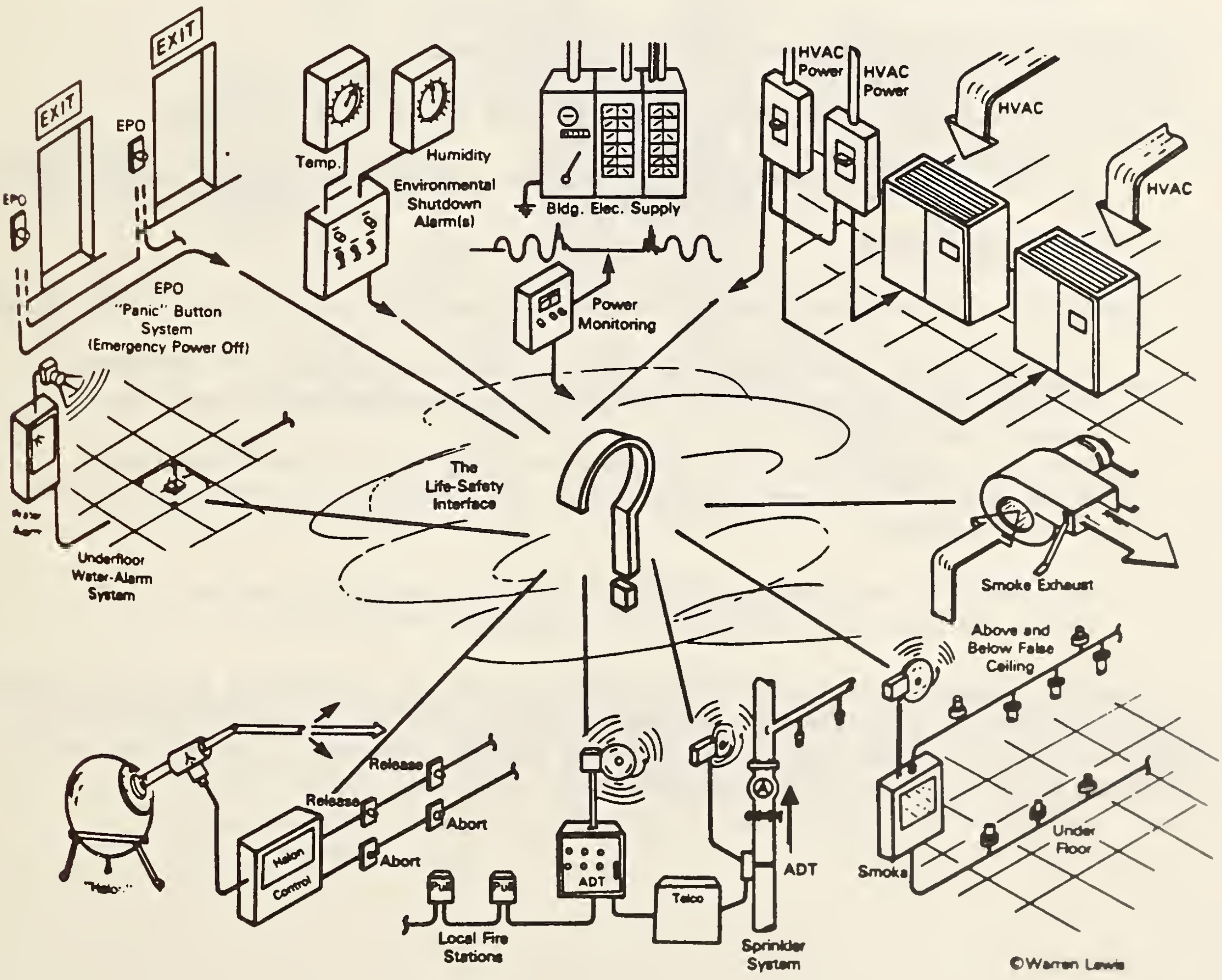


Figure 23. Life-safety interface elements

11.2 CRITERIA

- Ensure the safety of building occupants.
- Minimize the loss of equipment and data in the event of emergency.
- Minimize "downtime" of operations after emergency conditions.
- Establish adequate safeguards against activation of systems when not required.
- Systems should be easy to operate and monitor.
- Systems should be powered independently of main power system
- Systems should be designed to facilitate future expansion and/or changes.

11.3 TYPICAL APPROACH

The design of a life safety system can be accomplished by the following steps:

- Develop a list of all of the life-safety subsystems and individual devices and controls, then list the operating modes of each one.
- Develop a philosophy for linking and prioritizing the operations, showing which systems trigger other systems, or prevent other systems from operating.
- Resolve the time delays, inhibitions, and sequences necessary to eliminate logical conflicts and establish priorities.

If these systems can be placed in a single, readily accessible cabinet, and the circuits properly and clearly documented for installation, maintenance and future additions, many potential problems can be avoided. A possible configuration of such a system appears on the next page:

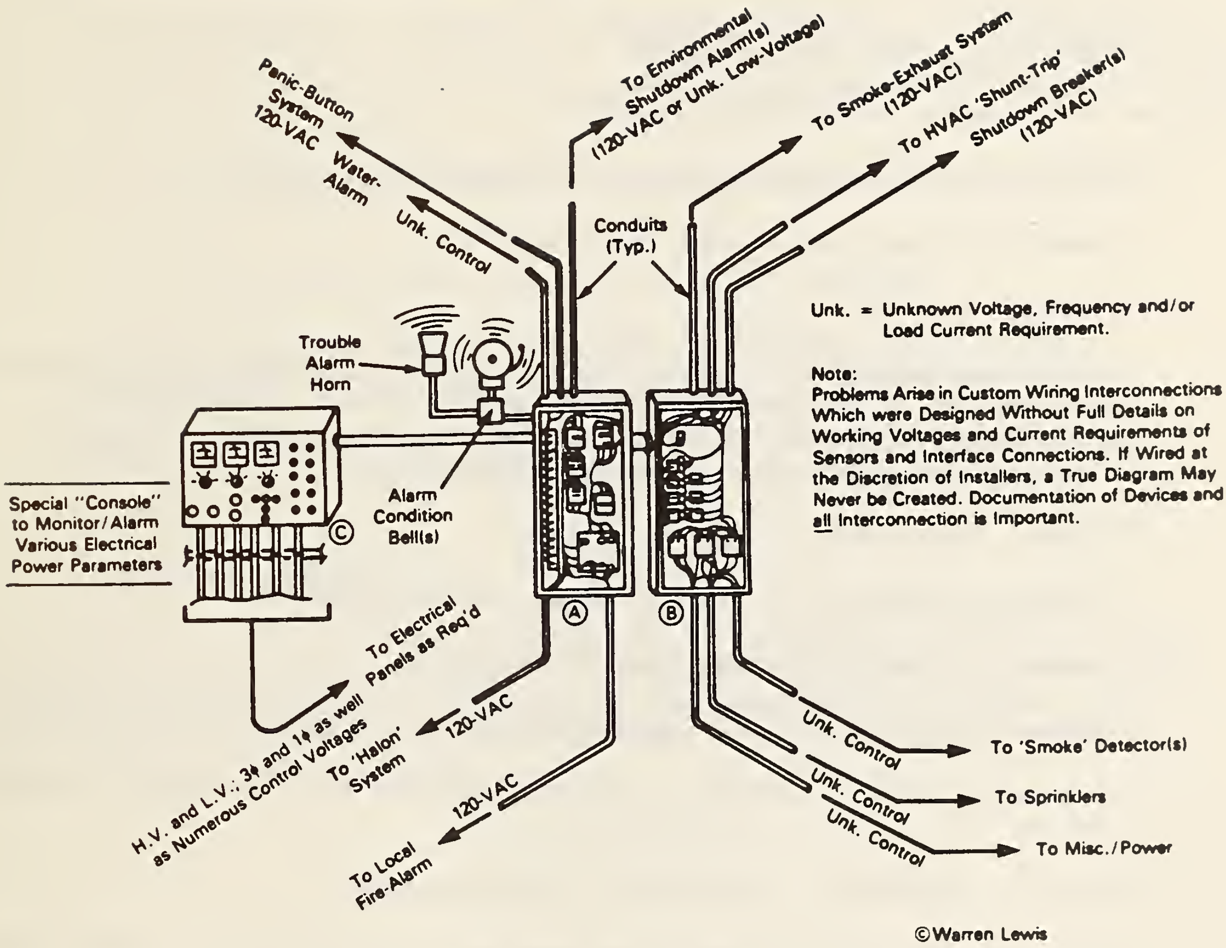


Figure 24. ADP site basic life-safety elements to be coordinated include: A-the halon fire suppression control system cabinet; B--the smoke, fire and sprinkler alarm and arming system cabinet, C--a "console" to monitor other parameters of the environment such as room temperature, humidity, water under the floor, status of power sources, HVAC equipment, etc.

11.4 CHECKLIST - LIFE SAFETY SYSTEMS

Systems should have the following features:

- Smoke detectors based on optical or ionization designs.
- Temperature and rate of heat rise detectors.
- Flame detectors.
- Halon discharge control units which accept inputs from sensing alarms. They supervise the systems, produce audible alarms, provide manual activation and manual override, time delays and equipment shutdown; finally, they suppress fires using halogen gas.
- "Panic" button for turning off power.
- Automatic shutdown of: central computer, HVAC system.
- Automatic startup of smoke removal fans.
- Automatic control of fire dampers, blocking air ventilation passages.
- Controlled personal access to central computer and life safety control system.
- Manual and automatic initiation of alarm systems.
- Fire related circuits should run separately in conduit containing only those conductors.
- A data logging system identifying significant changes in systems; the ability to access information concerning status of system components.
- A schedule for testing primary and backup life safety power systems.

11.5 CHECKLIST - CENTRAL CONTROL OF LIFE SAFETY SYSTEMS

- Location should be convenient to personnel expected to respond to them.
- Controls and displays should be grouped in accordance with major functions, e.g. fire, HVAC, power.
- The grouping of system elements should be consistent, e.g. locations of displays, controls.
- All indicators and controls should be clearly labeled.
- Schematic diagram should be available, including "as wired" and "as installed" corrections for all devices and interconnections.
- Formal acceptance tests should be conducted; scheduled maintenance and testing to verify system performance - typically anually or semi-annually

11.6 ENVIRONMENTAL CONTEXT

The design of the life safety system must be integrated with the other power, electrical and information systems in a building. For example in a building containing energy management and advanced telecommunications systems, the monitoring activities and the associated controls might be centralized with those of the life safety systems.

Following is an illustration of a life safety system control configuration:

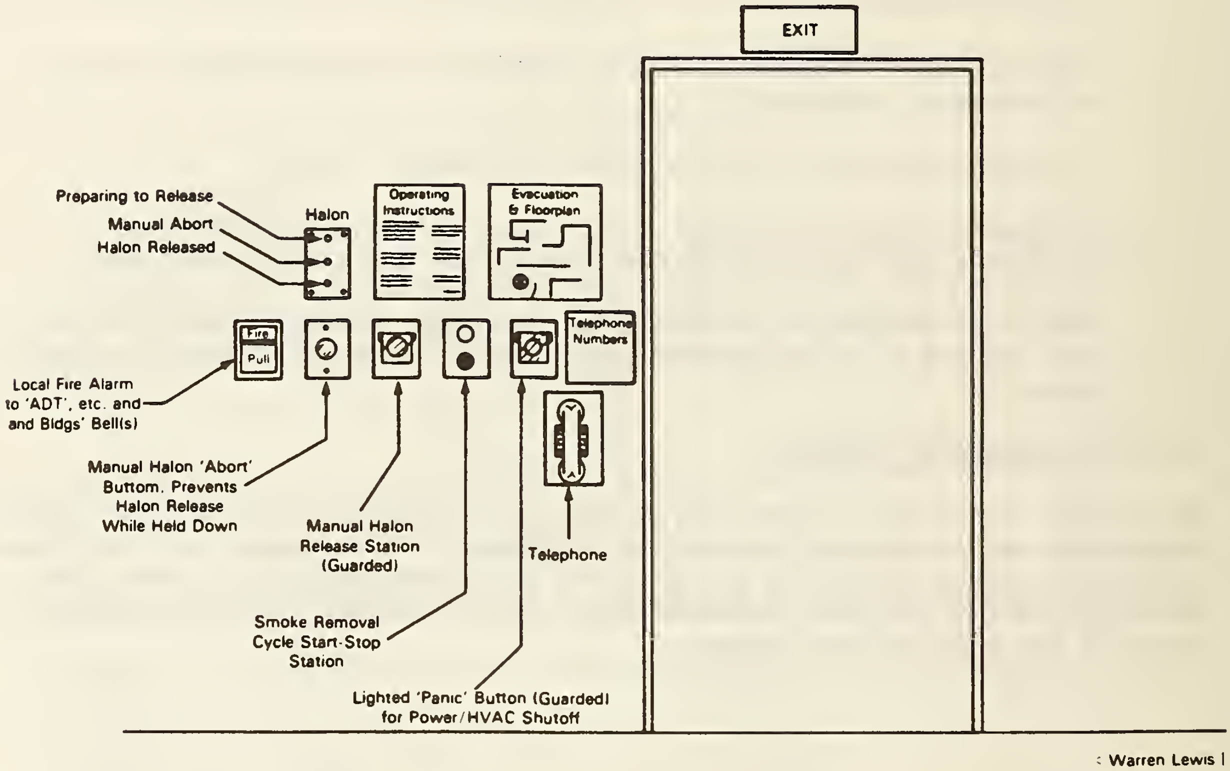


Figure 25. A well-organized, convenient, and coordinated arrangement of life-safety indicators and controls: An emergency telephone with separate line (not via PBX or switchboard) is needed near the exit and the life-safety indicators and controls. The audible alarm should not be so close to the telephone as to defeat attempts to communicate.

12. INTEGRATION OF COMMUNICATIONS AND AUTOMATION SYSTEMS (43)

A key requirement in OA design is the effective integration of the various systems comprising the modern office environment. The capability of integrating communication, monitoring and control systems reflects newly emerging technology which has only been tested in a few applications. Each major function is likely to have its own stand-alone processor with individual function multiplexers connected to them. Subsystems which should be considered for inclusion in an integrated network include:

- Voice and data communications.
- Office automation (and networking).
- HVAC, security, fire safety.
- Elevators.
- Lighting.

Features of the integrated system should be:

- Integration of energy management, HVAC system operations and maintenance, data acquisition and management, fire and smoke management, and system alarms.

- Air handling system, fans, duct smoke dampers, outside air, and exhaust dampers integrated with fire and smoke controls.

- State-of-the-art sensors.

- Distributed building automation system with stand-alone field interface devices.

- Direct digital controls.

- Conventional/adaptive algorithms for HVAC system controls.

- Fire system overrides other systems when necessary; it is operational at all times and secure from interference.

There are various levels of system integration:

- Non-integrated. Each system has stand alone processor and dedicated cabling.

- Shared cabling. The minimum level of integration involves separate processors and sensors or terminals with shared conduit and/or cable.

- Interfaced sub-systems. Separate, stand alone processors, actively interfaced to share data and communicate with one another. Cabling may or may not be shared.

- Total integration. Shared processor(s) and cable highways.

12.1. CHECKLIST FOR SYSTEMS INTEGRATION

- Which functions are integrated/controlled?
- Which functions can or must be controlled separately?
- For each major integrated function, what operations are controllable, and what features of control, programmability, input/output, display, etc. are available?
- What is the "architecture" of the system, i.e. central/distributed; redundancy, sensor types, conductor media?
- How does the system assure reliability?
    - What is done to protect functions, zones, the entire system?
    - What manual backup systems are available?
    - Who provides emergency repairs; how long will it take?
- What are the initial and operating costs of the system (including maintenance and repairs)?
- Does the system require dedicated staff to monitor and operate it? If so, what training and experience is needed?
- What special physical requirements does the system have, e.g. size of central and distributed processors and control panels, HVAC and power, cable runs?

ISSUES	PRESENT OFFICE	AUTOMATED OFFICE	POSSIBLE IMPACT
INTEGRATION SYSTEMS			
° Voice/data interface	Separated	Integrated using state-of-the-art equipment	- Less space - Power cables - Raised flooring - overhead ceilings with plenum Patch panels - Distribution systems - Data highways
° Security	Stand-alone	Integrated	- Electronic sensors - Fewer personnel - Less space - Maintaining devices
° Electrical	Decentralized	Centralized and integrated	- Automated - Cabling - Lighting control - Monitoring system
° Fire-safety	Separate system	Integrated with "Central nervous Systems	- Sensors - Automated - Alarms - Wiring
Environmental	Separate heating and A/C systems	Energy management system	- Automatic control - Wiring - Less space - Central control
° Telecommunications			
- Telephone Systems	Stand-alone voice	Combine voice/data (Digital PBX's)	- Different cabling requirement - Less equipment room space - Less equipment - Network implications
- Local area networks	Decentralized, stand-alone	Centralized, integrated	- Combined with other equipment systems - Cabling requirements - Interface - Interoperability - Equipment definition - Structure requirements
- Point-to-point and external communications systems	Dedicated Telephone lines	Hybrid (satellite, microwave fiber-optic, and telephone lines)	- Roof antennas - Cabling - Site surveys - Space for concentrators - multiplexors, etc.
- Facsimile (FAX) Systems	Stand-alone	A network integrated with other systems	- Interfaces - Cabling - Environment consideration
- Types of Cable	Multipair (3+) twisted copper, coaxial cable	Large capacity fiber triaxial Radio and/or Infrared Multimedia in single jacket Twisted fiber; coax replacement	- Increased size, protection of equipment in closet - More space needed for closets, vertical cable distribution

Table 17. Integration and Telecommunications systems - Possible design impact (43)

13. OFFICE MATERIALS (44)

13.1 NATURAL AND SYNTHETIC FABRICS (27)

13.1.1 Function

Aside from its other practical and aesthetic features, a major purpose for the use of fabrics is to contribute to the desired acoustical performance of the automated office. Fabrics are used extensively for floor coverings, furniture and panel systems, as a means of controlling noise and enhancing auditory privacy.

13.1.2 Criteria - Checklist (Fabrics)

- Permanency. Will the fiber content fade in the sunlight or disintegrate with age?
- Moisture and mildew resistance. Does the weave allow dimensional stability for dry and humid conditions? Will dampness promote mildew?
- Maintenance. Is is resistant to abrasion? Can it be washed, dry-cleaned or refinished?
- Fire resistance. Is it flameproof? Will it melt and produce dangerous flames and/or fumes?
- Installation. Is it easy to work with? Can it be easily replaced?
- Thermal resistance. Will it expand or contract with thermal absorption?

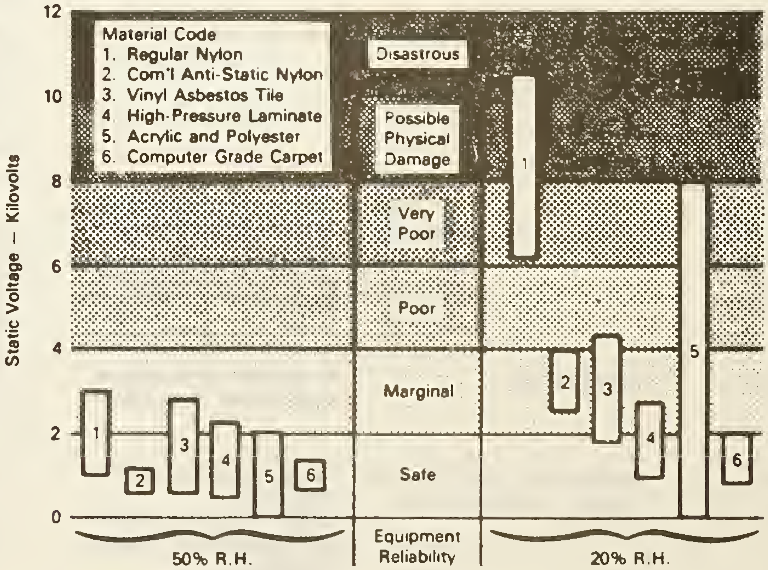


Figure 26. Typical static voltages generated by walking on common floor covering materials (18)

- Weight. How heavy is the material? Can it be easily handled?
- Sound absorption. What are its characteristics with respect to absorbing, dampening, reflecting sound?
- Appropriateness. Is it consistent with the uses of the space?
- Availability. Can the material be obtained for replacement and expansion purposes; for how long?
- Decorative palette. How varied are the colors and textures?
- Price. Is it cost effective?

13.1.3 Carpet Material Characteristics (27)

MATERIAL TYPE	POSITIVE FEATURES	NEGATIVE FEATURES
Wool	• Warm, soft and resilient • Fire and mildew resistent • Doesn't attract dirt • Resistant to aging and abrasions • Good color fastness to sunlight	• Supports static • Expensive
Nylon	• Very tough fiber • Good static control • Resistant to mildew • Resistant to aging and abrasions • Blends well with other fibers	• Melts on contact with flame • Attracts dirt
Polyester	• Water resistant, soft • Resistant to mildew • Resistant to wear and abrasions	• Loses strength with exposure to sun
Acrylic	• Good wearing properties • Resistant to sunlight • Resistant to abrasions • Low static electricity	• Poor soiling and cleaning properties
Polypropylene (Olefin) Indoor/Outdoor	• Resistant to acid, chemicals • Resistant to mildew, water exposure	• Low heat resistance

Table 18. Carpet Materials - Positive and Negative Features

13.2 CARPET TITLE

Office automation has led to the increased use of carpet tiles for floor coverings. Their modular design provides underfloor accessibility, easy maintenance and replacement consistent with the need for flexibility.

13.2.1 Criteria

The following performance features are important when carpet tiles are employed:

- Abrasion resistance and wearability.
- Appearance retention; the ability to withstand crushing, fading, soiling and maintenance.
- Proper maintenance.
- Appropriate combustion and smoke performance characteristics.
- Inhibiting the accumulation of static electricity through built-in special fibers, wires or coatings.
- Cost-effectiveness as compared with the materials and maintenance cost of alternative choices.
- Maintenancy of critical performance features after initial installation, e.g. loss of adhesion.

14. OVERVIEW - SPECIALIZED SPACES

A comprehensive literature search combined with a questionnaire survey and a roundtable meeting formed the basis for the information contained in the present document. These activities, augmented by interviews with architects and other professionals, resulted in the identification of specialized spaces which merit consideration in designing for office automation (46).

- An atrium. This can be used as a means of offsetting the technological emphasis of the automated office, by providing a connection with the outside, a change in scale, and a place for social contact.

- Training and media presentation rooms. Organizational and technological changes occur at such a rapid rate that a continuing need exists to upgrade personal skills and transmit information to staff members.

- Meeting rooms. With the popularity of open-space design, fewer spaces are available for private meetings of small groups of people. Such spaces, and those which can accomodate larger numbers of people are required to facilitate staff interactions, and offset the isolation inherent in many VDT-based activities.

- Centralized reproduction facilities. New and sophisticated systems provide the capability to produce documents with the quality formerly available only from printers. The cost of such systems can only be justified by organization-wide use. These systems are usually quite noisy and should be acoustically isolated from the general workfloor.

- Centralized information storage. For the forseeable future, paper will continue to be an important media for storing information. In addition, microfiche, magnetic tape and disks must be stored. The latter two types of storage require careful environmental control.

- Centralized communications and information processing. More offices are likely to contain CPUs and systems such as telex and facsimile reproduction. Such equipment require specialized spaces and facilities for occasional users.

- Equipment areas. As more technology is moved into the office, an increased need exists for spare parts and replacement systems as well as facilities for simple maintenance and checking. The demand for these resources is likely to accelerate as office activities are more dependent on automation, since equipment outages will be very costly in productivity.

- Clusters of offices, grouped on the basis of similarity of activities.

- Furnishing storage. With the popularity of open-office design, the increased acceptance of ergonomically responsive furnishings (tailored to individual needs), and the need to respond rapidly to change, there is likely to be a substantial need to maintain an inventory of furniture, panels, etc.

- Magnetic media storage. Careful environmental control is required to ensure that information is preserved. Warping and stretching occurs in hot environments. Low humidity can cause problems due to static buildup, allowing dust and dirt to accumulate. Variable environmental conditions can affect the longevity and reliability of media performance. Among other potential problems are:

  - Magnetic fields. Media should be kept away from transformers or large motors that generate magnetic fields.

  - Shock and vibration. These conditions can cause discs to lose information.

  - Chemical solvents. Volatile chemicals can degrade media, and should not be stored nearby.

14.1 TELECONFERENCE FACILITIES

14.1.1 Function

The high cost of travel and the proliferation of organizational meetings has increased the demand for the capability to conduct meetings remotely. The technology required to accomplish this has been available for some time, with costs being the major obstacle. Technological advances have resulted in substantial economies and increased communications capabilities, and it is anticipated that teleconferencing facilities will become more commonplace in the near future.

A teleconference is a meeting involving two or more people at two or more different locations, with discussions being transmitted through audio, digital, and/or video techniques. Video teleconferencing offers the greatest potential for substituting for meetings because of the availability of powerful technologies to simulate a live meeting.

14.1.2 Criteria

- The room should facilitate the communication of verbal and visual information and reflect the design needs of the system vendor.

- The space should be free from visual and noise distractions.

- Required support equipment should be readily accomodated without imparing communications.

- The decor of the room should be consistent with the normal work area of the major users.

14.1.3 Environmental Context

- The location of the room should be suitable for those expected to use it. It should not be part of an executive suite, unless top management are its primary users. In most instances middle managers can make most effective use of these facilities.

- The room should be located away from mechanical devices such as elevators, central air conditioning and heating, and from street and office sounds.

14.1.4 Support System Considerations

14.1.4.1 Acoustics

- Existing rooms are often converted to teleconference facilities, creating acoustical problems in some instances. Most such rooms are constructed of standard building materials that are 4 feet by 8 feet rectangles. These dimensions often lead to a room designed with a ratio of length of width to height of 3:3:1, which reinforces many negative acoustic properties such as reverberation. A ratio of 5:3:2 is more preferable. A still more effective way of reducing acoustical problems is to use non-parallel walls and/or having large pieces of furniture in the space to scatter sound.

- Careful acoustical treatment of all surfaces, walls, ceiling, and floors is required in such facilities.

- The noise from the support equipment can be minimized by locating HVAC equipment required for teleconferencing in acoustically isolated adjacent spaces.

14.1.4.2 HVAC Equipment

- In a fully equipped room containing facsimile systems and VDT equipment, provisions must be made for proper ventilation and for the air conditioning equipment.

14.1.4.3 Lighting and Color

- Because of the need to see people and visual displays clearly, lighting and color selection for the room are of critical importance.

- Room surfaces should be non-specularly-reflective. The colors selected, including those of carpets and furnishings should have neutral tones. (47)

- The system vendor should participate in the decision process for making lighting and color selections.

15. SUMMARY AND RECOMMENDATIONS

Developing appropriate designs for new office technologies poses a major challenge to the design and engineering professions. Since office automation is a relatively recent phenomenon, and one not yet subject to much systematic study, it would be premature to formulate performance criteria for office settings. However, designers have had to cope with these new technologies for more than a decade using a variety of design practices devised on the basis of their experience and professional judgement. These practices, together with published material in design and research publications, form the basis for the present report. Since this document is based upon limited findings, it is designated as an 'interim' guideline, with the anticipation that it will be periodically updated as better information becomes available. One method that might be used to upgrade the guideline is to have roundtable meetings of users and designers on a regular basis, perhaps annually.

As noted in the introduction of this report, the automation of office activities has profoundly affected the office as a place to work in ways that are not yet well understood. General agreement exists among office automation experts however that a broad range of interdependent issues should be considered when planning to automate office functions. These issues include: management, information processing, human resources (ergonomics), telecommunications, technological, and design.

The differences between the traditional office and the automated one has greatly increased the importance of office design as a contributing factor to organizational effectiveness. In the traditional office there is considerable opportunity for personal interaction among employees. For example, since most information exists in paper form, it must be physically handled and transmitted manually from person to person. Exchanging information and the drafting of documents therefore provides the opportunity for conversation and social exchanges. There is also a one-on-one relationship between the person initiating a document and the one responsible for putting it in final form, e.g. typing it. With the advent of electronic based information systems, a person at a workstation often communicates only with a VDT-based terminal during an eight hour workday. Little need exists in many activities to work personally with office colleagues. As a result, office workers have complained about a sense of isolation, and being subservient to technology (1). Office design can be used to alleviate these problems by providing places for informal conversations and a general appearance which provides visual relief from technology.

Technology has influenced the composition of the office workforce. It has had the effect of increasing the numbers of professionals and managers in the workforce, as a greater percentage of people are engaged in white collar work. These knowledge workers have demonstrated that they want a "high quality" work setting which is responsive to the mental and physical demands of their jobs. Questionnaire surveys have identified a desire for visual and auditory privacy, glare-free lighting, and control of the immediate environment as being important design issues for knowledge workers (4).

Unfortunately, at a time when the quality of the work environment has become more important, the introduction of technologies into offices has frequently resulted in a loss of environment quality, e.g. machines producing noise and heat being placed on desks designed to suport paper-based activities. This has occurred because office automation to date has been largely hardware-driven. It has resulted from the purchase of individual machines and components purported to increase office productivity. There has been insufficient planning for office automation in too many instances, especially with respect to design consequences (9).

Looking toward the future development of design criteria for office automation, improved information is needed in the following areas:

- Determining the effectiveness of the design practices that have been used to date. Considerable experience has been gained by the federal government and the private sector, but few systematic findings are available in the public domain. Evaluations of approaches that "work" or don't "work" would result in considerable dollar savings.

- In recent years, office design has followed a trend to open-space planning for traditional and automated office functions. Yet, surveys of office workers have indicated many problems with such designs. Post occupancy evaluations of these designs for automated offices should be conducted.

- Technological advancements have permitted the automation of many building systems, operational, service and environmental. However, the tradeoffs associated with such automation are not well understood and require investigation. For example, studies have shown that workers want more, not less control of their workspaces and environments (5).

- The integration of operational systems with other building service systems is receiving considerable attention by designers, but little consensus exists as to how to achieve this result. Field studies are required to develop the data needed for design criteria to accomplish this important function.

- In response to the need for better office automation planning, an improved architectural programming process should be developed. It should facilitate the incorportation of needed technologies into the office in a way that minimizes the disruption of ongoing activities, and do so in a cost effective manner.

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GLOSSARY

AMBIENT LIGHTING	- Lighting throughout an area that produces general illumination.
ANTHROPOMETRY	- The study of human body measurements, especially on a comparative basis.
AI	- Articulation Index.
ARTICULATION INDEX	- A numerically calculated measure of the intelligibility of transmitted or processed speech. It takes into account the limitation of the transmission path and the background noise.
ASHRAE	- American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
BASEBAND	- The band of frequencies occupied by all transmitted signals used to modulate the radio wave that is produced by the transmitter in the absence of a signal.
BROADBAND	- A band with a wide range of frequencies.
BUS	- A length of coaxial cable, to which microcomputer stations are attached.
CENTRAL PROCESSING UNIT	- The computer at the center of an on-line system which performs the processing according to an applications package.
COAXIAL CABLE	- A transmission line in which one conductor is contained inside and insulated from an outer metal tube that serves as a second conductor.
COEFFICIENT OF UTILIZATION	- The ratio of luminous flux (lumens) from a luminaire calculated as received on the work-plane to the luminous flux emitted by the luminaire's lamp alone.
CONTRAST RENDITION FACTOR	- The ratio of visual task contrast with a given lighting environment to the contrast with sphere (uniform) lighting.
CPU	- Central Processing Unit.
CU	- Coefficient of Utilization.
dB	- Decibel.

DECIBEL	- The unit of sound intensity.
DIFFUSER	- A device to redirect or scatter the light from a source, primarily by the process of diffuse transmission.
DISABILITY GLARE	- Glare resulting in reduced visual performance and visibility.
DISCOMFORT GLARE	- Glare producing discomfort; not necessarily interfering with performance.
DP	- Data Processing.
EFFECTIVE TEMPERATURE	- A combination of air temperature, air velocity, and relative humidity, used to define a comfort zone for people in buildings.
ERGONOMICS	- A subject area which deals with the interaction of person/machine and person/environment issues.
ET	- Effective Temperature.
FIBER OPTICS	- Very thin strands of glass, used to transmit information by means of light pulses.
FLANKING PATH	- Noise transmission by an indirect path, e.g. structural element.
HID	- High Intensity Discharge.
HIGH INTENSITY DISCHARGE	- A general group of lamps consisting of mercury, metal halide, and high pressure sodium sources.
IESNA	- Illuminating Engineering Society of North America.
ISO	- International Standards Organization.
KNOWLEDGE WORKER	- A person with major responsibilities for developing, analyzing and/or acquiring information, e.g. manager, professional.
LAMP LUMEN DEPRECIATION FACTOR	- The multiplier to be used in lighting calculations to relate the initial rated output of light sources to the anticipated minimum output based on the relamping program to be used.
LAN	- Local Area Network.
LOCAL AREA NETWORK	- Systems of computers and peripheral devices linked together in adjacent offices or buildings.

LUMINANCE CONTRAST	- The relationship between the luminance of an object and that of its immediate background.
MICROCOMPUTER	- A term used to describe the small physical size of a computer.
MULTIPLEX	- To interleave or simultaneously transmit two or more messages on a single channel.
NC CURVES	- Noise Criteria Curves.
NOISE CRITERIA CURVES	- Criteria used to rate the acceptability of continuous noise levels for performing given activities.
OA	- Office Automation
OCR	- Optical Character Reader.
OPTICAL CHARACTER READER	- The reading and identification of characters optically, under computer control.
PBX	- Private Branch Exchange.
POWER SURGE	- An increase of voltage levels 10% or more above normal, lasting from one half cycle to several seconds.
REFLECTED GLARE	- Glare resulting from specular reflections of high luminances on polished or glossy surfaces in the field of view.
SIGNAL TO NOISE RATO	- The ratio of signal intensity to noise intensity, usually expressed as the decibel difference between the signal and noise levels.
SIL	- Speech Interference Level.
SOUND ABSORPTION	- The change of sound energy into another form, usually heat, in passing through a medium or striking a surface.
SOUND TRANSMISSION CLASS	- The preferred single figure rating scheme designed to give an estimate of the sound insulation properties of a partition. Used when speech and office noise constitutes a major problem.
SOUND TRANSMISSION LOSS	- A measure of sound insulation. The amount of incident sound passing through a partition.

SPEECH INTERFERENCE LEVEL	- The arithmetic average of the sound pressure levels of noise in the three octave bands centered at 500, 1000, and 2000 herz.
SPIKE	- A sudden but brief electrical disturbance, reaching thousands of volts, with frequencies up to the megaherz level.
STC	- Sound Transmission Class.
STL	- Sound Transmission Loss.
TASK/AMBIENT LIGHTING	- A combination of task and ambient lighting in a given area, with the ambient lighting being lower in intensity and complimentary to the task lighting.
TWISTED PAIR	- A cable comprised of two small insulated conductors twisted together without a common covering.
TWX	- A network of telegraph-grade communications lines and terminals used to transmit messages.
UPS	- Uninterruptable power systems.
USER FRIENDLY	- A system requiring only a limited amount of experience, knowledge, or training to operate.
VCP	- Visual Comfort Probability
VDT	- Video Display Terminal.
VEILING REFLECTIONS	- Regular reflections superimposed upon diffuse reflections from an object that partially or totally obscures the details to be seen, by reducing the contrast.
VISUAL COMFORT PROBABILITY	- The rating of a lighting system expressed as a percent of people who, when viewing from a specified location and in a specified direction, will be expected to find it to be acceptable in terms of discomfort glare.
WHITE NOISE	- An acoustical stimulus composed of all audible frequencies at the same intensity with random phase relations between them; it sounds like "shhhh".
WORKSTATION	- The general physical environment in which the user works. It includes computer terminals, source documents, desks, chairs and lighting.
WP	- Word Processing.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

This report presents interim guidelines for the design of offices using automated technologies. It is based upon findings obtained by an extensive literature search, a questionnaire survey of design firms, an office automation roundtable, and interviews with design and other office automation professionals. The guidelines should be considered tentative, since the information is based primarily on judgement, rather than on formal investigations or on broad concensus from the design community. Furthermore, many important design issues have not been dealt with, because they have not yet been appropriately considered, and/or it is unclear what the design implications of automation are - e.g. will overall space needs be greater or less?

The introducation of automated systems into offices has changed the office setting as a place to work. Architects and other design professionals have responded to this technology by formulating a variety of design strategies. This report identifies design issues which merit consideration in automated offices, tentative criteria for environments and systems based on an overview of all resources used to develope this document, and typical approaches used accomplish design goals. Technological, ergonomic and organizational factors are considered from the standpoint of design implications.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

acoustics; design criteria; electrical systems; ergonomics; lighting,noise; office automation; office design criteria; office furnishings; safety systems; workstation.

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