# Mechanical Systems and Libraries

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## Introduction

THE ADVENT OF THE printing press brought a revolution, a continuing flood of printed material and audiovisual material—books and magazines, microfilm, tapes, and more—that affects every library. There is another well-known revolution affecting our culture and libraries—a technological revolution. As these changes affect our libraries, they also affect our library buildings. New conditions have developed today that give rise to some of the current approaches in mechanical, electrical, structural, and spatial design.

In this context, total building performance is crucial. Any building must be seen as an interrelationship between systems, between systems and the building, and between the building and the program. The challenge of design is to look at an integrated approach.

It is generally understood that a library is a multiuse building. It is not only a resource facility but also an educational learning center for all ages, a media center, a museum, a communications center, and more. This must be kept in perspective in order to address total building performance of mechanical and electrical systems that meet these various programs and needs which include browsing through books, papers, and periodicals to serious reading, listening to music, audiovisual presentations, electronic data transmission, data storage and retrieval, word processing, duplicating processes, clerical functions, office procedures, special events, and the list goes on and on.

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Occupancy patterns affect mechanical and electrical systems. Libraries are occupied year-round—throughout the day and at times well into the night. Generally staff members are in the building for an extended period of time whereas most users are there for only short time periods (some users do remain for longer periods). All ages, sexes, physical and mental capacities are there and the facilities must accommodate this variable occupancy and use.

It is a tough design job to take care of all of these multiple requirements and activities. It is difficult to create distinct environments within a building while retaining adaptability. However, each activity has a distinct requirement—thermally, visually, acoustically, spatially—and the challenge is to look at the distinct environmental requirements and how they interface.

## The Library Planning Team

Any building project, of course, involves a planning team. The library planning team usually includes the librarian, representatives from the library's governing authority, an architect, an engineer, and a library consultant. Today it can also include a lighting consultant, an electronics consultant, and a physiologist. These added participants can help to address the great variety of technical and ergonomic issues raised by a building project.

The team develops a functional program and, although the planning may be largely a task for the librarian and the consultant, the entire group can contribute to developing a functional building program. It is a team effort (we talk about total building performance, but there is total team performance, too). The written building program should include a spatial environmental program. This part of the program describes what has to happen with the temperature and environmental controls in each individual, discrete portion of the building for each hour of operation.

The final program should describe not only what *should* happen in the building, but what you think is *going* to happen in the future. Since it is hard to be a soothsayer, a building must be not so flexible as adaptable.

I take issue with the use of the word *flexible* because flexibility suggests redundancy. If mechanical systems are put on a grid—the lights, the air diffusers, the speakers—the building will have the flexibility to do just about anything, any time, but some of this is redundant because much equipment is installed and never used.

Instead, adaptability should be encouraged. Insist on a building that can accommodate change—even change that is unknown today. When we were designing the mechanical and electrical systems for the Salk Institute, we asked the client what was going to happen in the building and to give us a program and he replied that if he knew what was going to happen in the building he wouldn't need it. What he was saying was inherently the very nature of the building changes; design a building to accommodate whatever is going to happen in the future, but don't spend any money now doing it. This is a good trick.

In writing a functional program for present and anticipated use, the prognosis must be very modest. We can project five or ten years ahead, but it is harder to see twenty or thirty years into the future. On the other hand, an adaptable building can allow for change, and it is the building's mechanical and structural systems that are called upon to accommodate change if and when it occurs.

Part of the planning team's duties will be to examine whether to build new or retrofit (add onto the existing building or convert an existing structure). Certainly there are other important issues, but this one always comes up. Everybody loves a new building. It's a clean slate—a new piece of ground, a new building, a new program. You can do almost anything you want (if there's money), and you have a lot of freedom of choice to do it. On the other hand, when retrofitting a building, constraints are built into the program, and a serious evaluation of the existing facility must be done before a decision is made to go ahead with a retrofit.

An inventory should be made of structural, mechanical, and electrical assets and liabilities. The building must be evaluated for its condition and conformance with current codes and standards (for access, energy use, etc.) or its ability to be brought into conformance with code. Are the ceiling heights able to accommodate ducts, pipes, materials, and cables? Can the building accommodate programmatic, environmental, and spatial requirements? What are the liabilities?

There are always economic issues involving not only initial costs but life-cycle costs—what will it cost to own and operate the building over its lifetime? It is often possible to raise funds to build a library, or retrofit an existing building as a library, only to find that funds are not available for operations. Government support programs have been cut down tremendously, and it can be very hard to get funds to operate these buildings. Other things to be considered include:

—*Infrastructure.* Are the needed services available? Is there sufficient power, water, sewage disposal capacity delivered to the site?

—*Scheduling and staging.* How do you schedule the changes within the existing building so that you don't have dust, dirt, noise, and interference with the continuing activities? It may be beyond what the building can accommodate.

These are among the questions that should be answered before a decision is made on whether to build new or retrofit. As an aside, I must also note the importance of acceptance testing and postoccupancy evaluations.

The architect and engineer are responsible for specifying the acceptance tests to be run on a building before it is occupied. Acceptance tests are intended to pick up any differences between what was designed and what was built, but typically, when the final testing for occupancy is done, there is insufficient environmental testing.

Mechanical systems in buildings almost never run at full capacity—a full load occurs maybe 2.5 percent or 5 percent of the time during these evaluations. But acceptance tests are usually specified as a full-load test and I have never seen a thorough part-load test of a building.

What happens at part load? The air distribution pattern changes, the lighting effect is different, and the energy consumption and loads are different. As a result, equipment operating at part load may have lower efficiency than at full load.

A post occupancy evaluation is equally important and unfortunately it is hardly ever done. This evaluation asks does the building operate the way it was conceived? Does it meet its functional needs? Does it meet the environmental need? Does it use the amount of energy that was predicted?

Beyond the building itself, the planning team must also consider external influences for change. Change is happening in telecommunications and mechanical and electrical systems. There are changes in energy management systems and in building materials.

Energy issues may appear to be on a short-term hiatus, but another cycle will surely come around and hit us. Like a hurricane, we are in the eye of the storm. When the next energy cycle comes around it is going to be worse than before because of the finite nature and progressive costliness of mining and using energy supplies.

Libraries are not static any more than any other kind of building. There are changes in programs and services, and there will be changes in the building itself. A raised floor offers one design strategy to help libraries adapt to change.

**Raised Floors**

The raised floor consists of metal panels, usually two feet square, mounted on pedestals to form a continuous duct eight to twelve inches above the base floor to the underside of the raised floor. The ribs which act as stiffeners for each panel are filled with lightweight concrete to deaden sound and decrease deformation. Carpet squares are then put down on top of each panel. Any panel or group of panels can be lifted for access to ducts and cables which are placed in the void created by the raised floor.

Initially, this system was designed for computer floors installed in a generally limited area. Today entire buildings are designed with raised floors. The raised floor was originally for cabling for both power and communications. A raised floor permits the relocation of electrical and data transmission services in support of changing work patterns.

In some new installations, duct work is run through a raised floor too. The air supply might be in duct work with the return in the plenum surrounding the duct work, or the return might be in the duct work and the supply might be through the floor plenum.

Is a raised floor necessarily the best option? There is no one good answer. For a very small area, I would say no. Flatwire installed under removable carpet squares is less expensive. Flatwire is fine if extended out from the wall ten to twelve feet, but it has a limited applicability in a large area. If you want to cross an entire room, flatwire is not necessarily desirable because you have to disturb everything in the way to do it, and capacities are limited.

Another consideration to be made is that raised floors appear to be costly. It does cost about six to eight dollars a square foot more for this type of floor. In a multistory building, however, floor-to-ceiling height is saved because you do not need a full hung ceiling, and the savings in construction costs as a result of the building's lower overall height more than offset the cost of the raised floor. Also, future changes to power and communications cabling and ducts can be accomplished at much less cost than extending these services in hung ceilings or other types of distribution.

The raised floor also has the advantage that mechanical and electrical systems can be installed or relocated while working on the floor. This arrangement is a lot cheaper than working overhead on scaffolding, so there are actual savings in the installation costs with a raised floor. So for any area where change is anticipated, a raised floor system is worth analyzing.

## Lighting Considerations

Another consideration in planning for a new library or a retrofit is new developments in lighting—indirect, direct lighting, and more use of daylighting. People react physiologically and psychologically more positively under daylighting. Natural lighting is increasingly popular again, and there are many ways of bringing daylight into a building—e.g., an atrium, toplighting, a clerestory with clouded film to cut down glare (it is crucial in all cases to cut down glare) and now in development, fibre optics to bring daylight into building interiors. As part of total building performance, one must look at consequences of natural daylighting other than glare. For example, the ultraviolet radiation in daylight can be detrimental to materials. For this reason, too, natural light should be filtered.

The current building design may or may not be able to constructively accommodate the use of daylight. The building design may not allow the projection of daylight deep enough into the space for natural illumination and may not have a bright spot at the perimeter which means the interior will look dingy no matter how many footcandles you have (you can have 100 footcandles or more in the interior and 500 around the perimeter where the windows are but that space may still look dingy because of contrast). Handling natural illumination effectively is very important.

## Air Quality

Another building consideration is air quality. Indoor air quality is a serious concern with many existing buildings. Today there are problems with the "sick building syndrome" due to out-gassing from synthetic materials used in construction. The problem existed for a long time without being diagnosed. Many of the synthetic products used in construction give off significant quantities of toxic gasses—called out-gassing—which contaminate the atmosphere. This condition is exacerbated because buildings have been designed to be air tight in order to save energy by reducing air infiltration to the building, and thus reduces the amount of fresh air brought into the building. The out-gassing situation is compounded when fans are turned off at night to save energy time so that the concentration of contaminant build-up produces almost a lethal atmosphere in many of these buildings.

Working with the Canadian Department of Public Works for four years on the indoor air quality problem (among other things relating to total building performance), we found one building in Canada where over a period of a few weeks 600 people had to go to the hospital because they were seriously affected by the indoor environment; many other buildings were experiencing indoor air quality problems.

This is not meant to suggest that a tightly sealed building is a bad goal. On the contrary, by minimizing air infiltration, you reduce heat loss, heating and cooling loads are reduced accordingly, and the size of the mechanical equipment needed is reduced as is the amount of space the mechanical equipment requires.

The space for mechanical equipment is parasitic space. It does not contribute directly to the program; it just has to be there in order to make the building work. By reducing the space devoted to mechanical equipment, a more efficient design results.

One solution to the stale air problem is to employ a heat exchanger to temper or cool, depending upon the season, the outdoor air. Air from outdoors is brought in for ventilation and the stale air is expelled from the building. In this way fresh air can be brought into the building in accordance with physiological and air quality requirements (but without the penalty of higher energy use and operating costs). These competing values of improved fresh air circulation and minimal air infiltration must be weighed as part of the total building performance.

Indoor air quality interrelates closely with the air distribution system. It is not solely dependent upon that, but there is a very serious and important connection here.

There are conflicts between indoor air quality and air distribution. Variable air volume systems are often used to control space temperature, and are energy efficient. When the space temperature becomes satisfied under a cooling load, the system's mixing boxes close down, less air is circulated into the spaces, and less fresh air comes in. Also, when the temperature settings are satisfied, the air distribution pattern within the room changes. Instead of getting fresh air down to the workstations, down to the study carrels, and down to other work areas, the supply air is up at the ceiling where it bypasses the occupants. This situation short circuits supply air to the returns, and the indoor air quality problem is exacerbated. Air temperature is typically the controlling factor for air delivery; rarely is the indoor air quality monitored and then the outside air dampers operated according to the indoor air quality. Provisions now include sensors to monitor indoor air quality and then operate fresh air donners accordingly.

Furthermore, large workstations, full-panel study carrels, and furniture with skirts can interfere with air distribution. Too often there is little air movement where people are. Ventilation is put in primarily for people, but too often the people are not getting the ventilation because the structure, the physical fitting-out of the building, and the control systems prevent proper air distribution within the space. So there is a serious relationship between indoor air quality, air distribution, temperature, and humidity.

### Acoustics

Accoustical problems present a different challenge. A library is the focus of many distinct and sometimes interactive activities. The acoustical separation of spaces is important. Accoustical ceiling panels are installed routinely. These ceiling panels are bound to be inadequate because the noise is not generated up at the ceiling but by noisy people down at the floor who are operating keyboards, talking, sneezing, playing music, scraping chairs, rustling papers, and using printers—the noise is generated down in the work area. We have some acoustical-absorbent furniture, but it is often inadequate.

Noise should be absorbed at the source, and planners are moving in that direction. More sound absorbent material is being located down closer to where it originates rather than having sound travel to the ceiling where it is absorbed. This was accomplished in buildings in which we designed mechanical and electrical systems by stringing vertical sound baffles on wires well below the ceiling.

At the same time, care must be taken that the solution to acoustical problems does not interfere with air distribution. When sound patterns are interrupted, air circulation can be stopped as well, and another problem is created. So while these problems must be addressed as they occur, planners must anticipate the types of new problems the solutions can create within the framework of total building performance. This happens time and again in facilities planning and management.

### Climate Controls

There is increasing sophistication in the design of climate control systems for all types of buildings, and designers are responding to these microclimate conditions. California, for instance, identifies thirteen specific climatic zones in their energy code. Where we used to consider the climate of New York City as that of New York State, we are now interested in the climate where that particular building is built rather than at some remote air station or airport where the data happens to be available.

Environmental control in a library is different from many other buildings because it requires air conditioning and air quality control both for people and contents. People tolerate a rather narrow range of comfortable temperatures and humidity. Most library material lasts longer when the temperature and humidity are in a certain range; if it is too moist mildew forms on books, and if it is too dry materials crack and dry out. Also wide swings in relative humidity are undesirable. Steady indications, even though not at optimum relative humidity for the contents are preferable to variations in relative humidity.

Unfortunately, the preferred environments for people and material are not identical. Some rare material may pose especially stringent environmental requirements. For one recent project in California, we responded to those special requirements by putting those materials literally in a separate air conditioned and carefully controlled environment. The entire building did not require such extensive controls, and it would have been wasteful to install this system throughout the building.

In other words, do not install the most sophisticated and costly system unless the entire building needs it. Segregate the part or parts of the library that need special care. Note where there is a need for humidification, air cleaning, or other unique environmental controls.

Likewise, some equipment—computers particularly—have special temperature and humidity requirements. Some automated equipment is especially prone to malfunction unless the air has been heavily filtered and cleaned. Vendors can detail the environmental needs of specific equipment. Electronic equipment also generates a heat load which the building's mechanical systems must compensate for. Even though electronic equipment is sure to be miniaturized further, there will be more and more of it so the heat loads in libraries will continue to escalate. As a result, there will be more and more heat islands within the space that will need attention. This creates another type of special environment that may require separate controls.

So there is actually a three-part problem which consists of taking care of the people, the contents, and the equipment. The key here is to be discriminating. A broad-brush approach is not effective. The definitive requirements for each area must be examined as part of the total building performance.

Is a centralized or decentralized air conditioning system best? There is no controversy here. In a large building, the type of building most likely to develop truly specialized environments for certain collections and functions, a primary system where heating is centrally generated in a boiler and cooling is generated centrally as well is the best alternative. (It is hoped that energy consumption does not exceed 30,000 or 35,000 BTU per square foot per year although not so long ago it used to be 200,000 or 300,000 BTU per square foot per year. One of our recent designs, the New York Botanical Gardens in Millbrook, New York, operates at 19,000 BTU per square foot per year, which means that it is a very low-cost building to operate.) This main, centralized system should then be married with a decentralized system or systems in individual, discrete areas that require special environmental conditions. The decentralized system may be a heat pump, a fan/coil unit, or a miniature condensing unit in the particular area it serves. If a centralized system is connected to a decentralized system, then local control can be provided with the accompanying economies of the central, efficient equipment.

It is important to give people individual control of their environment. It does not mean that every user that comes in the library has an individual control that follows him around, but giving people control over their environment creates a great deal of user satisfaction. It gives them some stake in what they are doing—they feel that they are in control and are not subject to higher authority. This arrangement can be done more readily with a centralized/decentralized system.

## Summary

Looking ahead, buildings can accommodate alternative energy sources quite readily if these energy sources are conceived as part of the initial environmental program. Coal and nuclear power certainly have their drawbacks, so we are looking at alternative energy sources. We're getting into some new developments with photovoltaics and solar thermal energy. Photovoltaic solar cells convert sunlight directly into electricity. Photovoltaics are going to be the power source of the future, and the building must be designed now to accommodate these future technologies. Other developments include fibre optic light transmission, energy storage systems using phase changing materials, organic walls and glazing that change their properties to meet specific environmental conditions.

In summary, facilities design must be an integrated effort between people, materials, and systems. Adaptability is the key in designing a building that can handle anything that might arise in the future. But it is not necessary to spend large sums of money doing it.