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Facilities Manager

Volume 1 Number 1/2 Spring/Summer 1985

The Future of Campus Facilities Management

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Editor
Steve Howard

Editorial Assistant
Diana L. Jeffery

Publications Secretary
Maxine Mauldin

Design/Typography
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Letter from the Editor

Welcome to the debut issue of *Facilities Manager*, the new quarterly magazine of the Association of Physical Plant Administrators of Universities and Colleges (APPA). The magazine will be published every Spring, Summer, Fall, and Winter and is mailed automatically to the Institutional, Associate, Affiliate, and Subscribing members of APPA. (Of the APPA membership dues, $30 goes to the publication of *Facilities Manager*; subscriptions are $40 for four issues, $50 to foreign addresses.)

Our cover story this issue is on the future of facilities management in higher education, as predicted by six leaders in the campus facilities profession. While they may agree that there is nothing new under the sun, they each see a vast potential for the involvement of the facilities manager at our colleges and universities.

We are also proud to introduce you to our quarterly selection of the best management and technical articles around. This issue includes professional articles on such varied topics as roof maintenance, computer based maintenance prediction models, alternative financing of energy efficiency projects, and the innovative use of bar coding for fire inspection, stores inventory, and other physical plant applications. Each issue of *Facilities Manager* will bring you up-to-date articles on the topics you want to know more about.

Towards the back of the magazine you will find The Bookshelf—reviews and announcements designed to inform you of the latest publications and whether they are worth buying or not.

Upcoming issues of *Facilities Manager* will hold many more surprises as we improve and fine-tune the magazine for all our readers. Please take a moment to fill out the reader survey and return it to us so that we will know how to serve you better.

The development of a new magazine is an exciting, exhausting effort that also brings us a tremendous responsibility to our readers. Let us know if there is an article you'd like to see; or better yet, write it yourself and submit it for publication. If we fall down in our promise to bring you fine technical and management papers, or if you disagree with the statements of any of our authors, send us a letter. We'd be happy to share your comments in our next issue, and your letter will serve as a reminder of our commitment to excellence. And don't forget, if you only have positive comments we'd love to hear from you as well.

I would like to take a bit of space to thank some of the people who helped the Spring/Summer 1985 issue of *Facilities Manager* see the light of day: Norm Bedell and Stu Litzsinger, present and previous chairs of APPA's Professional Affairs Committee; the 1983-84 and 1984-85 Professional Affairs Committees; the APPA Executive Committee and Board of Directors; Nick Davis and everyone at Sans Serif; Eric Wiemann and the gang at Hundley Lithograph; Diana Jeffery and Maxine Mauldin; all the authors and reviewers who appear in this first issue; and, finally, the advertisers who took a chance on a fledgling publication even before seeing a finished product.

We hope you enjoy this premier issue of *Facilities Manager*, and we look forward to a long, healthy relationship.

Steve Howard, *Editor*

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The Future of Campus Facilities Management

by Steve Howard

The basic problems of the campus facilities manager have changed little over the past seventy-five years.

Steve Howard is editor of Facilities Manager. *Research assistance for this article was provided by Catherine A. Smith.*

Securing appropriate funding levels for regular maintenance and repair, training and motivating employees, keeping abreast of the latest technology, and finding a roof that won't leak are concerns that continue to plague managers today. Yet, the facilities management profession has encompassed many purposes since 1914, when the Association of Superintendents of Buildings and Grounds of Colleges and Universities was formed in Chicago with fifteen charter members.[1]

The past fifteen years have given rise to numerous technological advances, most of which are a result of the energy crisis of the mid-1970s and include cogeneration and fluidized bed combustion systems, smokestack scrubbers, more efficient chillers and boilers, and improved mechanical and electrical systems for buildings.

This period has also brought about new management techniques—the one-minute manager, quality circles, Theory Z, the M-Form Society, managing by objectives, managing by wandering around—all designed to improve the quality of the modern working environment.

But, without question, the greatest innovation for today's facilities manager is the computer. The computer now accelerates the departmental budgeting process, monitors energy management and fire protection systems, and provides comprehensive preventive maintenance scheduling. Administrators can communicate with each other—across campus or across the country—via electronic mail. Work order stations throughout campus give assignments to trades and maintenance employees from one central office. Parts stores provide perpetual inventory counts as items are requisitioned. Reports, memos, and correspondence can be entered, edited, and printed with a word processor without the need to type numerous drafts. These examples illustrate the vast potential of computer applications to physical plant functions.

But what of the future of facilities management in higher education? Will a new electronic wonder supplant the inroads paved by the computer? Probably not, but hardware modifications and the development of new software programs will continue to increase the power of the manager using them and enhance the efficiency of the facilities operations organization.

Will a consultant develop a new management technique that is *the* solution to all employer-employee problems? It's unlikely, but we certainly will see numerous contributions to the already bulging literature, the best of which will incorporate a common sense approach with a unique procedure for leadership and motivation.

The Enrollment Boom, Again

Six administrators recently discussed with *Facilities Manager* the present and future of facilities management on college and university campuses and warned that institutions may not be preparing fully for the increase in enrollments projected to hit U.S. campuses in the mid-1990s.

"Unless funds are provided to properly

[1] After several name changes, the Association of Physical Plant Administrators of Universities and Colleges (APPA) now has an international membership of 3,000 facilities professionals at 1,250 institutions of higher education. APPA's purpose is to promote excellence in the administration, care, operation, planning, and development of facilities in support of the academic and research functions of colleges and universities.

maintain our structures and facilities, someone is going to come along in the year 2000 and see 40-year-old buildings in worse shape than they are now," says **F. Louis Fackler**, assistant vice chancellor for facilities and services at the University of California–Santa Cruz. "Our maintenance budget is set up to handle only the day-to-day maintenance to keep the place running. But the overall mechanism to take care of the major budget expenses—the deferred maintenance items such as the repainting or complete reroofing of a building—never receives adequate funding. And as the campus gets older, the funding becomes less adequate."

Mark D. Langford, director of facilities management at the University of Missouri system, blames state legislatures for rarely having the foresight to fund many deferred maintenance projects. "If projections hold true that by 1995 we will see a major boom in the cycle of student enrollment, getting facilities in the proper state of repair and adapted for that environment is going to be a monumental task," he says. "Unfortunately, the state legislature usually does not see any further down the road than a year or two at a time, and certainly not ten years. By the time they recognize the need for new or renovated facilities, the problem will have already occurred."

Gene B. Cross, vice president for facilities at Kansas State University, agrees that increased enrollments will lead to most facilities problems in the year 2000. "The student demand is going to exceed the institution's ability to accommodate, much like what we experienced in the late-1960s," says Cross. "And it will be hard to catch up because we will again find ourselves coming into a growth situation from tight economic times. The real challenge of the professional facilities manager in higher education is to achieve equity in facilities funding."

For **Edward C. Bogard**, director of facilities management and planning at the Dallas County Community College District, the need for better communication and coordination among the academic, business, and facilities sectors is an important priority. "As we become more and more high-tech oriented, we are going to have to provide space that meets new demands that perhaps we do not have a clear picture of right now," says Bogard. "For instance, we are seeing a plethora of laboratories with microcomputers springing up on campus in locations that were not intended to house that kind of activity. Facilities managers are being asked to make those spaces more acceptable from an environmental standpoint.

"Hand in glove with that is the need for facilities managers to be extremely sensitive to the requirements and use of existing energy. We must take advantage of new technologies in terms of utilizing energy more efficiently and not waste it, as we have done in the past. We simply must be more aware of campus activities that require different kinds of energy," says Bogard.

Ever-changing academic programs—sometimes caused by great societal upheavals, yet which last only briefly in the curriculum—also diminish the physical plant department's ability to provide consistent, top-quality service to the institution. "Determining the impact of enrollments on available resources and accommodating the continuous change in academic programs is probably the greatest overriding problem we have today," says **Harvey H. Kaiser**, senior vice president for facilities administration at Syracuse University.

"As enrollments increase," he says, "we must continually consolidate our physical space and manage it for performance. In terms of curriculum, an active research university is constantly evolving new programs and research initiatives that require functional improvements to existing space or demands for new space. All of that has to be balanced against developing the resources to match those requirements."

Electronic education and expanded computer access for the entire campus is increasing in importance and will require the institution to recognize the quantity and quality of available space, according to Kaiser. "And as with many research universities, we have struggled with rapidly obsolescing research equipment and instrumentation," Kaiser says. "That, in turn, leads to a demand to acquire resources to improve our equipment and instrumentation, as well as our laboratory environments."

While **H.C. Lott, Jr.**, assistant vice president for plant management and construction at the University of Texas at Austin, agrees that high-tech developments will revolutionize certain physical plant functions, he believes that the ability to maintain an efficient, well-qualified, well-trained staff is

The Facilities Manager of 2005

We asked our six facilities experts to give their description of, or advice for, the typical campus facilities manager twenty years hence. Here's what they had to say. —*S.H.*

Edward C. Bogard

Dallas County Community College District

"In terms of the dollars and cents expended by an institution, the largest portion comes under the jurisdiction of the facilities manager in labor and utilities cost. He or she must be highly trained to handle the increased emphasis placed on facilities management in order to become a leading force in the academic community and help set or influence policy on how funds are spent for renovation, renewal, and new expansion. Institutions will regularly look to facilities managers to help them invest their funds wisely for campus modifications."

Gene B. Cross

Kansas State University

"Ninety to ninety-five percent of the individuals heading facilities operations have a technical background, and justifiably so; but the best ones also possess strong management capabilities. Smaller institutions have a greater demand for the technical expertise, and you can get by if you are weaker in other areas. But once the institution begins to grow, the administrator becomes more involved with schedules, programming, deferred maintenance programs, budget allocations, hiring, staff arbitration, affirmative action, and other management details than with the hands-on, technical needs of the institution. The ideal facilities manager will combine a strong technical background—a degree in engineering or architecture, for instance—with an MBA and proven management abilities."

F. Louis Fackler

University of California–Santa Cruz

"Very few people will be hired in professional facilities positions without formal education, and I foresee increased importance being placed on engineering and management degrees. While there will be more and more specialization, the top manager will not have to be a specialist in every area. Because we are continually pushing for greater professionalism in our field, the facilities manager of the future will be viewed as important a manager as any other on campus."

and will be the greatest problem facing campus facilities managers.

Says Lott, "We have a difficult time hiring and retaining individuals skilled in the working trades, such as carpenters, mechanics, painters, electricians, and plumbers, so we find ourselves hiring who we can get, training them for four or five years until they are at the journeyman level, and then watching them leave the university to go to a higher paying job in industry. There is a constant turnover. And as more companies get into the design and maintenance of high-tech facilities, more people will be lured away from the universities. Although we are building higher quality laboratory and research facilities, the more attractive positions are going to be in industry." Lott, like Langford, blames state legislation for the woeful lack of funds to attract and retain highly-qualified employees at all skill levels within state colleges and universities.

What Lies Ahead?

Although the educational facilities profession as a whole will see few if any major changes in the future, Lott believes the greatest contributions will occur at the individual institutional level. "It is hard to develop a management program at UT/Austin and implement it at MIT, for example," says Lott. "In developing new programs at a university campus, you use the basic concepts of good management and build it around your particular organization, budget, and staff. But the same program is not going to work for all institutions across the board."

Fackler sees the 1990s as a growth period for education not unlike that of the 1950s and 1960s. "It will be an excellent time for young people in management and engineering," he says, "and facilities management will be such an expanding field. We are going to be considered an integral part of the campus administrative team, because everything we do is so involved with research and other university activities."

Bogard stresses professionalism for facilities managers and planners and more understanding of the issues and needs of the academic community. "We need to become more visible to those people," says Bogard. "We are no longer in a position to merely sit back, answer questions, and solve problems. We need to show that we can solve certain problems of the community with a good functioning plan developed *before* we are asked by the administration. We need to develop a sense of planning and participation at the highest levels within the academic sector."

Langford warns that in order to deal effectively with vice chancellors and business officers, facilities managers must be better qualified to handle people and fiscal matters, as well as maintenance operations. "The management and technical skills of many of our facilities people are somewhat lacking," he says, "and that affects their ability to communicate with their superiors. The future is going to be an interesting time, but we have to be able to hold our own when competing for funds and dealing with the accounting operations of the institution."

The theme of the facilities manager as part of the decision-making team on campus is echoed by Kaiser, who states that "the future is dependent on those people now with careers or those who look towards careers in institutional physical plant management and realize that facilities management has a scope much broader than operations alone. It includes the areas of planning and real property, which then introduce the manager to policy making as opposed to simply operations management."

Finally, the essential value of the facilities manager to any college or university campus—large or small, public or private—is summarized by Cross. "The secret and key to success for the facilities manager, indeed for the president, chancellor, business officer, and other administrators, is to ensure that there is a balance in the allocation of resources to all areas within the institution. Keeping that balance within the physical resources ensures that the real mission of higher education—teaching, research, and community service—is being served to the fullest extent." ■

Harvey H. Kaiser
Syracuse University

"In terms of innovations or trends, institutions will strengthen their fiscal skills and management information systems. Facilities managers will find their responsibilities broadening in scope past operations and maintenance to encompass the management of real property (including the decision to buy, build, lease, or sell), telecommunications, planning, security, and other auxiliary activities. This broadening means they must also deepen their technical capabilities as well as their management skills, which will require degrees in both areas plus significant management experience."

Mark D. Langford
University of Missouri

"If we could get past the stigma that universities offer less than desirable positions and do not pay well, we would be able to attract top-notch, highly qualified people who are going to benefit the mission of higher education. And while the facilities manager's scope of responsibility will not change, we will see greater sophistication in automation systems and computer applications; this is going to require a more technically competent manager than we now have. In addition, the trend in industry for supervisors to work their way through the ranks to management positions is starting to occur in higher education. In time you will see more technically competent, qualified engineers in facilities management positions."

H. C. Lott, Jr.
University of Texas at Austin

"In twenty-five years I have seen very few changes in the facilities management field. The greatest innovations, of course, have been in data processing and telecommunications, but the basic management concepts that have been around forever can handle such timely concerns as the energy crisis and accessibility requirements in the 1970s, and the asbestos problem of today. But although a large number of facilities managers have degrees in business or come from a military background, the requirement in the future will be for engineers."

Letters

Readers wishing to respond to this or any other article in this issue should send their comments to Letters, Facilities Manager, 1446 Duke Street, Alexandria, VA 22314-3492. All letters should be typed, double-spaced, and no longer than 500 words in length. Shorter letters have a better chance of being published, and the editor reserves the right to edit for clarity or brevity.

Bar Coding Applications in Physical Plant Departments

by John A. Heinz

Introduction

Physical plant departments are constantly faced with the challenge of finding ways to optimize the use of their funding and personnel resources. One of the more difficult areas is to increase productivity by minimizing seemingly nonproductive time, including record keeping—time cards, preventive maintenance, fire protection system testing, cost accounting, etc. It is amazing to discover the extensive amount of cumulative record keeping time that this represents.

Mini- and microcomputers have come of age as a significant tool to help manage the massive amounts of data required to manage physical plant departments. We all have had varying degrees of experience with computers. Large departments may require the capacity of minicomputers to handle its data requirements. Small departments can, with thoughtful planning, do most of the same things with micros. Even the large departments, relying primarily on larger machines, will benefit by the appropriate use of micros. Thus, the field is expanding, actually bursting right out of its seams with potential.

Most data input is a manual transcription from some other resource document or record, most of which have been hand written by someone in the system. In the case of preventive maintenance, even though we may have started with a computer-generated work statement, the response to the computer is hand written by a mechanic, which must be manually transcribed to the computer. Parts disbursement to mechanics is hand recorded and transcribed to a computer. Time cards are hand written and transcribed to a computer. Many other relatively routine hand written information is ultimately manually transcribed to a computer.

There are two significant problems with this process. First, a lot of valuable labor time is wasted originally recording and redundantly transcribing this information. Second, an immense amount of error is introduced in the process. Writing skills are not one of the requirements to be a good mechanic. Consequently, their hand written information introduces great potential for error. Zeros, nines, and sixes often look the same. The data entry person will not only transcribe mistakes based on incorrect interpretation, but they too make a nominal percentage of errors. Additional time is then wasted finding and correcting errors, particularly when charging work to self-sustaining clients when totally unrelated items show up on their bills. It becomes somewhat overwhelming when you think carefully through the examples of nonproductive time consumed—recording data, transcribing data, researching and correcting errors, fielding phone calls, not to mention the heartburn induced when responding to calls from some less-than-graceful overbilled clients.

This, in my view, is the next big opportunity to enhance productivity: to eliminate, or at least minimize, manual transcription of data to the computer. For the moment, bar coding may be the answer.

The Uses of Bar Coding

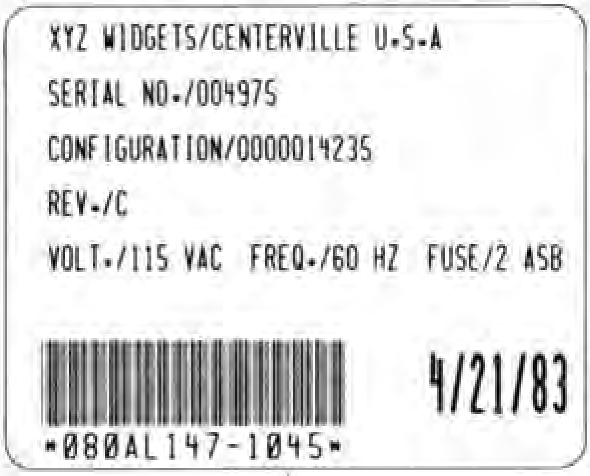
The food industry is the most visible user of bar coding. Most supermarket checkout areas are automated to read and record the bar code on product labels, thus speeding the process and maintaining a high degree of accuracy. Industry uses bar coding to identify and manage components on assembly lines and in stock. Modern warehousing is becoming more dependent upon bar code identification. A few forward thinking firms are using bar code identification with their employee time-clock stations. The trend is established, and the time has come for facilities management to capitalize on the benefits.

We have begun to do so at the University of Washington, but before I describe our activities I will briefly explain our building maintenance and alterations accounting system, which likely is different from yours but helps to establish the perspective.

All of our primary building equipment (supply fans, exhaust fans, pumps, refrigerated drinking fountains, etc.) have a digital identification (DI) number, which has four parts. First is a three-digit building number, second is a two-digit building floor number, third is a two-digit function number, and fourth is a two-digit specific number of the unit on the floor. The function numbers range from 01 to 99 and are used to identify the generic types of equipment. For example, function number 03 is refrigeration systems, function number 11 is swimming pool systems.

Fortunately, each craft has only a few function numbers to learn regarding their specialty areas. Thus, DI numbers not only provide a unique record number for each major component but are meaningful to the mechanics. With a DI number they know what building the item is in, what floor it is on, what kind of system or unit it is, and which one of several similar units on the floor it is. With only a DI number our

John A. Heinz is director, physical plant department of the University of Washington, Seattle Washington.



mechanics can virtually go directly to a particular piece of equipment.

Further, the DI number provides us with a convenient means to cost account all maintenance—by building, by generic categories within each building, or by generic categories throughout the entire campus or any specified building group. This can be of great benefit when assessing costs, developing budgets, and analyzing high cost problem areas. Thus, assurance of accurate records is imperative in order for the data to be useful.

Consider the preventive maintenance (PM) process. Every day a large segment of our work force is conducting PM, and each mechanic will be involved with several systems each day. In order to maintain not only accounting of their time but also accounting of maintenance activity and machinery history, the mechanic must fill out a somewhat complex time card. Often eight to ten nine-digit DI numbers must be entered on each card. Three hundred plumbers, refrigeration mechanics, electricians, and other tradespeople writing down 3,000 nine-digit numbers—plus their time for each one, all on small lines on a small time card—for later manual transcription into a computer results in a monumental data management problem.

And that is only one small part of our record keeping program. In addition, we have a 9,000 line-item repair parts store. Repair parts must be dispensed and accounted for against the system or component being repaired, which requires more DI number recording and parts number recording. We also have alterations projections—several thousand small size jobs totaling nearly $3 million worth each year—each with a project number for which time and materials must be accounted. Indeed, we have a monumental data management problem.

In a completely different area we maintain an extensive inventory of fire protection/prevention systems. With over 200 buildings and 12 million gross square feet, we have every kind of system available. We have more than 6,000 portable fire extinguishers, for example. The law requires that all of these systems and equipment be checked and tested on a regular basis and evidence of those checks or tests recorded for review by the regulatory agency.

Raw data entry alone has been keeping two full-time data entry operators busy, and they are usually several days behind. In addition, many other on-line staff members are busy entering and altering data. Again, imagine the time spent in the field putting down all of this data in the first place, the time required to enter it into the computer, and finally, all of the errors that are made that eventually someone else is finding and trying to correct, sometimes long after the error was created. Yes, we have a monumental data management problem, and that simply had to change.

Setting Up the Pilot Program

We decided to start in an area with the highest potential for success, working with a small crew of specialists willing to participate in the development of a pilot program. Our choice was the fire marshals and one of their many tasks—the monthly check of the 6,000 + portable fire extinguishers.

I met with one of the bar code industry's major equipment suppliers to determine equipment capability and costs. With that background I then set out to implement the program. First, we bought a bar code label maker (Figure 1) and a portable bar code reader (Figure 2). Then we made bar code labels for every fire extinguisher station on campus, using the DI numbering system. We then made unique bar code labels for every portable fire extinguisher both in the field and in replacement stock. The labels were placed on the fire extinguisher stations and the portable fire extinguishers.

At the same time we had one of our computer programmers write the relatively simple programs required for the bar code reader and our DEC PDP 11/34 and 44 computers so the information can be recorded and transferred directly to the computers. This was an interface program since the computers already were programmed for the entire fire extinguisher inventory and all building fire extinguisher stations. In addition, the fire marshals were given a bar code of their employee identification number.

With that, the program was ready to go. Each week certain groups of fire extinguishers must receive their routine check. To do so the fire marshal takes the portable bar code reader and first reads his ID number, which logs the individual doing the field checks, and makes his rounds. Next he reads the fire extinguisher station and then the fire extinguisher at that station. The bar code reader beeps if he does not do this in proper order; it will not record information unless it is done in the correct sequence. There is no need for hand written recording, and a vast area can be covered in a short period of time.

At the end of the day the bar code reader is plugged into the computer and the collected data instantly down-loaded, completely eliminating the need for data transcription by a data entry operator. Within minutes a printout can be produced that shows the date, the name of the individual checking the fire extinguisher station, and the fact that the fire extinguisher was in that station. Due to the precision of this process we are currently working with the local fire department to abolish the need to date and initial the paper tag on each fire extinguisher. I know we will ultimately receive that approval; however, bureaucratic systems are hard to change.

Every five years pressurized fire extinguishers must receive a hydrostatic pressure test. We do this on a group basis. We use the same process when we replace all fire extinguishers in several buildings with units from stock. The new extinguisher is installed and the station and extinguisher are read with the bar code reader. Upon completion of the exchanges and down-loading the data to the computer we instantly know which extinguisher is in which station, the date, and the responsible fire marshal. We also have a special bar code in the shop that, when read, indicates to the computer when extinguishers are out for pressure testing. Upon return another special bar code, followed by a group of extinguishers, indicates to the computer that they have been picked up and returned to stock, awaiting reuse in the field.

Consequently, we have an automatic way of tracking and recording the status of every portable fire extinguisher on campus, with dates and responsible party—all done with no hand written information or laborious transcription to the computer. And it is virtually error free.

Problems Force Modifications

There were some start-up problems, however. We found that the original bar code reader, specifically the contact wand scanner, would not read labels on textured surfaces, such as the fire extinguisher stations, or on curved surfaces, such as the fire extinguishers. This was overcome by buying a more expensive non-contact laser scanner (Figure 3). Even so, the cost is nothing compared to the labor savings. In addition, because I turned the idea over to someone else to implement, some important elements were left out and negatively affected the process. This did not help with the promotion with the fire marshals, and it took a while before I discovered what had happened. Now that these problems have been corrected the people are extremely enthusiastic. When we finally get fire department approval to stop initialing the paper tags we will be all the way there.

We have attempted to evaluate the cost savings in this pilot program area covering portable fire extinguishers. Our conclusion is that the time saved, including time previously wasted reviewing and correcting recording errors, conservatively amounts to more than $20,000 per year. That is nearly equivalent to gaining the services of one full-time employee out in the field doing the more important functions fire marshals are trained to do.

The next step is more difficult, primarily because it encompasses a much larger body of people. It is being done on a pilot program basis working with selected shops, more or less one at a time. Initially, part of the process is being done somewhat manually until we can obtain equipment to do the job totally automatically.

Figure 1: Bar code label maker.

The first part of the next step is to gain bar code control of alterations project work for the several thousand projects each year. All physical plant requisitions have a sequential number. These requisitions are printed in the university's print plant. I worked with the print plant manager and found that for $25,000 he can purchase the necessary auxiliary equipment so that the sequential number can be printed in bar code along with the current number. Until that occurs we can manually add the bar coded number using the bar code label maker. This step is not that difficult to do and is done via interconnection of the label maker to a computer terminal, which the clerical staff already use. The label is then affixed to the requisition. This only takes a moment and will save a lot of time in the future.

Also, all employees are now being given bar coded employee ID numbers and the stores program will be placing bar code labels on all of the parts bins. Further, we plan to purchase nearly two dozen of the less expensive contact wand scanner bar code readers, one for each craft shop.

The Completed Program

All projects will have a unique bar coded ID, as will all employees and nearly all parts. At the end of each day employees will read their ID bar code, followed by the project bar code and the amount of time on the job (read from a bar coded number plaque at each bar code reader station). The sequence after reading the employee ID number can be repeated as many times as necessary for the work done that day. A "stop" bar code ends the sequence. Thus, all employees will no longer fill out time cards and instead will record their day's activity in the bar code readers. Special bar codes will be developed for training, supervision, and similar kinds of non-project activity. When parts are dispensed to projects, the stores clerks will read the project number bar code, the parts or materials number, and the number of units dispensed.

On a daily basis the bar code readers will be picked up and the data down-loaded directly to the computer. Management reports will be available the following day on every project and will include transactions and costs to date. The computer will automatically cost account all time and materials against the projects, and simultaneously record all work activity to each individual's personal time record and adjust inventory according to the number of parts

Facilities Manager

READER SURVEY

Since this is the premiere issue of *Facilities Manager*, we would like to hear from our readers regarding its content and appeal. By finding out your reaction we can continue to refine the magazine's editorial content to better fulfill your needs. So, please take the time to complete the following survey and return it to our office. The postage is on us.

Please check the box which best describes your job:

- ☐ physical plant management
- ☐ maintenance management
- ☐ grounds services
- ☐ housekeeping services
- ☐ energy management
- ☐ architect
- ☐ engineer
- ☐ business officer
- ☐ corporate officer
- ☐ other ____________________

Do you pass along your issue? ☐ yes ☐ no If yes, how many other people see it? ______

Please rate the following articles:

	AMOUNT OF INTEREST		
	very interested	somewhat interested	not interested
Feature: The Future of Facilities Management	☐	☐	☐
Maintainable Roof System	☐	☐	☐
Bar Coding Applications	☐	☐	☐
Computer-Based Maintenance	☐	☐	☐
State Policy Initiatives on Energy Financing	☐	☐	☐
Book Reviews	☐	☐	☐

Which of the following subjects would you like to see more articles on? *(check as many as apply)*

- ☐ energy
- ☐ grounds
- ☐ housekeeping
- ☐ roofing
- ☐ training
- ☐ computers
- ☐ safety
- ☐ budgeting
- ☐ higher education
- ☐ personnel
- ☐ engineering
- ☐ telecommunications
- ☐ contracting
- ☐ other ____________________

Which of the following departments would you like to see added to the magazine? *(check as many as apply)*

- ☐ government/legislative affairs
- ☐ new ideas in physical plant management
- ☐ new products
- ☐ other ____________________

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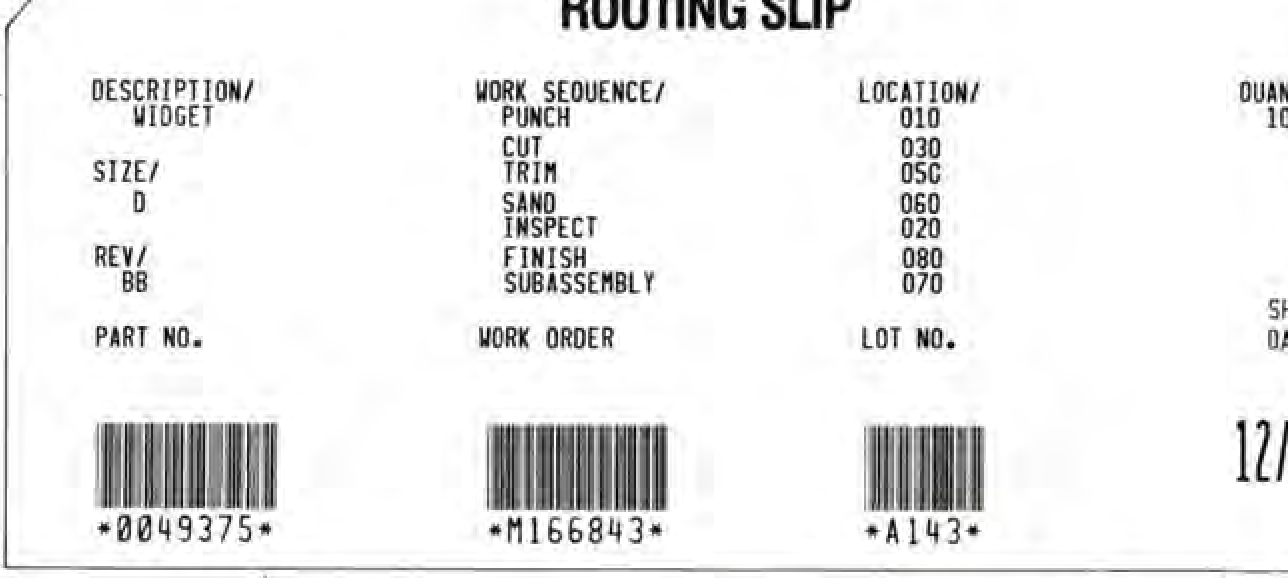
ROUTING SLIP

DESCRIPTION/ WIDGET

SIZE/ D

REV/ BB

PART NO.

0049375

WORK SEQUENCE/ PUNCH, CUT, TRIM, SAND, INSPECT, FINISH, SUBASSEMBLY

WORK ORDER

M166843

LOCATION/
010
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LOT NO.

A143

dispensed. Virtually all of this will be done automatically without the need for manual data transcription and, again, virtually error free.

It is appropriate practice for supervisors to routinely review and validate their employee's time cards, yet now time cards will no longer exist. Consequently, computer programming will be developed to appropriately display this information on the supervisor's video display terminal for review each day. Any corrections can be made as necessary, followed by the supervisor's validation. Also, the status of all projects will be available on VDTs to supervisors and managers, minimizing the need for computer printouts.

The PM program will be operated the same way. We are currently working to get the computer to bar code the DI numbers on the computer generated PM work assignments; thus, mechanics can simply scan the bar codes and their time. This is currently a problem that may not be resolved satisfactorily without some further graphics-related improvements and, perhaps, changing our printers to a different type. In the meantime, manually produced bar code labels will be affixed on the PM work sheets. Even though this is extra time spent at one end of the system, it will save time at the other end and result in an overall net gain.

I have analyzed the overall time saving once the system is fully operational, and I can safely predict that the system will save more than $250,000 each year in time currently spent documenting, recording and accounting for all of the work completed and correcting any record keeping mistakes. In an ideal world, that is time that will be transferred to more productive use elsewhere in the system.

We will use the contact wand scanner/reader in each shop and in the parts stores. It can be left in place on a desk or table for use in time-carding, or worn on a belt when moving about in the parts store. The contact wand scanner must be held close to the bar code and scanned from left to right. The reader is easily programmed and the programs are easily changed to serve different specific purposes.

Figure 2: Portable contact bar code reader.

The non-contact laser scanner/reader is essentially the same as the first except that it is a more expensive, more flexible scanner for reading distant bar codes (up to twelve inches away), at odd angles or on odd surfaces. A light beam shows when you are on target and a beep sounds to indicate successful reading.

About the size of a double-deck desk in-basket, the label maker is simple to use. It does require special rolls of label material. The contact wand scanner/reader costs about $1,900, while the non-contact laser scanner/reader costs about $3,600. I will have about two dozen of the contact unit located in various shops and stores, and only two of the non-contact unit for the fire marshals. The bar code label maker costs about $2,100. Due to the fact that my major shop complexes are in three dispersed locations, I will need three units.

So my entire equipment cost will be in the range of about $58,000; a one-time cost that will ultimately save $250,000 per year thereafter. Most departments probably would not have to spend nearly as much.

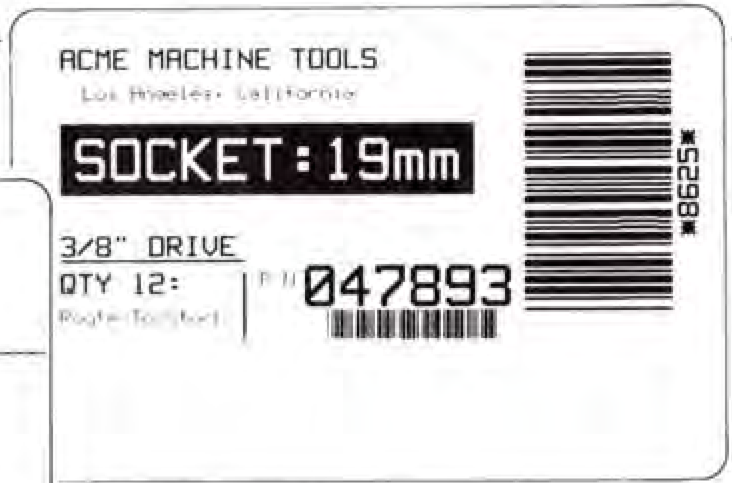
There are many different bar code styles and you will discover that there are several international standard bar codes. We decided to use code 39, which is a standard code well suited to this application. Some of the bar codes are miniaturized and consequently are difficult to work with.

Other Bar Coding Applications

The foregoing discussion has been focused on areas that are essentially pure physical plant activities. Knowing that physical plant departments often take on many collateral duties, or often work closely with other service units on campus, it seems appropriate to trigger some thoughts in related areas.

Property control is usually a big problem; for example, movable equipment such as desks, chairs, and typewriters. Somebody is usually responsible for annually confirming the inventory.

Such equipment should be given a bar coded ID so that the annual inventory can be accomplished using the non-contact laser scanner. If there is a further need to know where the equipment is located, geographic areas within buildings could be bar coded by placing the bar code geographic ID in a central office. One would read the geographic area bar code; subsequent equipment readings would be assumed to be in that area. A "reset" bar code would be used to end a series and reset the reader to require a new location code reading before reading more equipment. Direct down-load



to properly programmed computer would identify the date, survey person, and location and confirm the existence of all equipment read.

Another area is *food service facilities*, which generally uses a lot of prepackaged, prepriced, quick take-out food. Since some type of label is often affixed, there may be good reason to bar code the label for faster handling by the cashiers and more accurate price control. Secondary purposes of bar coding food might result in data for management to assess product popularity or time-of-day and time-of-year studies to assess which products sell best at various times. Such data could influence food service planning.

Mail handling and postage is often a centralized service. Even though handled centrally, postage costs are often recharged to departments. Departments could be required to place bar coded departmental or budget ID labels in the lower right-hand corner of all outgoing mail. An automatic sorter could weigh and scan the letters, stamp the correct postage amount, and automatically recharge the proper budget. To save envelope typing time, the bar coded label could be expanded to include the appropriate return address and then be placed in the upper left-hand corner. Such labels could be provided on rolls by the central mail service at nominal cost to departments.

Most campuses have a *central purchasing and stores* program, from which departments obtain consumable supplies. Supply requests could include a place for the bar coded budget label, to be put on by the requesting department. With that and bar coded supplies identification, the stores clerks filling orders could easily record these transactions using the belt-mounted portable bar code reader, which, in turn, would be down-loaded directly to the computer for automatic recharge and inventory adjustment. The same bar coding would facilitate inventory control when restocking central stores; again, minimizing

Figure 3: Non-contact laser scanner.

time consuming hand written paperwork and increasing accuracy.

Conclusion

I will end by saying that this is a fun project that has great potential to improve physical plant and university operations; what I have offered only scratches the surface of that potential. I hope that you have been stimulated to look into this process on your own and develop your own ideas and applications. Whereas we are using this in conjunction with minicomputers, the process will also work well with micros. Only the scale is different.

I strongly recommend that you start small and build up to a comprehensive program. The pilot program approach works extremely well for two reasons. First, you can have a controlled learning experience with a manageable small group of people, which also gives you an opportunity to evaluate equipment without a large, irreversible investment. Second, a successful pilot program is the best sales approach for the somewhat apprehensive and skeptical main body of your work force and fewer problems will occur as you expand from a well developed foundation of experience. ■

The Maintainable Roof System: A Guide for Architects and Facilities Managers

by Dr. Heydon Z. Lewis, P.E.

Introduction

For many years roofs were considered by building owners and designers alike to be the same as the foundation and walls of a building—they did not require any maintenance until they wore out and were replaced. We know now that roofs will perform better if they receive regular maintenance. Roof systems have become more sophisticated to cope with changing needs, particularly the need for greater thermal insulation.

This normally leads to increased capital investment in the roof system, especially since one cannot now afford to indiscriminately replace a roof before its intended life span. Further, the inconvenience of a tearoff due to dirt, restricted access around the building, interference with building operations, etc., along with the risk of water entry while portions of the roof are removed, warrants retaining the existing roof system in place as long as is economically practical.

This article will discuss the maintenance of roof systems and more importantly, consideration of the need for maintenance in the initial budgetary planning of the building through the design and specification stage to the actual construction or installation of the roof system. The concept of a roof as a system is emphasized along with specific design alternatives that can increase the long-term usefulness of the roof system.

Heydon Z. Lewis is president of Thermo-Scan Engineering, Inc., Littleton, Colorado, and a faculty member of the Roofing Industry Educational Institute.

My experiences of inspecting roofs have found that several factors were associated repeatedly with the premature failure of a roof. These three factors include poor drainage systems, poor details for installation of roof accessories, and poor access to all parts of the roof area, both on the large and small scale. In short, more roofs have been destroyed by neglect than by acts of nature or old age.

This has lead me to the **maintainable roof concept**. Stated very simply, this means that in addition to being buildable, the roof should be designed such that its component parts need less recurring maintenance and can be repaired or replaced easily without the need to remove the entire roof or even seriously damage satisfactory areas of the roof. It recognizes that the roof must function as a system together with the supporting structure and any accessory uses of the roof level. How is this different from the roofs being installed at present?

First, there are many different methods for creating a waterproofing membrane on the upper surface of a building. The on-site constructed bituminous membrane, or built-up roof (BUR), has been around the longest of the principal membranes and has the greatest background of experience and knowledge. It is not without its problems, however. The greatest is the unavoidable requirement to fabricate it on-site during uncontrollable weather conditions with little opportunity for formal quality control methods. There have been many failures of built-up roofs, many of which were not the fault of the system but rather that the roof was neglected until it was in serious trouble.

Somewhat unfortunately, just as the knowledge and techniques to avoid problems with built-up roofs became generally available, along came the single-ply membranes with such glowing promises of infallibility that they appeared to have come straight from heaven. Time has shown that they are not without problems of their own and that neglect and the importance of proper design remain common to both systems. There are other roofing systems, such as the liquid applied systems, but none of these is perfect in spite of the manufacturers' long-term warranties. There are fundamental concepts that must be observed if one is to have a successful roofing system, regardless of the type of membrane to be installed.

Second, since there are now so many alternatives in the selection of membranes, it is easy to take a system or combination of components that will work fine on one type of building or in one climate and assume that it will work satisfactorily in all applications. For example, the sheet single-ply membranes are vulnerable to damage due to uncontrolled foot traffic or vandalism. This means that one should be careful about their use on a school building, although on a multi-story commercial building, with all mechanical equipment in the penthouse, they would likely work fine. Another concern is a loose-laid, rock ballasted membrane system which is a designer's dream because it is inexpensive. Inexpensive, that is, until one tries to find a leak under the rock that may have been caused by the rocks themselves. There is a definite trend toward more mechanical attachment of insulation on metal decks; what effect will this have in the future when the roof system dies of old age and must be removed down to the structural deck?

Currently, we are creating lots of little mine fields for those who must assume long-term responsibility for the operation of a building. The way to avoid these future problems is by giving design attention to the three fundamental features of the maintainable roof concept, namely, good drainage and drains, good accessory details, and good access to the roof and around its equipment. These fundamentals apply to any type of roof membrane system, although they may be implemented differently for the different systems. The concepts apply equally to remedial roof design as to the design of new buildings.

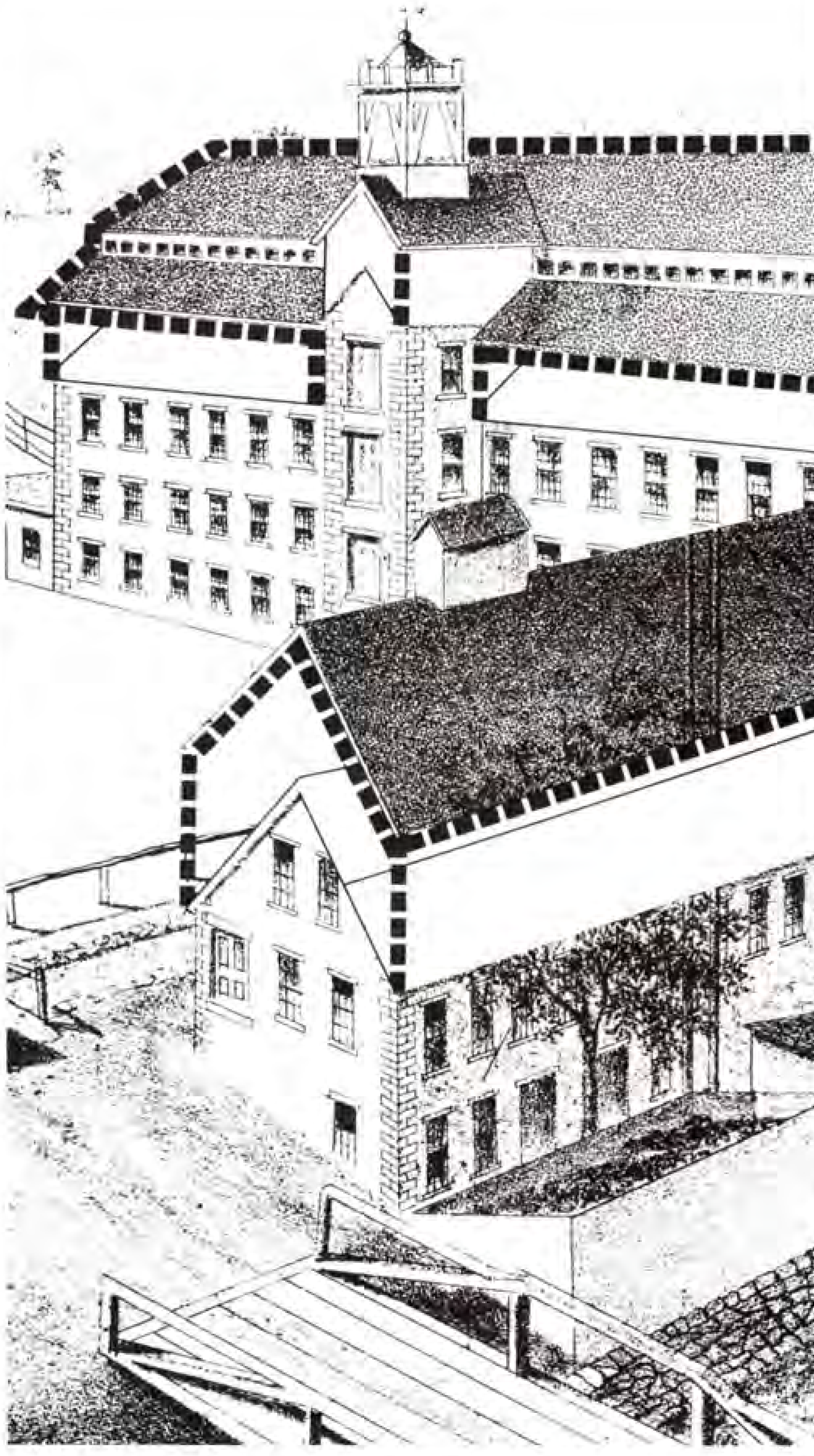
Design Concepts

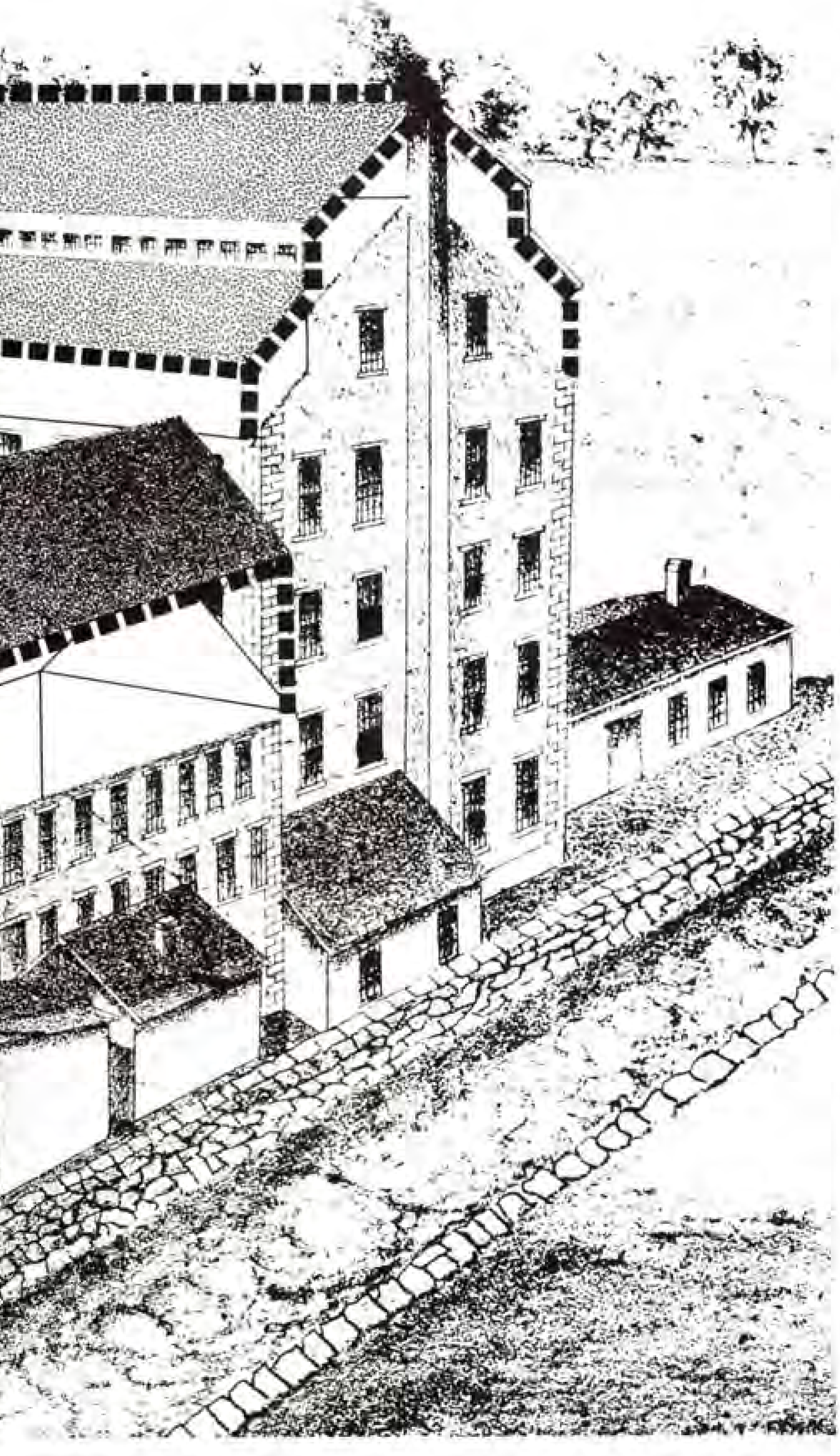
Drainage

Positive Slope All roofs should be sloped to remove water promptly. I agree with chapter three of C. W. Griffin's *Manual of Built-Up Roof Systems*, which discusses drainage and the adverse effects of ignoring positive slope. Regardless of how little the membrane itself is affected by standing water, ponding has a detrimental effect on the structure and maximizes the potential for interior damage when a failure occurs in the membrane. There are two basic ways to obtain slope, either in the deck or by tapered insulation. There are advantages and disadvantages to both. I recommend that the deck be sloped where it is easy and that tapered insulation be used otherwise. There is much dispute over how much slope to use. A 1/8-inch slope per foot will drain satisfactorily. The question is how much design slope should be used to assure that the 1/8-inch slope is actually achieved.

Camber or sag of beams and heavy point loads must be considered. Location of the drains in mid-span where the normal sag of the structure will be greatest will assure good drainage, as contrasted to locations near columns where the piping is easier but no sag occurs. One must consider all live and dead loads including future expansion when planning the design slope. There are some hazards to providing too much slope, as water may be able to run to the drains too quickly for their capacity, causing water to run overtop of the base flashing, if nearby. One should also consider that no roof deck turns out exactly the way one wants it, so include design provisions for installation of small bleeder drains in low spots that may develop after the building has had time to settle.

Avoid Ponding Having decided to slope the surface, next assure that nothing interferes with water flow toward the drains. Avoid locating long skylights, HVAC units, etc., perpendicular to the slope that will trap water. Where such units are necessary, install saddles or crickets to divert the water flow around the units toward the drains. The next major design decision is





how to prevent water from standing in the valleys or along walls between drains. If drains are too far apart in the valley, there will be ponding. Fifty feet between drains should be the desired maximum spacing. Crickets and saddles are then required to assure complete drainage. An interior valley will often be located over a beam-column line so that drains must be offset one to two feet away from the bottom of the valley. Since there must be a continuous joint in the insulation board along the valley line, this increases the potential for splitting an adhered membrane, particularly BUR. Again, crickets are necessary to move the valley line to the drain line and to divert water into the drains.

Side Effects When a building has multiple levels, even as simple as a central penthouse, the intersection of the sloped roof with walls must be carefully considered. A slope of 1/4-inch per foot gives a 25-inch rise over 100 feet. If the high side of the roof is against a wall, the surface elevation, including insulation thickness, must be defined carefully to assure space for installation of the counterflashing under windows and doors. If there is a wall along the sloped side of the roof, particular attention must be given to installation of the counterflashing. If the wall is concrete, a surface mounted unit can be attached following the same slope as the deck once the roof is in place. If the wall is brick or block, the masonry drawings must show where the receiver changes courses. If there is a center ridge line that dead-ends against a wall, then the roof surface elevation must be carefully calculated to define the height of the counterflashing and assure that with a low parapet wall one does not run out of wall height.

Drainage Systems Selection There are many alternatives but one in particular has routinely been a problem; namely, running water over sectionalized metal gravel stops at the perimeter edge of a roof. This is asking for trouble due to the difficulty of preventing failures of the membrane at the metal joints, particularly with BUR. In freezing climates any exterior drainage including scuppers and downspouts will likely be a problem. This leaves internal drains as the preferred alternative; however, be careful to plan for overflow drainage.

All drains, whether internal or scuppers, should be installed in sumps using tapered insulation to avoid a tendency toward ponding created by the additional layers of material around the drain. Coal tar bitumen roofs must have special design care to avoid letting the bitumen get into the drain pipes and to provide a means for removing it if it does. Sumps also prevent a minor accumulation of debris on the strainer from causing widespread ponding. The strainer should be easily removable and its top must extend several inches above the adjacent roof surface. Each major roof section should have at least two drains. The overflow drains should be designed so as not to be obstructable by the same debris as the primary drains. One must consider hailstones as potential debris because mixed with gravel, they can plug a drain for a considerable period. All scupper headers should have an overflow port to permit water to escape should the downspout become obstructed. Preferably, the downspouts should have an open front face.

ANSI Standard A58.1-1982 notes that the structure should be designed to support water assuming that all primary drains are not functioning. Gutters are satisfactory with steep roofs, e.g., metal or shingles, but be careful to avoid ice dams in freezing climates. This is a thermal envelope problem and not a roof problem, although there are ways to minimize damage by installing a truly sealed membrane under the shingles.

Each roof level of significant size should have its own drainage piping connected directly to the storm drain; do not cascade water from higher levels onto lower levels. The latter is a particular problem when designing additions to buildings. Controlled flow drains can be the kiss of death to a building because they are more easily plugged than normal drain strainers. If there is a storm drainage problem, the water should be retained on the property in basins in parking lots and landscaped areas, but never on the roof of a building. Insurance companies should refuse to cover buildings using controlled flow roof drainage.

Accessory Details

The second part of the maintainable roof concept pertains to accessory details, which refers to the many cross-section drawings on an architectural plan showing how specific elements are to be installed. Traditionally, these have been planar cross-sections, but many problems can be attributed directly to the non-use of isometric drawings that better illustrate what is desired and can often warn the designer that something is not going to fit. With the current availability of good three dimensional computer-aided design and drafting programs, there is little excuse for not providing adequate detail drawings.

Metal Water should be prevented from standing on or flowing over metal wherever possible, since it can fail from rust much more easily than the membrane. Use raised perimeter edge details and scuppers where the climate is suitable for exterior drainage. Where the membrane is attached to metal, the thermal expansion-contraction coefficients will likely damage the membrane more than the metal. Long runs of metal must have waterproof contraction joints designed into them and all metal penetrations should have a simple flashed curb around them. All coping covers and HVAC ducts should have sloping top surfaces to shed water and sufficient structural capacity to prevent deflection under snow loads. All joints between metal sections should be standing seam or equivalent to keep the joint away from the water plane and to permit some amount of thermal movement. All metal assemblies, from counterflashings to HVAC ducts, should be disassemblable; never use solder or rivets for an entire assembly.

Spacing All equipment, piping and walkways should be mounted on flashed curbs or pipe pedestals. Wherever possible, route gas pipes and electrical conduit someplace other than across the roof. Pitch pockets should not be used for sealing around penetrations unless the building occupant has a preventive maintenance program that assures that the pockets will be inspected every six months and refilled as needed.

Where pitch pockets are used, a movable metal hood or umbrella can sometimes be effective in shedding water away from the pocket. However, it must not be installed so as to prevent easy inspection of the pocket. Adequate space must be provided between penetrations to permit a full base flashing to be installed. Route electrical conduit up inside the curb rather than via a pitch pocket outside the curb. There should be adequate space under all equipment over the roof, including provision for insulation in future roofs, to permit easy access under the equipment. The Details Manual of the National Roofing Contractors Association (NRCA) has illustrations for appropriate items. Use standard details wherever possible to reduce the cost of fabricating one-of-a-kind designs.

Walls Parapet walls need more than cursory attention. If the wall is not directly attached to the roof deck, special provision must be made to avoid damage to the base flashing due to differential movement. The top course of block should be solid; bricks turned on edge are unacceptable. Metal coping covers should be sloped inward. Tilt-up wall panels deserve particular caution as the alignment of the tops and edges may be poor. For this reason such walls should always have a coping cover to keep water out of the joints between panels. Under no circumstances should the coping cover be set into a receiver in the top of a wall, especially a precast wall in a freezing climate.

Roof Shape Keep the shape of the roof as simple as possible. While multiple re-entrant corners provide architectural style, they are a potential disaster. At the very least they drive up the cost unnecessarily. At worst they concentrate stress on the membrane at the corners, leading to splits and tears in cold weather. Do not change the edge details back and forth from parapet to low profile, for example. This is often done where precast panels create a parapet edge while special inset door and window sections create a low profile edge. Use area dividers to break the roof into simple rectangular shapes as necessary.

Cooling Towers Cooling towers should not be located on roofs. However, knowing that they will be anyway, special precautions can avoid the common failures. Make certain that adequate space is provided for access under the tower to reach all piping, etc. For large towers this should be at least four feet above the roof surface. Install a curb attached to the deck completely around the tower to prevent water that enters the roof here from damaging the rest of the roof. Install a high quality smooth surface membrane within the tower work area; this will facilitate cleaning sediment and finding punctures. Install at least one roof drain so that flushing operations do not cause water and debris to run out onto the rest of the roof.

The designer should be aware that screening walls around cooling towers may reduce their operational effectiveness as much as 50 percent. Such walls should be louvered to permit air flow and avoid the serious wall vibration that can develop in a windstorm. The mounting of the wall absolutely must not use pitch pockets since the vibration will rapidly break their seals; use flashed curbs instead. For long walls, provide access doorways, preferably with no actual door, at opposite ends to facilitate access for maintenance.

Differential Movement Expansion joints need specific design attention, both as to their location and installation. Joints are needed wherever there is the potential for differential movement in the structure, such as the site of internal structural joints or where an addition is attached to an existing building. Less well known are places where a metal deck changes direction or where long precast beams meet end-to-end over an internal beam-column line. The old rule-of-thumb of placing a joint every 200 feet on a roof has not proven out. If the internal components of the roof system are properly attached, there is no need for such joint; if they are not, the joint will probably not prevent splitting anyway. There is often a benefit to installing area dividers to reduce the size of large roof areas. Flush expansion joint covers, particularly those where water is intended to flow over them, should be banned.

Before designing a joint detail, consider first in how many different directions can the roof move. The elastic membrane joint covers, properly installed on a curb, accept movement perpendicular to the joint well but not when parallel to the joint. If both types of movement are possible, then the joint should be the generic type that has a metal cap attached to one curb overhanging the other curb. In direct contradiction to vendor literature, elastic membrane joint covers should not be mounted with one side attached to a wall. Otherwise, the membrane traps the water that runs down the wall on top of the boot, the boot always has a splice somewhere, and the water always seems to find the failed splice.

The proper detail is shown in the NRCA Detail Manual for the non-wall supported deck. If there is a corner in a joint, the designer should ask himself if he knows what he is doing. If this occurs with an addition, there is not much one can do; otherwise, careful attention should be given to what type of movement is going to occur and why. Use factory molded corners wherever possible. Isometric detail drawings should be provided for all terminations of expansion joints, not just the normal cross-section in the middle. Under most circumstances a roof expansion joint cannot terminate until it reaches ground level, unless it closes on itself. This means that it must have an orderly transition through the parapet wall or edge detail into the wall expansion joint. If there is no wall expansion joint, the designer should be asking himself what the purpose is for the roof joint.

An often overlooked differential movement possibility is in the vertical plane. The roof deck is usually part of the overall structural system going down to the foundation. On the other hand, plumbing piping and other components may be laid on grade with vertical extensions that penetrate the roof. If the soil is not stable or if interior floor loads cause settlement, these penetrations will likely break their seals unless provision is made for movement. Heavy snow loads may deflect the deck sufficiently to break lead boots on pipes. Sometimes the problem is as simple as vibration of an electrical generator system's exhaust pipe. Flashed curbs will usually have either a bellows or a short horizontal run.

Mechanical Equipment A penthouse is a much better place for mechanical equipment than on the roof. The additional cost of a penthouse becomes a minor factor when you consider the following: energy loss/gain via poorly insulated housing and ducts and loss of conditioned air through access doors, damage done to the roof by persons working on the equipment, lack of preventive maintenance on units during inclement weather, problems created by screening fences, junk left on the roof after equipment repair, ad infinitum.

If after this admonishment you still want rooftop units, then make sure they are mounted on proper curbs. Since the deck may be sloped, plan to level the unit so that the condensate pan may drain onto the roof, not into the ducts. Plan on buying the highest quality units available, which means they will have tops with standing seam joints sloped to prevent standing water; hinged access doors and replaceable gaskets; insulation at least as good as the rest of the building; and louvers on the air intake to prevent ingestion of rain. The curb will have a two-piece counterflashing installed so that the base flashing can be repaired in the future without raising the unit. The gas pipe's drip leg will be several inches above the roof surface.

Sheet Metal All sheet metal material such as coping covers and counterflashings should be designed for easy removal without interfering with the operation of anything. This includes large skylights and HVAC units. No conduit or piping should be attached to coping covers. Where conduit runs along the perimeter of the building for security lighting, both the lamps and the conduit must be mounted on the wall, not the coping cover. Where pipes cross over flashings or wall tops, there should be sufficient clearance to permit removal of the metal without disturbing the pipes. Where HVAC ducts are placed on the roof, one must be careful to design the terminations of the ducts such that water will not be able to run down a sloped section of duct and stand against a joint going into a wall or a unit.

Particular attention should be given to the canvas vibration isolation boots as to their protection from hail damage and replacement when they fail of old age. Where ducts run for fifteen to twenty feet across a roof, one should ask why there is not a better solution. Long runs interfere with personnel attempting roof inspection. Wide ducts must include interior structural support for snow loads, even in Florida. Where coping covers and counterflashings do not close on themselves, isometric drawings should illustrate how the metal is to terminate or make the transition from one method to another. This is not a matter to be left to the field creativity of the sheet metal installer.

"Don't Fits" This colloquial term applies to situations such as where three walls of different width and heighth intersect at slightly different points. There is virtually no way for the coping cover to be installed so that a proper seal can be maintained. Walls that have mixed use of block, brick, or precast concrete are prime culprits.

Caulk Someone has said that the most dangerous phrase in an architect's vocabulary is "caulk as necessary." Caulking should be reserved for sealing joints in vertical surfaces between relatively stable components of the building. It should not be used where significant water will stand or regularly run across the joint. All caulking systems should carefully observe the vendor's requirements for backer rods and avoidance of excessive contact area.

Unusual Accessories Items such as radio or satellite antennas, solar panels, and weather instruments often must be located on the roof in spite of a designer's best efforts to keep the roof clear. The wind-induced vibrations and the associated piping and maintenance traffic are two problems that must be addressed. Proper curbs will usually avoid problems. Antennas should not be attached to sewer vent pipes.

Structural Considerations One is often tempted to hang interior accessories from the roof deck to avoid designing specific alternatives. This has two potential problems: the weight may create localized ponding problems and the deck may become damaged and need replacement. It is far safer to specify that all HVAC boxes and ducts, light fixtures and conduit, and grid ceilings be hung directly from the structural members. This will permit the structural engineer to better define the true loading on roof beams. In remedial design situations the designer must be aware of asbestos potential in the insulation sprayed on structural members for fire protection.

Unique System Considerations My comments thus far have been basic and generally relevent to all types of membrane systems. But there are considerations specific to certain systems. The sprayed urethane foam roof system is somewhat of a misnomer as the foam is not the roof but only the insulation; the coating is the waterproofing layer. Therefore, careful attention must be paid to selection of the coating.

Next, sprayed foam roofs are often advertised as "self-flashing" since the foam can be built up easily around penetrations. While this is a valid advantage, these systems are *not* "self-counterflashing" and need to have the exposed top edge of the foam protected by a normal counterflashing that will shed water over the edge should it begin to come loose.

Next, there are some mechanically attached single-ply membrane systems that warrant careful evaluation. Some penetrate the membrane with screws for attachment and seal the hole with a caulk. Others use a metal channel or other device below the membrane to secure the sheet without actually penetrating the membrane. One must evaluate the potential for these fasteners to damage the membrane or to come loose along with the long-term availability of replacement parts. Single-ply membranes typically have unique procedures for sealing the membrane at penetrations or where it attaches to a perimeter edge.

Finally, the inverted roof system, in which the insulation layer is placed on top of the membrane, is really more like a below-grade waterproofing system than a traditional roof. This system is extremely difficult to maintain; basically, it must be done right the first time around. The substrate should be very stable, such as with reinforced cast-in-place concrete, to reduce the risk of damage from building movement.

Access

The third aspect of the maintainable roof concept is that the roof and its components must be easily accessible for inspection while at he same time controlling unauthorized access.

People Access A roof is not a playground, a sundeck, a greenhouse, a solar experiment station, or a storage site. It is the second most important part of the building, after the foundation, namely for its weather protection. It should be used only for that purpose. It does, however, need easy access for regular inspection or such inspection will be neither regular nor frequent. Walkout access from the extension of a stairwell is usually best, although access from a penthouse is also good. If the penthouse has equipment that must be regularly replaced, such as, air filters, then the freight elevator should extend into the penthouse. If the roof is large, there should be multiple access points at opposite ends to avoid unnecessary backtracking. Scuttle hatches are intended to be oriented only one way relative to the ladder. Avoid hatches that go through custodial closets, which oftentimes are jammed with storage.

Ladders Where there are multiple levels there should be ladders between all levels, even if there are separate access points. One should be able to reach all areas of the roof with one access point; if not, the roof will not get the inspection it needs. Ladders should be mounted only to the wall, never tied into the roof at the top. Where the ladder goes over a wall there should be steps on the top side if the wall is over 18 inches high. The lower ends of ladders need careful attention to assure that they will not interfere with the base and counterflashing on the wall.

Doors The door must be high enough to permit the wall counterflashing to run under the sill without changing style or elevation. There should also be protection for the base flashing as this is an easily damaged point. A removable step bolted to the wall is often a useful solution.

Walkways The problems associated with walkways can generate an argument in most roofing groups. Asphaltic pad walkways cause almost as many problems as they eliminate. Wooden duckboards are a poor choice; if they do not damage the roof under them, they end up as a safety hazard once the boards rot and break. The solution to this matter starts with careful examination of the need for walkways in the first place. Why is frequent roof foot traffic needed? If traffic is infrequent it may be better not to install walkways at all. If traffic is frequent, and particularly if concentrated along certain routes, then raised walkways made from metal or fiberglass grating mounted on flashed curbs will provide better protection for the roof. For small high traffic sites, such as at the bottom of a ladder, heavy rubber pads laid loose on any type of membrane can be useful.

Working Access Access around equipment has been briefly discussed. It truly comes down to common sense; whatever cannot be reached easily for future inspection and repair will be neglected. Neglect kills more roofs than hailstorms, bad design, wet materials, and poor workmanship combined. The easiest way to think of proper access is to consider how the roof, which is the absolute last item, will be installed on the building. This will be the case ten to twenty years later when a new roof is needed. A good way to enforce this concept is to use a temporary roof during construction and indeed install the actual roof last.

Inspection Access Access for inspection from above has already been addressed, but access for inspection from below is a concept often overlooked. The structural frame of the building must be protected from the heat of a fire to provide approximately two hours for control of the fire before the frame will be damaged to the point that structural deformation will occur. This may be accomplished by spraying any exposed steel beams or columns with an insulation material. Spraying a metal deck is often not required but there will always be a certain amount of overspray anyway. This material can absorb considerable water before a drip begins. Unfortunately, the water in the spray process often causes some rust staining, which can be difficult to distinguish from new leaks.

A second method is to install a fire-rated ceiling, usually off gypsum board, directly below the structural steel. However, this prevents direct observation of the underside of the metal deck and seriously interferes with an inspection. A further problem is that sections damaged by leaks are rarely replaced so that the fire rating is destroyed. This approach is the less desirable of the two.

A third problem area occurs when a fixed plaster ceiling is used instead of a grid ceiling with removable panels, or when the panels in the latter interlock to the point that they must be destroyed to be removed. These ceilings generally form the bottom of an HVAC plenum. Any such fixed ceilings should have access doors, fire rated if necessary, placed regularly in easily accessible hallways to permit observation of the bottom of the roof deck.

High Interior Humidity This design concept does not properly fit under any of the above categories but is sufficiently important to warrant serious design attention. It is well known that spaces with high humidity, such as swimming pools, locker rooms, process areas, and cold storage rooms, may have problems with condensation in the insulation layer. The traditional solution has been to install a vapor retarder, sometimes incorrectly called a vapor barrier, between the space and the insulation. This does not address the problem of condensation on a metal deck due to inadequate thermal insulation, which can arise from a variety of causes, some not related to the roof. This problem is included as a maintainable roof problem since one does not want the metal deck to rust out from below. A better design alternative is to intentionally keep such spaces away from the exterior surfaces of the building by surrounding them with spaces of normal occupancy that have normal HVAC air movement. If cost is a serious problem, these spaces need not be finished and thus can be assigned for storage use.

Workmanship The last design concept recognizes that regardless of the type of roof system used, a certain portion must be constructed on-site under conditions that may be less than desirable. Further, there are no licensing requirements for roofing or metal tradespersons and no elaborate national codes upon which to rely. Therefore, there will be problems installing the best of roofs. Nothing is idiot proof; however, the designer has a responsibility to recognize that roofing is a difficult trade and that the system should tolerate minor worksmanship problems.

Redundancy has long been a technique for avoiding workmanship problems. This is one of the reasons for the continued use of the built-up roof, but it applies to other systems as well. The modified bitumen systems that have a two-ply membrane beneath the top sheet have redundancy. When applying a liquid membrane, multiple applications will avoid thin spots. A useful technique is to make the first coat red, the second coat black, and the last coat a third color. Covering the contrasting colors forces a certain amount of redundancy and, as an added benefit, indicates when it is time to consider recoating.

Maintenance Services Finally, the design process must consider how the roof will actually be maintained. The traditional built-up roof has many different materials available and many persons trained to do repair. The newer roofs, be they single-ply membranes or liquid applied, require materials, and to some extent, tools, that are not readily available. In addition, some of the materials have a limited shelf life. Thus, one should consider the availability of maintenance services. There are few restrictions if the roof will be in a major city with a variety of contractors. However, if the building is in a small town, it may be better to stick with the bituminous oriented products, either BUR or modified, since they are more easily maintained.

Another consideration is how tolerant the system is of neglect. The sprayed urethane foam roof is dependent upon having the coating intact to protect the foam from ultraviolet radiation. The foam will break down quickly if damaged areas are not repaired promptly. It would not be a good choice for a building owner with a poor maintenance program and no intention of changing it. Another major consideration is how one will locate leaks that undoubtedly will occur in the life of the roof. Rock ballasted roofs render most moisture surveys either difficult, expensive, or invalid. Paver ballasted membranes using pavers heavy enough to permit only 50 percent coverage, while retaining adequate total weight, will permit moisture surveys and the membrane can be exposed more easily.

The Professional Pessimist This is simply the designer playing the devil's advocate. No one intentionally designs a roof to fail, but it might. Simply standing back and asking a few "what if" questions can save considerable grief later.

Construction Concepts

System Design The roof is a collection of many different items that must be considered as a total system. If the designer intends to let the HVAC vendors bid their choice of a roof-top unit, then provisions must be made to adjust the size of curbs to fit. The designer must decide just how much substitution to permit and how it will be accommodated. There is such difference between a built-up roof and a single-ply roof that one or the other should be selected during the design phase. If not, the architect must give careful consideration to all relevant drawings and specifications to the extent that complete alternate sets may be required.

Conference Once the contractor(s) has been selected, the specifications for roofing, plumbing, decking, sheet-metal, and electrical should be reviewed with the architect, appropriate consulting designers, general contractor, all subcontractors (even those not associated with the roof itself), and material suppliers. At the same time, review the sequence of events leading to roof installation including all the accessories that must be installed prior to roof work. Confirm in writing that all parties understand and accept the drawings and specifications as a complete system. Be sure that all parties understand the sequence of events and the need for protection of all completed components.

Confirm all requirements for delivery and storage of materials, including certification from vendors of material quality. Acknowledge unusual deck load restrictions. Resolve any ambiguity over alternatives. Confirm in writing the procedures for reviewing shop drawings. Define scheduling alternatives in the event that critical materials are not available when scheduled for delivery.

Schedules Whenever the construction schedule meets with unacceptable weather, consider the use of a temporary roof, which should also be considered if roof installation cannot be the last phase in the sequence of construction tasks. Any heavy equipment for setting should be installed, recognizing that the construction crane will not be available for future repair work.

Existing Buildings If the roofing project involves working around an existing building, whether the building is occupied or not, certain additional precautions must be taken to protect the building, its tenants, the contents, and the surrounding area. Define what areas can be used by the contractor for storage and particularly where a kettle, if required, will be located. Define fire safety requirements and include a review by a fire department representative.

Specify how removed material will be disposed of and how often. Protect the building and surrounding areas from damage from materials such as bitumen or sprayed foam. Define the procedures to be used in removing an old membrane that will open the building to water entry. Common sense says that only what can be closed in one day should be opened, but areas with a tendency toward rapid development of summer thunderstorms may need closer coordination and control.

Quality Control Determining the criteria for acceptance of the roof deck for installation of the roof. Define what are unacceptable weather conditions for installation of roofing components. Define what quality control measures must be taken by the roofing contractor or owner. The concept of full-time, on-site inspection by the owner's representative is more valuable than all the bonds and warranties in the world. It is far better to detect and correct workmanship problems while the roof is being installed than to find and argue about them once everything is completed.

Materials Protection Store all roofing materials that may be damaged by weather exposure inside trailer vans or acceptable on-site temporary sheds. Permit the contractor to bring to the roof only those materials that can be used in that day's work. Define what mechanical devices are acceptable or necessary for the removal of old roofing, transport of materials, and installation of new materials.

Procedures Define which working, safety, and housekeeping procedures will be required or unacceptable. If you want the contractor to remove gravel from the wheels of his equipment to avoid puncturing the membrane, then spell it out. If you want mechanical felt layers rather than hand mopping, spell it out. If you want sandbags for temporary ballast of sheet membranes rather than old car tires, spell it out.

Water cutoffs should be installed at the end of every working day, unless the job is in the desert during the dry season and then only if the owner accepts responsibility for the risk in exchange for lower costs. When the sheet metal will be installed by a contractor different from the roofing contractor, define how the roof system will be protected from water entry should the counterflashings and coping covers, etc., not be installed immediately after roof installation.

Acceptance Define what constitutes acceptance of the roof system, both for intermediate payment and final acceptance. The roofing contractor should not be placed in the double jeopardy of waiting after his work is completed until other trades have the opportunity to ruin the roof before being paid. Continuous inspection is the best guarantee that the work was done properly. A nondestructive moisture survey can be conducted after the completion of the roof to determine if leaks exist. Define what tests cuts will be taken, how they will be tested, and what the consequences are of non-compliance.

Warranty Define when the warranty, if any, begins, what procedures are to be followed in the event problems develop, and what records must be kept. Decide what hazards are not the responsibility of the roofing contractor, such as damage by other trades. Discuss what dispute resolution procedure will be used in the event problems develop that cannot be resolved. Especially define where the contractor's warranty ends and the manufacturer's long-term materials warranty begins, along with what party assumes responsibility in the event of financial failure of a contractor. Define what party must inspect the roof to activate the manufacturer's warranty.

Procurement Finally, a good roofing system is most achievable under conditions of mutual trust, confidence, and cooperation. The competitive bidding process for selection of a contractor is one of the more important components of the building. If a contractor intentionally bids low and plans to make up the difference in change orders, obtaining a good roofing system is going to be a painful experience for all concerned, at best. Where there is an alternative between competitive bidding and negotiated selection, the latter should be given serious consideration.

Management and Maintenance Concepts

Regular Inspection The key to satisfactory service of a roof system once installed is to catch problems before they become serious. Frequency of inspection depends somewhat on the level of abuse of the roof. Any roof should be inspected twice a year and after any significant weather event, such as a hailstorm or wind storm. Much useful information can be gained by going onto roofs immediately after a rain.

Tenant Improvements Installation of additional HVAC units, lights, and antennas by tenants leads to a multitude of problems ranging from simple water entry to structure overload. All persons responsible for real property must establish careful procedures to control installation of such accessories. Often an owner is not aware that a tenant improvement ruined his roof until after the responsible party has moved on.

Act Promptly Do not ignore leaks; they are your only warning that serious damage is being done to your building. Establish a definite system by which on-site custodial or other maintenance persons will keep a simple log of when and where leaks were observed, regardless of how small, and what happened after they were repaired.

Remedial Roofing Even the best roofs will develop problems sometime during their life cycle. The goal of the maintainable roof concept is to minimize damage. This means that problems should be detected before large amounts of the roof system are damaged. One should not be making wholesale replacements of roofs except when they fail from old age. Remedial roofing is different from simple patching or repair. Patching is only the temporary stoppage of the water entry; repair goes further to eliminate what caused the problem. True remedial roofing includes removal of all damaged materials, replacement by new materials, installation of a localized new membrane, and addition of any new measures to make the area more maintainable. This may involve improvement of drainage, installation of better counterflashings, etc., as previously described.

Comprehensive Roof Inspection There are many different components to a roof inspection and each must contribute information regarding the condition of the roof. Visual inspection is the traditional method. The more recently available nondestructive moisture surveys provide invaluable information as to the location and extent of wet insulation, something that simply cannot be determined visually. Comprehensive inspection is not necessary every year or for every little leak. However, if one is making repeated patches to stop a leak without success, it is entirely probable that the true problem is not being addressed. This is the time for a comprehensive roof inspection; particularly if a roof has a history of problems and its replacement is being contemplated. *Never replace a roof until you know why it failed.* This seems rather obvious but its disregard has led to the unnecessary replacement of many perfectly good roofs when the true problem lay elsewhere.

Summary

There is nothing inherently wrong with any current type of roof system, so long as it is designed specifically for the building where it will be used and can accommodate the normal problems of workmanship and the need for ongoing maintenance that any building will encounter. Proper design and construction observation are more likely to provide satisfactory long-term performance than is any warranty. Finally, there is nothing like an injection of common sense to make roofs last longer. ■

Personal Computer Based Maintenance Prediction Model

by Edgar S. Neely, Jr.
and Robert D. Neathammer

Introduction

The U.S. Army Construction Engineering Research Laboratory (USA-CERL) is developing a personal computer based facility maintenance prediction model for the Department of the Army. This simulation model will predict the actual activities over any specified ten-year planning period and calculate all labor, equipment, material, and dollar resources required to support the maintenance plan. This simulation model will be used throughout the world to develop the Army long-range planning program for facility maintenance, but it can also be applied to nongovernmental organizations for maintenance planning. University and Army facilities are both composed of classrooms, laboratories, dormitories, roads, grounds, and utilities. Since the construction components are also similar, the data can be directly applied to university resource prediction.

The objectives of this research are to: 1) clarify terminology between all Army elements and develop one standard set of definitions for the Army, 2) document the state of the art in maintenance prediction within the United States, 3) develop short-term improvements to current prediction methods, 4) develop a new model that would uniformly address predictions in the planning, design, and maintenance phases of facility development, and 5) produce meaningful information for installation maintainers.

Our approach has been to identify the state of the art in government, private industry, and universities; visit installations worldwide to determine actual needs and current conditions of facilities; develop alternative models for further study; develop a standard computer system to simulate maintenance procedures; test the computer system at selected installations; refine the computer system; and implement it worldwide.

Edgar S. Neely, Jr. is civil engineer and Robert D. Neathammer is staff statistician at the Construction Engineering Research Laboratory of the U.S. Army, Champaign, Illinois.

Current Forecasting Methods

Forecasting an accurate ten-year facility maintenance resource plan for the Army is extremely difficult. The installation maintenance personnel develop the first year's resource estimate based upon the current inhouse work force and expected contract work. The forecasting method assumes that the remaining nine years' maintenance requirements will remain constant except for inflation, and that the cost of previously required but not performed maintenance will increase 3 percent per year. During the last ten years this forecasting method has proven to be acceptable for determining budget year requirements but is not accurate for long-term planning.

Conclusions and recommendations of studies and audit reports during the last decade have repeatedly expressed the need for management to improve forecasting methods. Improvements have been slow because of difficulty in developing relationships between facility characteristics and resource requirements, lack of maintenance standards, inconsistent calculation methods and definitions, and lack of life cycle cost data for individual facility components.

Maintenance resource estimates are normally prepared during the planning, design, and maintenance phases. During the planning phase management must forecast the planned facilities maintenance requirements. If existing facilities are being replaced, their current maintenance resources must be determined also. During design, costs of construction plus twenty-five-year maintenance costs for each facility component must be considered. Finally, during the maintenance phase the maintenance manager annually calculates the resources required to keep each facility in an acceptable condition. At present most organizations apply a different forecasting method in each of the three periods; therefore, the forecasts are not compatible.

The Army's budgeting system provides funds annually and requires all funds to be expended during that year. The Army does not apply the sinking fund account concept often used for maintenance funding. Therefore, it is extremely important that management be able to predict exactly what resources will be required for each year.

During the past few years approximately 55 percent of Army maintenance resources have been spent on buildings; 11 percent on heating, ventilating, and air conditioning (HVAC) plants; 6 percent on improved grounds; 5 percent on roads; and 4 percent on water and sewage treatment plants. The remaining 19 percent is composed of facility types that require a smaller resource percentage.

Current Research Program

The approach taken in this research program has been to: 1) determine the state of the art in maintenance resource forecasting, 2) identify actual Army forecasting requirements, 3) propose alternative forecasting prediction models for review and comparison, 4) implement the most promising models, 5) test the models on family housing facilities, 6) evaluate the test results and suggest improvements, 7) refine the models based upon the test evaluation, and 8) implement the system worldwide and monitor usage. The first four of the above activities have been completed and work is continuing on the fifth activity.

A steering committee was formed to direct this research effort and is composed of one management representative each from six installations, four major commands, Corps of Engineers Headquarters, and each of the other offices involved in the Army resource programming review and approval cycle. In order to coordinate this research within the Department of Defense, representatives of the Navy and Air Force are ex-officio steering committee members. The steering committee directs, reviews, and approves all research efforts.

State of the Art

The actual state of the art is extremely difficult to identify. Published literature contains very little maintenance oriented material and a limited number of national organizations disseminate maintenance information. Most information must be obtained from personnel contacts with each organization involved with forecasting maintenance requirements.

More than thirty-six organizations contributed information, including government agencies, universities and colleges, maintenance associations, private companies operating large complexes, and management consulting firms. The results showed that most prediction methods were manual, not computerized; computer systems were used primarily for scheduling preventive maintenance.

Most organizations separated maintenance into two categories: maintenance, defined as all maintenance activities below a subjective cost limit; and repair, defined as all maintenance activities costing more than the subjective cost limit. Maintenance is usually determined by taking the previous year's expenditures and projecting the next year's requirements (historical projection). Repair is determined by inspection of the facilities and projects defined for each facility.

The most detailed study identified was performed by Stanford University. Stanford developed a facility component model to predict the resource requirements for each facility. Individual facility requirements over the life of the facility showed large peaks and valleys. When all facilities were combined, the shape of the total resource requirement curve was similar to a mountain range with several peaks and valleys.

Army Requirements

Six installations in the United States and four in Germany were visited to determine current forecasting methods, historic data available (and its relative accuracy), and actual forecasting needs of the installations. Most installations are only performing maintenance predictions for one or two years, but a few are applying manual five-year forecasting plans. Historical data on individual facilities is incomplete. As much as 50 percent of the total resources are related to contract work that is usually not entered into the computer system against the appropriate individual facility. All installations made two emphatic statements, however. First, in order to provide meaningful information, the forecasting models must relate to the actual facilities on the installation; if not, the installation would have no incentive to enter accurate data into the model. Second, the installation is understaffed and cannot enter large amounts of data into a new computer system; therefore, it must have only minimal operational requirements.

Alternative Prediction Models

Six models were developed, and a short description of each follows.

Model 1: ***Continuation of the Current Method*** This method was not acceptable to the steering committee since it did not relate to the actual condition of the facilities at the installation.

Model 2: ***Historical Funding*** This method uses previous year's expenditures as reported by sixteen Army Management System (AMS) codes. The expenditures are increased by an inflation percentage to forecast the future. The AMS codes provide funding data only for large groups of facilities such as family housing or unaccompanied personnel facilities. This model was not acceptable to the steering committee because it was based upon the funding provided in the past and not on the requirements of the actual facilities. This method only perpetuates the status quo in which some installations have been underfunded and others overfunded.

Model 3: ***Installation Developed Manual Five-Year Plan*** The installation would be required to develop a manual five-year plan based upon the knowledge of installation personnel. This model was not acceptable due to the large amount of human resources required to develop the plan. Several installations are currently doing this but the majority are not interested in expending resources in this manner.

Model 4: ***Application of the Existing Integrated Facilities System (IFS)*** IFS is the current computer system used at the installation to keep track of individual facility information. This model was not acceptable because the level of component detail is not sufficient to adequately describe the facility, and most installations are not updating the component information within the system.

Model 5: ***Application of an Expanded Integrated Facilities System-Redesign*** This would require that the IFS be redesigned to contain all required component information and/or personal computers be used to perform the forecasting and interfaced into IFS for data transfer. This was the selected model because it was based upon the actual facility requirements at the installation. All steering committee members were concerned about the labor hours required to operate such a system. The research must document the resources required to operate and maintain such a system before the steering committee will recommend worldwide implementation of this model.

Model 6: ***Fixed Percentage of the Current Replacement Cost*** This model was not acceptable because all research to date by other organizations pointed to the conclusion that the resources required by a facility are not constant every year. The results of the current research program will prove or disprove this assumption for the Army.

Model Implementation

Model implementation has been divided into maintenance activity resource development, computer system development, and housing research.

Maintenance Activity Resource Development

Resources required to perform building, HVAC plants, improved grounds, water/sewage treatment plants, and road facility maintenance activities are currently being developed. The labor required to perform approximately 60 percent of all maintenance activities has been previously determined and published in a series of documents known as Engineered Performance Standards.

Maintenance of HVAC equipment is a function of operating hours and temperature. The United States has been divided into ten climate zones and annual maintenance requirements have been changed for each zone.

Maintenance resources include four groups: direct resources, indirect resources, travel time, and administrative resources.

Direct Resources Labor, materials, and equipment resources are being developed to represent the normal or standard maintenance required by a facility component. In order to keep the resource data base as small as possible the material monetary resources have been converted into an equivalent labor hour representation. Adjustment factors are being developed to address such items as the type of occupant, length of stay of occupant, adverse weather conditions, and design/construction techniques.

Indirect Resources Four types of indirect resources are related to labor. First, delay allowance, which covers all types of

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delays and personal time. Second, craft time delay allowance, which includes delays such as interference with the occupant and/or other trades. Third, job preparation, which covers receiving job assignments, instructions, planning work, and laying out/picking up tools. Fourth, material handling, which covers moving materials from site to task work area. All of these items can be expressed as a percentage of the direct craft labor and combined into one figure. For example, 30 percent for all building trades except boilerwork, and 40 percent for boilerwork.

Travel Time Travel time from shop to site varies from ten minutes to more than an hour and may be as labor intensive as performing the activity itself. The actual travel time to each group of facilities will be used in the model.

Administrative Resources Such resources vary greatly from installation to installation and are usually expressed as a percentage of direct labor. The actual rates for each craft at an installation will be applied in the model.

Computer System Development

Three existing computer systems require interface actions in order to implement the Army maintenance data base. In the planning phase the existing system is known as the DD1391 Processor; a small set of interface programs is required to incorporate the new data base. In the design phase the existing system is known as the Computer Aided Cost Estimating System. In the operations and maintenance phase the existing system is known as the Integrated Facilities System (IFS). The remainder of this section describes the major software development for the maintenance phase.

The research computer software to support the prediction model is written for any IBM PC compatible computer. This system is currently a resident on an IBM PC XT, IBM PC AT, and COMPAQ-PLUS and is composed of three basic subsystems.

Department of the Army Functions This subsystem includes the development and maintenance of the basic data needed by each installation to perform resource forecasts. The data includes the Army organization chart, facility codes and classification categories (F4C), component/task resource tables, standard travel zone times, standard task performance methods, federal wage grade rates, and standard trades in shops table. These data are currently under development by USA-CERL and will be sent from the Department of the Army to each Major Command (MACOM). The MACOMS will review, adjust, and approve the data and send it to the installations, who will then load the data into their computers for use in processing.

Installation Functions The first function for each installation is to define their actual management procedures within the computer. This includes definition of additional travel times, actual methods used to perform work tasks (i.e., contractor, inhouse, troop, occupant), contractor/government labor and equipment rates, and shop composition.

The second function is to describe the facilities being maintained. The installation is divided into management areas. The facilities within each area are combined by similar floor plans, construction, and weather conditions. One facility from each group is selected as its typical facility. The facility components are entered into the model. The component definition detail level is governed by the installation. Factors such as occupant type and length of occupancy are entered to complete the facility group definition.

The third function is to calculate and review facility resources. The data base can be kept updated to reflect the most important dates related to the maintenance of the facility, such as the last roof replacement date. If the installation uses the model at the detailed component level a number of current manual functions could be performed within the computer including such items as interior-exterior paint schedules and floor covering schedules.

The fourth function is to prepare summary resource reports for higher authority review and approval.

Review and Approval Functions Installation resource summaries are to be sent to MACOM for review, approval, and combination into a MACOM summary. MACOM and installation data are then sent to the Department of the Army for review and approval.

Housing Research

The model will be first tested using family and unaccompanied personnel (similar to college dorms) housing facilities at the ten test installations. Each installation will segment housing into groups of similarly constructed facilities (i.e., two-bedroom officers quarters constructed in 1960). The as-built drawings for one typical facility in each group will be used to generate a facility component quantity takeoff. The components will be entered into the prediction model and a resource prediction will be made for fiscal years 1974–83. The resource predictions will be compared to the actual expenditures and the backlog of maintenance that remains to be performed. Comparisons will be made for similar housing constructed the same year at different installations. Generalized component, system, and facility resources will be calculated based upon the composition of the actual facilities.

The family housing at the ten installations adequately represents the majority of family housing constructed in the Army since World War II. A number of the installations have a few facilities that were constructed before World War II that must be handled on an individual basis.

> "[The historical funding method] only perpetuates the status quo in which some installations have been underfunded and others overfunded."

The model will be taken to each test installation for a training and testing period. A portable COMPAQ-PLUS computer will be used during this period. Each installation will apply the system to the family housing facilities and generate a forecast for fiscal years 1985–94. The installation will evaluate the system's effectiveness before the next steering committee meeting.

Evaluation

Upon completion of all installation testing, the steering committee will meet to evaluate the model and to provide further direction towards the systems fielding.

Summary

The research for the first facility category codes is scheduled for completion in August 1985. If the result of this research is acceptable to the steering commitee, funds will be provided to perform research on the remaining facility category codes.

The maintenance resource prediction model is not limited to Army applications. This system can be used by any federal, state, or local government agency, college or university, or any private company to develop accurate resource forecasts.

The USA-CERL does not want to duplicate research that has been performed by other organizations. If the reader is aware of similar research programs, the authors would appreciate notification of them. ■

State Policy Initiatives for Financing Energy Efficiency in Public Buildings

by the Higher Education Energy Task Force

An energy efficient physical plant is a resource that should be developed as part of sound fiscal management. Our buildings and equipment were constructed without regard for energy operating costs. As a result, there exist tremendous opportunities for energy cost control through improved building operations and maintenance and capital investments in energy efficiency.

Yet, while faced with excellent investment opportunities in energy efficiency improvements, states are experiencing severe fiscal crises; the resources available for financing energy efficiency are limited. Given the power of new alternative financing options, however, public administrators can begin to view energy efficiency improvements as investments with attractive returns. This paper will demonstrate that lack of state resources need no longer be a barrier to developing cost-effective energy efficiency projects. Alternative financing can be arranged for all projects.

Alternative Financing

The main principle of energy financing is straightforward: energy conservation saves money, and the savings can be used to pay for the improvements. By properly financing energy efficiency investments, state campuses can generate immediate positive cash savings. In other words, economically sound projects can be self-financing.

The rationale for exploring alternative financing is equally straightforward: in the competition for limited resources many cost-effective projects are not being funded. In light of the availability of alternative financing options, energy efficiency offers compelling opportunities for cost reduction that no astute manager can afford to overlook.

While recognizing their capital constrained position, public institutions can still take an aggressive approach to developing their energy cost savings potential by using alternative financing. Delaying projects means losing the potential cost savings they offer. Delay can also inflate project costs.

Alternative financing offers a way to implement projects expeditiously. In the final section of this paper, the following financing options are discussed:

- tax-exempt bonds
- municipal leasing
- shared savings contracting
- third-party project financing

Alternative Financing with Private Capital

Accessing private capital for energy efficiency projects offers several important advantages. It can:

- relieve the burden of funding from state and local budgets
- generate an immediate positive cash flow to the state
- free scarce state resources and preserve borrowing capacity for other purposes
- expedite acquisition of energy saving equipment and thereby avoid losing potential energy savings (which delayed implementation causes)
- make use of the energy management and project development expertise of the private sector
- transfer the risks associated with energy project development and operations to the private sector

Before we discuss individual financing techniques, we shall examine the case for making energy efficiency an administrative priority and outline several important changes in budgeting and procurement procedures necessary to facilitate and stimulate the development of projects and the use of alternative financing.

Why Be Concerned with Energy Efficiency?

Nationwide, higher education spent an estimated $3.2 billion on energy costs in FY 1981-82. This amount is equivalent to the salaries of 129,000 full-time faculty, $363 for every full-time student, or one-and-one-half times the budget of college libraries nationally. The estimated energy expenditure for public schools (K-12) is $4.5 billion; for hospitals, over $3.4 billion, equaling $2,517 per bed per year. High energy costs have taken their toll on municipal budgets. A 1980 survey of 1,550 local governments by the International City Management Association revealed that energy expenditures were the second highest line item in the annual operating budgets of 56 percent of the local governments surveyed.

A dollar spent on energy is one less dollar available for valuable programs and services. A clear, direct equation between energy and cost control needs to be made in the minds of public administrators.

These energy costs will continue to rise, especially in the wake of natural gas deregulation. For example, two-thirds of the nation's hospitals use natural gas as their primary fuel. Assuming natural gas prices will double by 1986, which is expected

The Energy Task Force is a committee of the Association of Physical Plant Administrators of Universities and Colleges. This is one of a series of eight papers published in Financing Campus Energy Conservation Projects.

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under the current Natural Gas Policy Act deregulation schedule, $900 million will be added to hospital fuel bills. Even though the price of oil has fallen recently from approximately $34 to $28 per barrel, the economic potential in improved energy efficiency is still very great. Remember that as recently as 1979 oil prices were $14/barrel; in 1972 they were $1.50/barrel. The relative efficiency of our energy systems has *not* yet caught up with the price increases of the 1970s. Energy efficiency still represents a major opportunity for cost-control in the public sector.

Another area of concern related to energy efficiency is facilities renewal. Major investments will be required in the coming decades for renovating and upgrading aging capital facilities. Energy efficiency improvements work hand-in-hand with and can be the beginnings of a capital renewal program. Energy cost savings can significantly offset the costs of deferred maintenance expenditures.

Energy efficiency offers numerous other public economic benefits: jobs in the conservation industry, a reduced loss of purchasing power from the local economy to pay for energy imports, the healthy multiplier effects of increasing the local circulation of goods and services, and lower costs for public services.

Charge to State Legislatures and Executive Agencies

State legislatures and executive agencies need to commit to and develop procedures for financing all cost-effective energy efficiency projects in the buildings for which the state owns, operates, and pays the energy bills directly. There is immediate cost-control potential here. Second, state government needs to concern itself with cost-control and facilities renewal in institutions for which they have indirect fiscal or public responsibility: schools, hospitals, colleges and universities, and municipal facilities, as these facilities are operated in the public purpose.

The Department of Energy's Institutional Conservation Program, popularly known as the Schools and Hospitals Grants Program, is searching for policy initiatives that will promote the financing of energy conservation, work with the private sector and market forces, and require a minimal budgetary commitment from the Federal Treasury. Whatever funding level is achieved for future grant cycles, it will be grossly inadequate to finance all the cost-effective energy projects that are being identified within these sectors. This change in federal support is shifting responsibility for energy financing to state and local initiatives, making it necessary that states commit to developing all cost effective energy efficiency projects.

Adopt New Capital Budgeting Procedures and Financing Techniques

Initiative #1 *Assess the Energy Savings Potential In All Public Buildings*—It is critical that public agencies continue to collect energy data on their buildings and identify efficiency projects. This is the initial phase of project development that only the building owner/manager can undertake. Accurate data is needed to prioritize projects, attract private financing, negotiate sound contracts, and independently monitor results. Funding for audits and engineering feasibility studies should continue aggressively.

As an aside, one possible source of funds for energy audits or even minor improvements is reserve repair and replacement funds established by bond indentures for buildings originally funded by bonds. Federal "oil overcharge" funds could also be used for this purpose.

State energy offices (SEOs) should continue to assemble information on potential energy efficiency projects as they have under the federal schools and hospitals program. Then, alternative financing can be arranged.

Initiative #2 *Commit to Funding All Cost-Effective Energy Projects*—States should commit to funding and developing all the energy efficiency projects that are cost-effective. The criteria for cost effectiveness are:

1. The project meets the state's target rate of return.
2. The project can be financed on a positive-cash-flow basis.

This policy should be communicated clearly to all institutional plant managers. The policy should indicate to building and finance managers that energy projects meeting the specified economic criteria are fundable or, additionally, that energy finance and service contracts with private firms that meet specified criteria are acceptable.

Initiative #3 *Present Energy Projects Separately for Capital Budgeting*—Because of their cost-saving nature, energy efficiency improvements should be presented separately for capital budgeting. This will encourage physical plant managers to bring energy investments up the line. Further, it will allow the financial returns of the projects to be highlighted and alternative funding sources to be explored even if regular capital appropriations are not forthcoming.

Initiative #4 *Lift the Capital Ceiling for Energy Projects by Demonstrating Access to Capital*—Many states, through the capital budgeting process, impose a ceiling on allowed annual capital expenditures. Because energy projects compete directly for funds with projects vitally related to a campus' mission, they are often cut to meet the ceiling and preserve the other priorities. Even when cost-effective energy projects have been identified and engineered, they are not always submitted for appropriations.

Access to external capital to implement campus energy projects can easily be demonstrated. Funding for energy projects does not have to compete for internal resources.

Initiative #5 *Confirm or Clearly Authorize the Contractual Ability of State Institutions* *to Use Alternative Financing*—Public institutions must live within strict constitutional debt limitations and cannot incur multi-year liabilities, except bonded indebtedness. This restriction may place limits on their ability to use private financing mechanisms. For example, in Massachusetts, public institutions can only lease certain property—buses, computers—and are not currently authorized to lease energy equipment. In New York, legislation has been introduced to allow only up to ten-year energy service contracts.

These restrictions against incurring multi-year liabilities can be dealt with contractually with use of a "non-appropriations" or "fiscal funding-out" clause. This clause is discussed in the section below on municipal leasing.

Several other legal issues can arise if a state institution proceeds to enter alternative financing contracts concerning procurement procedures, labor relations, leasing of state property to developers, and financing. To encourage use of alternative financing, legislation clearly authorizing it is helpful. An excellent example of such legislation is California Senate Bill 701 passed in 1982.

In many cases, procurement law will have to be changed. Each state has its own laws that act as barriers to the procurement of energy project financing from private sources. Identifying legal barriers and revising the laws to permit private financing necessarily will be an individual state-by-state process.

Initiative #6 *Develop Procurement Procedures for Alternative Financing*—State governments should develop procedures for utilizing private capital financing of energy efficiency improvements. There may be economies in centralizing financing expertise in one state office and then making it available to other state agencies and public-purpose institutions. State energy offices, purchasing, general services, public works—all these may be the appropriate office to undertake the task.

After researching and qualifying financing mechanisms and specific plans offered by private business, the energy financing office could serve to connect those institutions needing financing with firms that can provide it. By assembling cost-effective energy projects the SEO could attract investor interest in this market. The office's goal would be to provide information that would open up the marketplace and assist both public institutions and private businesses in engaging in mutually beneficial transactions.

In order to utilize private capital, public agencies must continue to identify energy projects and develop procedures and standards for procuring financing. Several states, notably New Jersey, Washington, Minnesota, California, Delaware, New York, and Pennsylvania, have developed or are developing procurement guidelines for alternative energy conservation financing and services. The New York State Energy Research and Development Authority is currently involved in a demonstration program to broker energy performance contracts for several institutions, including a state owned psychiatric hospital and two public schools.

Initiative #7 *Designate a Budget Line for Making Alternative Finance Payments*—To use alternative financing, the budget line item out of which the financing payments will be made must be identified. If an institution has identified an energy conservation measure which will repay its initial costs in one year or less, it should be allowed the budgetary flexibility to spend or transfer funds out of its utility/fuel account to implement this measure. Washington State has recently passed legislation to allow this practice. This practice is not allowed in many state institutions and unnecessarily prevents expeditious implementation of conservation measures.

Massachusetts has considered taking this logic another step further by allowing funds to be spent from the fuel account budget line for lease, debt service, and other forms of energy efficiency financing payments if the transaction creates a positive cash flow (that is, payments are less than energy savings). This policy would encourage use of innovative financing programs and give institutional managers the budgetary flexibility to initiate such transactions.

Initiative #8 *Create a New Energy Budgeting System for Stimulating Efficiency*—Individual public institutions typically do not have incentives to save energy. If energy savings are achieved these saved dollars revert 100 percent back to the state general coffers. Few, if any, dollars are returned to the institution that generated the savings.

If future energy budgets are based on historic energy expenditures, the agency may have a positive disincentive to conserve. One manager, in anticipation of a governor's mandate to cut utility costs by a fixed percentage of existing expenditures, deliberately refrained from implementing all energy conservation measures in order to protect future budget allocations. Administrators knew that utility bills would be paid whatever their amount. The state legislature had granted supplemental appropriations for energy cost overruns in the past, a widespread common practice. The institution, therefore, had no incentive to submit all identified energy projects in their capital request because, if funded, they would effectively reduce their capital appropriation for other purposes and would reduce their energy operating budget in future fiscal periods. Not only can institutions lack incentive, they often lack the resources necessary for effective energy management.

> "The potential dollar savings available from institutional energy conservation are so great, they have attracted the interest of private business."

The solution is to create an energy budgeting system to stimulate efficiency. The new system has two purposes. The first is to reward energy efficiency and management successes. The system should localize incentives to conserve energy with the end user and other energy managers by allowing them to retain part of their energy savings.

Second, the system should provide resources for energy management. A portion of avoided energy costs can systematically be garnered for reinvestment in the efficiency program. This system creates stable parameters necessary for effective management and, in the process, institutes a performance monitoring system.

A small percentage of avoided energy costs are being distributed back to the individual campus administrations within the State University of New York system. California, Utah, and North Dakota are also investigating such a policy. A Colorado program allows local campuses to retain all energy cost savings beyond 12.5 percent of the total energy budget and also penalizes the campus for exceeding their allocation by more than 12.5 percent.

Components of an Energy Budgeting System

Three important issues have to be addressed in designing the new energy budgeting system to stimulate efficiency:

- how far into the future should energy costs savings be calculated,

- how should subsequent years' energy budgets be calculated, and,

- what stipulations should be placed on the use of saved energy dollars.

Budget in Energy Units—Distinguishing between energy units and dollars is the key to this budgeting system. A base year energy consumption level, expressed in energy units, is established. The previous year's consumption corrected for weather could be used. This amount becomes the energy budget for the next year.

Budget Over a Five-Year Period—In order to provide continuity for the budgeting system and create stable parameters for planning, a five-year budget is created. This long time horizon is critical to the success of the program.

Base year consumption is the energy budget for year 1 of the plan. Subsequent years' budgets can be the exact same base corrected for changes in the amount of total space served and in building operating patterns, *or* they can decline as progress is made toward an efficiency target. If the latter method is chosen, then a five-year efficiency target from operations and maintenance (O & M) improvements should be set. The institution then establishes energy consumption and efficiency targets for each of the next five years. If new experience and conditions warrant it, the target can be changed. Changes should reflect improved accuracy in estimating energy use and not compromise the goal of creating incentives for efficiency. At the end of the five-year period a new base year should be established.

Calculate Energy Savings and Convert Into Cost Savings—The difference between the amount of energy budgeted and the amount actually consumed is the savings. The savings will be broken out into savings from 1) capital projects, and 2) operations and maintenance improvements. The calculation of energy saved should correct for weather and changes in operating hours and increased space.

Either the actual prevailing prices, or the estimated price on which the dollar budget was based, can be used to calculate the dollar savings. If prices rise unexpectedly, then there may be no excess dollars in the energy budget for distribution; yet, you may still want to calculate and distribute energy savings at the prevailing prices. Energy savings have become more valuable, increasing the importance of conservation. On the other hand, higher than estimated energy prices may consume all available funds for distribution, making it impossible to stick to the budgeting system. How the budgeting system will respond in such cases—where actual prices deviate significantly from estimated prices—needs to be addressed.

Again, the goal of this system is to create incentives for reduction in *consumption*. The institution or energy manager should not bear the risk of, or benefit solely from, unanticipated changes in energy prices. For example, if no improvement in efficiency occurs yet prices fall, then even though a budget excess will exist, it is not attributable to energy management and should not be distributed under the program.

Develop a Schedule for Distribution of Savings—Once the value of savings is determined, the funds can be distributed. A schedule for savings distribution—which group should get what percentage of each type of savings in what years—needs to be negotiated.

Funds can go to three groups with the following stipulations for their use:

The Building/Agency Energy Users—A small portion of avoided costs can be distributed for general purpose or program, preferably a highly visible item to maximize the public relations value of the money. This group should only share in savings attributable to O & M improvements.

An Energy Project Fund—Funds can be used for energy engineering studies and consulting services, financing payments, or on direct costs of efficiency projects and other expenses related to the energy management program, e.g., submeters. Savings from both capital and O & M projects should be distributed to the energy project fund.

The General State Fund—If the energy budget is declining over the years, this decline can represent all or part of the general fund's portion of O & M energy savings. Of course, no stipulations are put on savings reverting to the general fund. Five years after their implementation, all savings from capital projects could revert to the general fund.

Tax-Exempt Bonds

The term alternative financing for energy projects refers to any source or method of financing other than state appropriations made through the normal capital budgeting procedure. This definition includes the use of tax-exempt bonds. The reason for defining them as alternative is that bond financing of energy projects, though it is a traditional method of funding, does not have to cost the state government any money. Given an economically sound project, the annual debt service on the bonds will be less than the energy cost savings, resulting in immediate cash flow improvement. It is critical that this investment perspective and positive cash flow approach be adopted.

Tax-exempt bonds are the traditional method for public institutions to finance capital projects. The two types of government bonds are: 1) general obligations (G.O.) bonds, and 2) revenue bonds. Because general obligations bonds are an established method for financing capital facilities, they are the first option to be examined for funding public sector energy efficiency improvements.

The critical element in bond financing of energy projects is how the bonds are secured and what their source of repayment will be. The flow of funds, tracing the saved energy dollars to the debt service payments, needs to be mapped out clearly. A direct connection needs to be made between the savings and the bond payments. No agency or institution should be penalized for implementing energy projects. That is, if an institution is required to make the debt service payments, they should also be allocated a portion of the savings.

Debt-issuing capacity is a limited resource. Some states or public institutions may be near their prudent debt carrying capacity. Although bond financing of energy projects will cause immediate net savings, it will lower debt service ratios. State officials must make a policy decision whether to use their borrowing capacity for energy projects or conserve it for other purposes. The attractiveness of other financing options which have a lesser impact on borrowing capacity will be a factor in this decision.

States have operated grant and loan programs for public sector energy projects financed with G.O. bonds. The federal schools and hospitals program remains an excellent model for grants programs operated at the state level. This program could be assumed and expanded by state governments using state general obligation bond financing.

New Jersey issued $50 million in general obligation bonds in November 1980 to finance energy improvements in the 40 million square feet of state owned buildings. A bill is pending for a $25 million issue for conservation grants program to local school districts.

California has issued G.O. bonds to provide matching funds for federal grants under the schools and hospitals grant program.

Massachusetts is considering an innovative program for financing energy efficiency projects for state and municipal facilities to be funded by general obligation bonds. The original bond principal would establish a revolving loan fund. Individual loan terms would be arranged so that debt service payments would be less than annual energy savings. Debt service would be deposited back into the loan fund for reinvestment in additional projects. Forty-five million dollars was originally proposed to initiate the program; this amount has been reduced to $10 million in a bill now before the state legislature.

Nebraska has committed $5 million per year for the next five years for a public schools energy conservation grants program. The state grant covers 75 percent of the project costs, requiring a 25 percent matching local contribution. The funding derives from oil and gas severance taxes, which, of course, all states do not enjoy.

Herricks School District, Long Island, New York, and Jefferson County, Colorado recently gained voter approval for bond issues solely to finance energy conservation projects. These issues were presented to the voters in terms of the total tax dollars that the school districts would save by implementing the energy projects. The debt service on the bonds was designed to be less than the energy savings, thus generating a positive cash flow from the project. Voters apparently understood this logic.

Revenue Bonds—Revenue bonds typically are secured by the revenues of the project being financed. The cash flow from operation of the project serves as security and the source of bond debt service. Because energy efficiency projects save costs rather than generate revenues, they are not eligible for a strictly self-supported project financing. One important exception exists to this rule. If the project generates power (electricity or steam) for sale, then those revenues could be used as security.

Second, a private business entity could intervene between the bond authority and the public institution. Using the bond proceeds, the private firm would make energy efficiency improvements under one of several contractual arrangements. The payments from the institution to the private firm would serve as the revenue stream to secure the bonds. The advantage of a pure project revenue financing is that it is "off credit" for the institution; the institution's capacity to borrow for other purposes is not diminished by the transaction.

States can utilize revenue bond authorities for financing public sector energy projects through third-party financing. The issuing authorities have no taxing power. Bonds issued by these authorities are not a debt of the state or local government that established them. No government obligation is created by these bond issues. These authorities are an ideal and identifiable vehicle for energy project financing.

Municipal Leasing

A municipal lease is a conditional finance or purchase agreement, structured like a simple loan, with the interest income being tax-exempt to the lessor. At the end of the lease term, ownership of the property passes to the lessee. Just like a municipal bond, interest income on the municipal lease payment is tax-exempt to the lessor. Interest rates are, therefore, very favorable, currently around 10 percent, just slightly above the municipal bond rate. With typical lease terms (5-year lease at 10 percent) all energy projects with a 3.5-year simple payback period can be implemented on an immediate positive cash flow basis. If the lease term is extended, longer payback projects can be implemented for positive cash flow.

A municipal lease does not constitute long-term debt of the lessee. It does not encumber the lessee's future budgets or reduce—to the degree that bonded indebtedness would—an institution's borrowing capacity. The lease includes a clause limiting the lessee's obligation to make the lease payments to a single fiscal period. The lessee is obligated to make every effort to secure appropriations for lease payments, but, by removing the fixed obligation to make payments in future fiscal periods, the restriction against creating multi-year liabilities is satisfied.

Creating any state obligation raises the concern of overextending the state's credit. Municipal lease financing of energy projects addresses this concern in two ways. First, energy projects are particularly well suited for municipal lease financing because they can be financed on a positive cash flow basis. Lease payments can be structured to be less than debt service. This is a cost-cutting transaction. Second, the municipal lease satisfies all legal restrictions against incurring multi-year liabilities. Thus, a legislator or administrator should approve of municipal lease financing of energy projects when the transaction can meet the positive cash flow criteria.

To move forward on municipal lease financing, state officials must determine:

1. Is this a desirable method?
2. What are the state's procedures and laws for using municipal leasing?
3. What source or budget line for lease payments would be used; could lease

payments be made out of the utility line (given that energy cost savings is greater than debt service)? Would an established account line be used or would a new one be established?

4. What criteria and financial analysis procedures would be used for deciding what projects to finance with municipal leasing?

5. What are current market rates and terms for leasing in your state?

Shared Savings Financing for Energy Efficiency Investments

The three most common barriers you will find in trying to exploit your institution's energy savings potential are: the lack of in-house expertise and administrative momentum needed to identify and implement projects, the lack of up-front capital, and the lack of guaranties or certainty to reassure public administrators that a project will actually produce the promised savings at a reasonable cost.

The potential dollar savings available from institutional energy conservation are so great they have attracted the interest of private business which, in turn, has begun to address and eliminate barriers to energy efficiency investment with what is known as "shared savings" contracting.

Shared savings is a generic term for an agreement in which a private company offers to execute energy efficiency capital improvements in exchange for a portion of the energy cost savings that accrue. Typically, such a company enters into a long-term contract and, at its expense, engineers, installs, and manages or comanages an energy efficiency system for a building.

The most attractive feature of this arrangement is that no up-front costs are incurred by your budget. Capital is provided by the private firm. The cost of that capital is spread out over the length of the contract through the service payments paid by your school. The service payments are made out of the energy savings generated by the project. Further, the private firm assumes many of the risks of the installation. Your campus is only required to pay a percentage of what it saves. If no savings are realized, no payment is due.

Energy Service Contracts—An energy service company is a full service company that contracts to provide given levels of heating, cooling, lighting, and equipment use. The company assumes all responsibility for the utility bill payments of the school and makes its profit on the spread between its cost of providing energy services and its fees.

Fees are guaranteed to be a negotiated percentage of what the same level of energy services would have cost if you kept operating at the same level of efficiency. In other words, your campus can never pay more for its energy than it presently pays, assuming price levels remain the same. The company makes capital improvements to provide energy services more efficiently, at no direct expense to your institution. All you pay are the contract payments.

Shared Savings—Shared savings contracts function much the same as full service contracts, but are more common because their scope is less comprehensive, aiming at one project or one series of projects and has most commonly been used for energy control systems. Other types of installations financable by shared savings financing are heat recovery systems, boiler fuel conversions, cogeneration, and more. Whole packages of general energy systems improvements have been included under shared savings arrangements. This type of financing, while new, is gaining in frequency and reputation because of its inherent flexibility.

The share of savings required by the investor to make the investment economically attractive depends on the firm's cost of capital and other variables, and will vary from 50 percent to as high as 90 percent. Remember, however, payments are based solely on savings realized. If no savings accrue, then you as the energy user are not liable to make payments for capital improvements or services rendered. In this way the firm has every incentive to perform. Shared savings contracts are being written for terms of five to twelve years.

Third Party Project Financing of Central Plant Facilities

Many state institutions operate large central plants. On any campus the central plant is the first place to look for efficiency improvements. Major projects such as cogeneration or conversion to alternative fuels like biomass or waste can offer tremendous savings in energy supply and fuel costs. These projects are excellent candidates for private capital financing.

Central plant projects are well suited to "third-party financing." Third-party financing is a generic term for arrangements where a private, independent contractor will design, build, finance, and even own and operate the plant. The private party can lease the facility back to the state, similar to current state lease-purchase agreements for office buildings, or it can assume plant operational responsibility and enter into long-term energy sales contracts for the sale of utilities. In the latter case, the real property on which the plant is sited would be leased to the private party. The private party is typically organized as a limited partnership and utilizes debt leverage to maximize the tax benefits to the investors.

The California Department of General Services recently contracted for third-party development of ten cogeneration plants. Pennsylvania will soon be issuing a request for proposal for financing cogeneration in state facilities.

The University of Texas has utilized this method for financing the construction of conventional boiler plants. Dade County, Florida is considering leasing a cogeneration plant in a similar arrangement. The county will operate the plant and sell electricity to the local utility. Thermal output will be used to power absorption chillers for cooling. The county estimates a first year net profit of $700,000 from electricity revenues and saved energy costs. After ten years Dade County can purchase the plant for a nominal sum.

Utility participation—The state's role as public utility regulator is important in developing small power projects. Regulations requiring utilities to interconnect with small power producers and purchase power from them at rates approaching the utility's "avoided cost" should be enforced at the state level to create a positive regulatory climate for such projects. Utilities can also play a major role in financing energy efficiency projects as an economic alternative to the construction of new generating capacity.

Conclusion

As the above discussion indicates, there are many options for financing cost-effective energy efficiency investments. Implementing these projects constitutes sound fiscal policy and need not languish for lack of public funds. ■

The Bookshelf

The Demise of the Lone Ranger, or "Who Was That Masked Man?"

Managing for Excellence: The Guide to Developing High Performance in Contemporary Organizations, by David L. Bradford & Allan R. Cohen. New York: John Wiley & Sons, 1984. 301 pp. $18.95, hardcover.

"Excellence" has become the buzzword of the Eighties. Unfortunately, much of the literature dealing with excellence explores the subject from a level that has little practical application for the middle manager. While we can control our behavior as managers, we do not necessarily have control over institutional norms and behavior. Most of the current books stress overall institutional excellence while neglecting the perspective of the departmental or divisional manager, who may have little influence on the total organization, but who can have great influence within his or her own operational area. The beauty of *Managing for Excellence* is that it addresses the concerns of the middle manager in specific and practical detail.

Bradford and Cohen propose a new model of leadership, one they tested with more than 200 middle- and upper-middle managers. They based their model on what they had seen in high-performance departments, namely: 1) energy and commitment among subordinates, 2) a cohesive team, 3) fast-paced problem-solving meetings, 4) a healthy, supportive competitive spirit, and 5) the leader's belief in the abilities and intentions of his or her subordinates.

In discussions with middle managers, the authors learned that managers want three things: to be able to pick and build their own team; to have an exciting job that is important to the organization; and to have the boss get out of the way. The essential issue for most managers is to take control of what happens to them; according to Bradford and Cohen, sharing responsibility is the key.

In contemporary organizations, change and a lack of predictability are facts of life. Paradoxically, because of the changing nature of work, the key to excellence lies not in the manager but in his or her subordinates. It is the subordinates, individually, who have the time and ability to keep up with change and to keep close to the client. Therefore, the concept of the shared responsibility team is the vehicle for creating departmental or divisional excellence.

To carry out this charge, the post-heroic leader appears. Unlike the Lone Ranger, who rushes in to save the situation and leaves a silver bullet behind (and thus weakens the subordinates by not allowing them crucial tests of their abilities), the post-heroic leader manages by sharing responsibility and control.

This manager-as-developer model has six characteristics: 1) a common, unifying vision, 2) a cohesive, interdependent team, 3) open, two-way communication, 4) responsibility and influence are pushed downward to subordinates, 5) control comes from the common goal, team spirit and loyalty and the abilities within each individual, and 6) everyone has the right to raise and resolve interpersonal and task problems.

The results of the developer approach include completing tasks at a high level of quality (because of the interdependence of the team and the open communication that exists) and an increased sense of responsibility among team members that extends to managerial as well as task issues and increased motivation. The major benefit is that it frees the manager to spend time on things only he or she can do, and where the biggest payoffs are. Such activities could include outwardly directed activities that would anticipate major institutional policy shifts or improving delivery systems as a result of interaction with client groups.

There are two things of particular interest to those of us in plant administration who face technological change—diminishing budgets and inadequate staffing. First, Bradford and Cohen tested the manager-as-developer model by conducting workshops for more than 200 managers and refining the model with each subsequent group until they had a model that "was learnable despite its sophistication, practical despite its newness, and useful to managers facing the toughest complexities of today's organizations." In addition, they have provided a step-by-step approach to achieving the model. Since most of us have resources right on the campus who can act as facilitators in this process, the model becomes one that is both practical and attainable. (I would not recommend that a manager try to institute such a change without at least some expert facilitation at the outset for the simple reason that it is difficult simultaneously to be part of a process and to observe and analyze the process.)

The model is not without its paradoxes and the authors recognize that fact. Chief among the paradoxes is that managers increase their power by giving their subordinates greater power, a concept that may cause some difficulty. But the authors believe strongly that the payoffs are well worth the risks and this belief infuses the book with a life of its own.

For the busy plant administrator, I would like to suggest that the book be read in the following order. Begin with the preface, then read the chapters in this order: 9, 7, 3, 4, 6, 5, 8, 2, and 1.

This method was suggested to me as a way of getting through the material quickly and efficiently. Except for the preface and the last chapter, which are to be read in their entirety, all other chapters can be mastered by reading the introduction and the conclusion and skimming the rest. The meat of the book exists in the preface and chapters 9, 7, and 3.

I highly recommend *Managing for Excellence* as an extremely practical book that all of us can use to improve our operations.

Copies are available for $18.95 from John Wiley & Sons, Inc., One Wiley Drive, Somerset, NJ 08873.

—**Phyllis Rossiter Forbes**
Director, Administrative Services
University of New Hampshire
Durham, New Hampshire

Making a Case for Participatory Management

Working Together, by John Simmons & William Mares. New York: Alfred A. Knopf, Inc., 1983. 319 pp. $15.95, hardcover.

Working Together is a book about an idea whose time, apparently, has come. Basically, the book deals with better ways to organize work by increasing the involvement of employees in both management and ownership of the companies that employ them. The fundamental purpose of this involvement is for people to gain more control over their lives at work.

Simmons and Mares present a compelling and informative documentation of the approaches, experiences, successes, and failures of more than forty private firms and public agencies in the past and current history of participatory management. Their treatment of the subject is comprehensive, if not exhaustive, and while their strong advocacy of participatory management is obvious, the book is at least equally devoted to the difficulties involved in achieving constructive participation.

The authors' stated purpose of the book is to outline the conditions for successful participation efforts. To that end, the book is a success. It is well-written, easy to read, and of definite interest to anyone involved in labor relations.

The book is divided into three sections that more than adequately and equitably cover the subject matter. The first section identifies and addresses the problems most evident and pervasive in the American workplace: that is, the decline of productivity and the decay of the work ethic. The second section illustrates the wide spectrum of changes that have occurred in the last ten or twelve years in a variety of private and public organizations. These changes have taken place at all organizational levels, from the shop floor to the president's suite, and involve new patterns of behavior, new ways to distribute profits and power, and new concepts of ownership and management.

The third and meatiest section is entitled "Problems on the Way to Participation." Its six chapters clearly identify the range of topics covered: conflicting objectives, getting started, sharing decision making, participatory leadership, middle managers in the middle, and union reluctance and cooperation. Another chapter reviews the current forces affecting participation and discusses ways and means of accomplishing meaningful advances of participatory management.

Working Together is not a shop manual for the repair and maintenance of ailing organizations. It does, however, make a significant point in addressing the need for and benefits of organizational reform and in outlining the conditions required for successful participation efforts. I believe the book should be read, if not studied, by all facilities managers who have at heart the best interest of their employees and their institutions and who wish to minimize the traditional adversarial relationship between labor and management.

While the book has a heavy emphasis on private enterprise environments, many of the concepts discussed are both directly and indirectly applicable to public sector and private institutions. The growing interest in quality circles in physical plants around the country is concrete evidence of the beginning stages of increasing employee participation in plant management.

As time goes on, this participation is almost certain to grow in direct reflection of the trends in private industry. Indeed, increased employee involvement in decisions affecting the workplace will be a necessity if physical plants are to attract and retain the younger and technically qualified employee needed for the maintenance and operation of our increasingly complex institutions. The creative and responsible plant manager will seek constructive employee involvement in decision areas traditionally reserved for management in order to more fully utilize the resources of all employees and to promote personal and professional growth at all levels of plant organization.

Both blue collar and white collar, union and non-union employees will want more say about their working lives. *Working Together* will provide some of the background needed for constructive change. The rest will be up to management.

Working Together is available for $15.95 from Random House, Inc., 80 Newbridge Road, Bergenfield, NJ 07621.

—**Charles W. DeKovic**
Director, Facilities Services
California State University, Hayward
Hayward, California

Guide to High-Tech Support

Computer-Aided Facilities Planning, by H. Lee Hales. New York: Marcel Dekker, Inc., 1984. 326 pp. $49.75, hardcover.

Computer-Aided Facilities Planning has not been written specifically for the facilities management operation of a university, but it does highlight areas where computers may be effectively utilized in a physical plant environment. In a general sense, the author shows how planning functions and traditionally non-computerized areas can be effectively improved. While this book is oriented toward space utilization and facilities planning, it also provides insight into the evaluation process for determining whether physical plant functions could benefit from computer-aided support.

In order for the reader to understand how computer aids can assist in the facilities planning process, the author spends several chapters outlining the types of planning, decision making, and designing processes that are involved. Considerable time is spent on space analysis and space relationships and existing techniques for evaluating these functions.

This basic introduction to facilities planning provides useful insight into the necessary planning and decision making processes of the facility architect, but would only be useful to the physical plant administrator if facilities planning was part of the physical plant department's function. After the introduction of these planning processes the author identifies the five main areas of computer-aided support: decision making, engineering, design and drafting, word processing, and information management.

Several chapters identify the hardware necessary to implement computer-aided support. This part of the book is particularly useful to the novitiate. The author provides good insight into the various sizes of computer systems, the relative merits of the different hardware approaches and introduces some of the buzzwords that are so common in the computer industry. The description of the various software packages follows a similar development, leading the reader through the necessary decision making processes to identify the user's needs and appropriate software applications.

The author also discusses the hardware and software selection process. He identifies specific selection criteria and procedures and provides insight into the concerns that must be addressed to ensure a successful computer-aided support system.

In conclusion, this book is a fundamental introduction to the use of computer-aided support. Many of the initial stumbling blocks to implementation are discussed and the reader is provided with some insight into the world of purchasing, operating, and maintaining computer systems. Finally, computer-aided support can assist facilities managers in a variety of areas; this book is helpful in identifying where it can be most effectively implemented and the best hardware and software available now to do the job.

Computer-Aided Facilities Planning is available for $49.75 from Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016.

—Gary L. Reynolds
Assistant Director, Physical Plant
Iowa State University
Ames, Iowa

Recommended Reading

An Annotated Bibliography of the College Union, vol. 4, ed. by Nancy T. Davis. Bloomington, Ind.: Association of College Unions-International, 1984. 155 pp.

This bibliography includes 659 reference listings covering all aspects of college unions and student activities centers. Of particular interest to physical plant administrators are chapters 2 and 3. Chapter 2, Planning the College Union, has select entries on design, remodeling, and renovation of the college union. Chapter 3, Operating the College Union, includes sources on providing energy, equipment, and maintenance for the college union. This book is available from the Association of College Unions-International, 400 East Seventh Street, Bloomington, IN 47405; 812/332-8017.

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The Directory of Industrial Heat Processing and Combustion Equipment, 1984-1985. Published for the Industrial Heating Equipment Association. Atlanta: The Fairmont Press, Inc., 1985. 180 pp. $25, softcover.

This book is an excellent source for those seeking information on heat processing and combustion equipment. The first seventy pages contain advertising for manufacturers and include descriptions and pictures of the various products they offer. This is followed by a listing of over 380 U.S. manufacturers active in this field. These manufacturers are then cross-referenced according to product classifications such as furnaces, ovens, electric heating equipment, etc.

The remainder of the directory lists organizations associated with the industry including: U.S. government departments, federal agencies, congressional committees, state energy offices, and engineering and scientific societies. There is also a handy reference section in the back on conversion factors, temperature scales, and terminology.

The directory is available for $25 from The Fairmont Press, Inc., P.O. Box 14227, Atlanta, GA 30324.

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Incentives and Disincentives for Effective Management, by James A. Hyatt & Aurora A. Santiago. Washington: National Association of College and University Business Officers, 1984. 56 pp. $5, softcover.

This booklet examines the incentive and disincentive programs in higher education management. It is useful to institutions who wish to consider how the budgetary process can serve as a vehicle for institutional flexibility and increase management effectiveness. The publication emphasizes the need for state legislatures and agencies to provide flexibility in management, promote efficient use of state resources, and revise archaic and rigid regulations.

Several case studies are presented that highlight successful state programs. Both state and institutional perspectives are included on the following topics: appropriation controls, regulatory disincentives, incentives to management flexibility through deregulation, administration of local revenue, and the budgetary process.

Copies of this publication are available for $5 from NACUBO, P.O. Box 35024, Washington, DC 20013.

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4. All articles must be typed, double-spaced, or they will be returned unread. Articles should be between 10 and 25 pages in length.

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8. Authors are unpaid but will receive reprints of their published article or copies of the magazine. They may also subscribe to *Facilities Manager* at half price.

9. If you have any questions or require further information, call Steve Howard at 703/684-1446.

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