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Recommended Practices for U.S. Postal Service Roofing Program

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U.S. Postal Service
Design Management Division
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U.S. POSTAL SERVICE ROOFING
PROGRAM

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
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ABSTRACT

This study was conducted for the United States Postal Service (USPS) to provide technical recommendations to improve the quality of its low-sloped roofing. Two major tasks were carried out: 1) a review of current USPS roofing practices, and 2) a review of roof management programs used by other organizations in the public and private sectors. A comparison of USPS practices with the elements of effective roof management programs provided the basis for recommendations to USPS.

This report presents the final results of the study including the trends in current USPS roofing practices and the recommendations to the USPS. Three options which USPS may take as steps to improve its roofing are suggested. The first option is to develop a total roof management program. The second option is to adopt some pertinent practices which are included in effective roof management programs. The third option is to take some smaller steps from a list of items for reducing the limitations identified in current USPS practices. A benefit to NBS in obtaining the information gathered in the study was the identification of measurement research needs related to improved roofing performance, particularly for organizations having large inventories of buildings.

Key words: construction; design; low-sloped roofs; maintenance; management; performance; recommendations; repair; roofing

1. INTRODUCTION

1.1 Background

The United States Postal Service (USPS), like many organizations with a large stock of buildings, has serious concerns about the performance of low-sloped roofing systems. The waterproofing of these systems is provided by the use of a continuous membrane which must retain its integrity over the intended service life. For most systems, it is anticipated that with proper maintenance they will remain serviceable for 15 to 20 years or more. However, in many cases, the anticipated service life is not achieved. Experience has shown that many low-sloped roofing systems do not reach their expected service life to the extent that poor performance of roofs is considered a major problem for industrial and commercial buildings [1]. For example, in a survey of owners of such buildings, roof leaks were reported as one of the more common problems [2]. Another indicator of poor performance is that, although roofing system cost does not generally exceed 5 percent of the total cost of a new building, about 50 percent of the lawsuits regarding building constructions involve roofs [3].

The USPS is aware of the impact of poor roofing performance on the costs of constructing and maintaining buildings with low-sloped roofs. It has within its system over 34,000 buildings. Although most of the buildings are leased, these are predominantly the smaller ones. As a consequence, USPS has direct responsibility for approximately 100 million square feet of roofing,

and the majority of this roofing is low-sloped. The leased buildings have about an equal amount of roofing for which USPS may have indirect responsibility. A conservative estimate of USPS annual roofing costs is \$30 million.

The buildings in the USPS system are spread across the United States. As a result, USPS roof design, construction, and maintenance procedures vary widely depending upon local practices and preferences. In view of the complexity of its roofing situation, USPS considered that significant cost savings might be achieved through improvements in its roofing practices.

The USPS requested the National Bureau of Standards (NBS) to provide technical support in order to recommend improvement in the quality assurance of its low-sloped roofing. In providing this support, a study having two major tasks was carried out: 1) a review of USPS roofing practices, and 2) a review of roof management programs used by other organizations in both the public and private sectors. The first task was intended to identify and describe the USPS roofing practices and to determine their strengths and weaknesses. The intent of the second task was to define the essential elements which comprise effective roof management programs. By comparing the USPS roofing practices with the elements of effective roof management programs, a basis would be set for providing recommendations to USPS for improving its roofing practices.

This report presents summary results of the study including an overview of USPS roofing practices and the study recommend-

ations. The results of the first task on USPS roofing practices are given in a report entitled, "USPS Roofing Practices," [4]. The results of the second task on roof management are given in a report entitled, "Roof Management Programs," [5].

1.2 Objective

The objective of this study is to provide the technical basis for recommendations for steps which may be taken by the USPS to improve its roofing practices.

1.3 Scope

The information concerning USPS roofing practices was obtained from personnel responsible for the design, construction, and maintenance of low-sloped roofing. The information gathered included data on new, replacement, and repair applications. Discussions related to USPS roofing practices were held with personnel at Headquarters level, those in the design field offices, and those in the maintenance field offices. Also discussions were held with individuals from architectural/engineering (A/E) and roofing consulting firms which provide roofing services to USPS. The study did not address the economics of roof management directly, although they must ultimately be the justification for roof management programs. In general, it was found that a roof management program may increase new roofing costs 5 to 25 percent above the costs for those roofs constructed without benefit of such a program [5]. However, individuals

involved with roof management indicate that the increased service from the roofing offsets the higher initial costs.

The information concerning roof management programs was obtained from discussions with persons knowledgeable in the field. Discussions were held with representatives of large organizations which are multi-regional with large stocks of multi-purpose buildings to review their roof management programs. Also discussions were held with individuals who provide roof management services to building owners to review the steps incorporated in these services. A benefit to NBS in obtaining the information gathered in the study was the identification of measurement research needs related to improved roofing performance, particularly for organizations having large inventories of buildings.

2. USPS ROOFING PRACTICES

The study of the USPS roofing practices identified a number of advantages and limitations in the program [4]. These areas are summarized in this section of this report under the following topics: roof performance, program flexibility, design, construction and workmanship, responsibility, guide specifications and other documents, maintenance inspections, maintenance and repair, maintenance guidelines and related documents, and training. It is noted that the review of the USPS practices identified trends in the mode of operation. Practices vary between the different offices within the organization.

2.1 Roof Performance

The USPS is typical of many organizations which have a large inventory of buildings situated across the U.S. Design and construction of roofing is handled separately from maintenance and repair activities. In general, many low-sloped roofing systems, both built-up bituminous and single-ply, have performed satisfactorily. It was found that many aspects of current USPS roofing practice are consistent with accepted industry practice. Nevertheless, a number of limitations were also identified and consequently, these are areas for improvement. Roofing problems have been numerous enough that many USPS staff consider roofing to be a major facility problem. In the course of the study, many examples of premature failures and early replacement of roofing were described. The problems were found to be typical of

those associated with low-sloped roofing. As a consequence, it is considered apropos that USPS take steps to improve its roofing practices and activities with the aim of reducing the number of premature failures.

2.2 Program Flexibility

One of the strengths of the USPS roofing program is its flexibility. The USPS program does not, in general, have restrictions that preclude changes in its mode of operation and the use of new procedures. For example, USPS can use outside expertise, new materials, innovative methods of application, and diagnostic procedures if the staff determines that their use will benefit USPS. This flexibility is a result of the autonomy that the field offices have in conducting their roofing activities. However, this flexibility can also be a weakness in the system in cases, for example, where the staff makes use of new materials or systems without their adequate review and evidence of long-term service life, and incorporation of proper controls.

2.3 Design

The design of most USPS roofing is conducted by an A/E under contract to USPS and under the direction of a project manager. If the designer does not possess adequate knowledge of roofing, it is likely that less-than-satisfactory design will be obtained. USPS does not have guide specifications and, in many offices, only a few guidelines are available for designers who provide

roofing assistance. To help assure that the roof design will be adequate, Headquarter's projects include the requirement that the A/E will use a roofing specialist to provide design review. In addition, some Field Real Estate and Building Offices (FREBOs) also carry out this practice for new roofing, and have the design done by a specialist in the case of re-roofing. This practice has been found to result in successful roofing design for the few years that it has been in use. However, not all the FREBOs are using roofing specialists in this manner, but place full confidence in the A/E's knowledge of roofing. A shortcoming of this point of view is that the roofing industry has changed drastically over the last decade with a proliferation of many new materials and systems. It is difficult for A/E firms to keep abreast of these changes unless they have on their staffs at least one designer who specializes in roofing. Of course, it is important that, in cases where a roofing specialist is hired to provide design assistance, the individual should be carefully selected as having the proper background and training. USPS is responsible for the selection of the roofing specialists used in its programs, but uniform guidelines for their selection have not been prepared.

2.3.1 Materials Selection

USPS uses all types of materials in its roofing constructions including built-up bituminous, single-ply, and spray-in-place polyurethane foam. In those cases where roofing specialists are providing design assistance, the selection of the material is

guided by the specialist. Where general A/Es are providing design, little guidance may be given by the FREBO except for suggesting which general types of systems should or should not be specified. Advice on the limitations in use of different materials and systems is seldom given. This practice has shortcomings in cases where the designer is not adequately familiar with the performance of the material of choice. The selected material may not be proper for the job at hand, and other materials may be more suitable. Although the USPS project manager reviews the A/E submittal, many of them have difficulties in keeping abreast of the use of the many new materials and systems which have entered the market in the last few years.

Since USPS uses a broad spectrum of materials, it has the opportunity to learn of their performance under different conditions and climates. Such knowledge might be useful to prevent repetition of errors in cases where less-than-satisfactory performance has occurred. However, USPS design personnel seldom receive feedback on the roofs which they design, unless problems have occurred. Furthermore, the feedback is seldom used to prepare guide bulletins to alert other USPS staff of situations which have resulted in the poor performance.

2.4 Construction and Workmanship

In many cases, workmanship during application of low-sloped roofing systems is considered by USPS staff to be satisfactory. However, in other cases, the staff members have indicated that it

is unsatisfactory to the extent that workmanship is considered to be one of the most serious deficiencies with USPS roofing practice.

Private sector contractors apply all USPS roofing, and are selected on an open bid process. Such a selection process may, in some cases, result in the awarding of the contract to a firm which is not adequately qualified. Although USPS staff consider factors such as experience, training, costs, and approval by a material manufacturer, uniform criteria for contractor selection are not available in the USPS system. In many cases, the regions or FREBO offices have developed guidelines for their own use. Also, in many cases, USPS offices attempt to hold contractors accountable for correcting deficiencies in roofing traceable to unacceptable workmanship. However, some offices have expressed a need to have criteria available for defining an acceptable membrane as fabricated in the field, particularly with regard to allowable tolerances. It is noted that standard criteria for judging the acceptability of all types of roofing systems are not available, although the National Roofing Contractors Association (NRCA) has published the guidelines, "Quality Control in the Application of Built-Up Roofing" [6].

The FREBOs often use term contractors (a firm under contract for a given time period) for roofing applications. This practice has the advantage that the contractor is available to respond to requests for work without prolonged delay. Some roofing specialists who provide roof services to USPS have questioned the adequacy of

some term contractors. They indicate that the term contractors are, in some cases, not qualified to complete all the jobs requested of them. USPS experience supports this point of view. Instances were reported to NBS staff where: term contractors were not provided with additional work because of unsatisfactory performance; their contracts were not renewed; and their contracts were terminated. These specialists expressed concern over unqualified term contractors because they may be given a number of jobs to do over the length of the contract. The evidence suggests that the methods used to select contractors should be improved to reduce the incidence of unsatisfactory workmanship.

USPS Headquarters and some FREBOs use full-time inspection for all roofing jobs, while other FREBOs use the practice for those jobs which exceed a given dollar limit. The inspector is normally a roofing specialist. In contrast, some FREBOs require no inspection during construction, unless the project A/E determines that it is necessary. In these cases, the A/E is responsible for assuring that the inspection is conducted. The use of full-time inspection by a specialist during roof application is a practice that has been incorporated in many roof management programs as a step to provide quality control of roofing. Moreover, recently the Architect's Liability Committee of the American Institute of Architects (AIA) recommended to AIA that inspection during roof construction be provided by specialists as a positive step to reduce roofing problems.

2.5 Responsibility

A key element incorporated in roof management is the assignment of responsibility for the various activities that are carried out in the roof management program. Most USPS offices conducting roofing have no key staff member who has the responsibility for coordination of the roofing activities. This is the case for both those offices conducting design and construction, as well as those doing maintenance and repair. One exception to this finding is that some offices that use roofing specialists for design and construction assistance have assigned a project manager as a roofing coordinator.

With regard to another area of responsibility, USPS does not presently have a mechanism for assigning the total responsibility for design and materials selection, construction, and serviceability of its roofing systems to a single source. The concept of single source responsibility is a major aspect of some roof management programs.

2.6 Guide Specification and Other Documents

USPS does not have available guide specifications concerning roof design and construction, although many offices including headquarters provide some general limited guidelines on roof construction requirements. The lack of guide specifications can be a serious limitation in the USPS program, particularly in those cases where roofing expertise is not used to assist the project manager in design and construction. Today's roofing

market contains numerous types of materials and systems [7]. USPS design and maintenance personnel have difficulty in keeping abreast of the new products. As a result, USPS project managers may approve or select roofing systems with which they have little familiarity.

An obvious limitation to the use of guide specifications is the constant need for updating. However, a possible mechanism to overcome this limitation is to use documents that are developed by the industry and not prepared in-house. An example would be the NRCA "Roofing and Waterproofing Manual" [8]. Many USPS project managers involved in design use this document, as well as others developed by industry. However, the practice is far from being universal throughout the USPS system, as many staff have indicated that they make little reference to industry documents.

USPS Headquarters has prepared "short form specifications" for use by field personnel to assist in the design of small roofing projects. Although this practice is a step toward providing control in the preparation of specifications by those field personnel who are not trained designers, the "short form specifications" must be maintained current to be useful. Review of the "short form specifications" has indicated that revision and updating are needed.

2.7 Maintenance Inspections

Roofing inspections are normally conducted as planned events for the majority of USPS roofs. Nevertheless, USPS staff have

indicated that a number of roofs are not inspected regularly, but only when a problem, normally a leak, develops. USPS directives require that an annual inspection be conducted by a local maintenance officer except where storm damage is suspected, the climate is severe, or the roof has a history of problems. Then more frequent inspection is required. The routine inspection is intended to determine if any deficiencies have developed and to initiate necessary repairs. In addition, any routine house-keeping such as the cleaning of drains should be carried out. It is noted that, in contrast to USPS practice, it is recommended in the Asphalt Roofing Manufacturers Association (ARMA)/National Roofing Contractors Association, "Manual of Roof Maintenance and Roof Repair" [9], that regular inspection of the roof should be made at least twice a year.

The Building Maintenance and Engineering Office (BMEO) staff conduct in-depth inspections of roofs in conjunction with general inspections of buildings. The frequency of such inspections is, on the average, every 2 to 3 years. Problems encountered by BMEO staff during inspections are typical of those normally found for low-sloped roofs. An important finding of the study is that defects often observed by BMEO staff are clogged drains and debris on the roofs. This indicates that the local routine inspections are not always carried out as intended in the USPS maintenance policy. Minor defects such as clogged drains can lead to major roof problems if not corrected.

To assist those inspecting roofs, USPS has developed two checklists. One is for use by local maintenance personnel, while the other is for BMEO staff. Both checklists are strongly orientated towards built-up roofing. It is accepted by USPS that those using the forms are knowledgeable regarding roof inspection. However, as a consequence, if those using the lists are not adequately trained, these checklists do not contain sufficient information to assist the inspector adequately. Roofing specialists under contract to FREBOs reported that they had been requested to investigate roofs which had been designated for replacement by the inspector. It was indicated that, in some cases, the roofs in question were not in need of replacement but only required repair. Apparently, local inspectors had observed defects in the roofing, misinterpreted the magnitude of the problem, and recommended replacement.

USPS does not have guidelines to assist in making decisions as to when repair or replacement is needed. This is not a unique circumstance, since this is generally true in the industry. Such decisions are often based, in part, on the experience and training of the individual evaluating the roof. In general, it is considered that the USPS should take steps to improve the ability of inspectors to evaluate roofs. This would include emphasis on training and providing documents to assist those who are not thoroughly trained in roof inspections.

Non-destructive evaluation (NDE) techniques are used frequently by many BMEO staff. This occurs either on a routine

basis or after observing a roof and determining that moisture may be present and a NDE survey is warranted. The use of such surveys has been effective in that roofs have been successfully renovated where only the wet section was replaced, while the remainder of the roofing was left in place since it was in satisfactory condition and functional. Nevertheless, in spite of the cost savings achieved in these cases, some BMEOs do not make much use of NDE surveys.

USPS has encouraged the use of NDE surveys. BMEOs have nuclear meters and staff trained in their operation. Moreover, local maintenance officers are instructed to request a NDE survey if their inspection of a roof indicates that moisture may have penetrated the system. The Maintenance Technical Support Center (MTSC) was providing training to BMEO staff in the use of nuclear meters, but this training has recently been discontinued. It was reported that the responsibility for training maintenance inspectors in the use of NDE equipment is scheduled to be shifted to the regions. It is suggested that USPS continue to use NDE evaluations of roofing, either in-house or by contract, as needed for conducting roofing investigations.

2.8 Maintenance and Repair

Repair of defects in a roof observed during inspection are generally carried out by roofing contractors, although building maintenance crews do some minor repair. The roofing contractors

are often term contractors who are thus available to provide repair without undue delay.

Essentially no "on-the-spot" repair is carried out during roof inspections. Thus, all observed defects are corrected at a later date. USPS practice has the flexibility to have emergency repairs made within a day's time. However, normal repairs often require two or more months to be done. In an extreme example found in this study, one roof went without repair for over a year during which time leaks continued when it rained.

In the case of minor repairs, the local maintenance officer or BMEO provides the work order for completion. If major repairs (normally greater than \$5000) are needed, then the BMEO requests the services of a FREBO to provide the design and construction. The BMEO may prepare a work order and have a procurement office issue a repair contract up to \$25,000, if the BMEO staff believes that they have the capability to do the design. In this case, the BMEO may often use a "short form specification." This practice has limitations considering that, in general, the BMEO staff members are not trained designers and the "short form specifications" are in need of revision.

BMEO offices keep maintenance and repair records for the roofs under their responsibility. Although in most instances the records are kept current by the BMEO, examples were cited where the record keeping was inadequate. USPS has initiated a computer-based data management system to identify needed building maintenance and repair work, its costs, and its progress. This system allows

for the tracking of roofing repair. However, it does not provide for identification of the specific problem at hand or its causes. In addition, information regarding the roof construction and its age are not part of the data file.

2.9 Maintenance Guidelines, Bulletins, and Related Documents

USPS has guidelines available on roof maintenance, although not all maintenance staff members are aware of these documents. The main document is Chapter 2 of Maintenance Handbook #6 which gives guidelines for repair and alteration inspections. It also includes summary tables on techniques for conducting minor repair. In reviewing this document, a number of observations were made. The document considers primarily built-up roofing and not single-ply or other types for commercial and industrial buildings. The information provided on built-up roofing is in need of revision and updating to reflect changes in built-up roofing technology which have occurred in recent years. Also, since the document provides information in summary form, it is not adequate for inspectors who have little experience with roofing.

The MTSC prepares bulletins for distribution to the maintenance staff. Many staff find the bulletins to be of assistance, but not all staff are aware of these bulletins. Similarly, many staff make use of industry documents which can provide valuable assistance regarding roof maintenance and repair. However, a small percentage do not use industry-prepared documents at all.

2.10 Training

USPS provides training for its design and construction, as well as maintenance and repair staff involved with roofing. However, less than one quarter of these staff members indicate that they attend training courses annually. Reluctance to take time away from the office and the work at hand is cited as a major reason for not attending courses more often. Many staff have expressed that they have difficulty in keeping current with the new materials and systems which are presently used for roofing.

The primary source for training for maintenance and repair personnel is the MTSC. Both design and construction, and maintenance and repair personnel attend industry courses such as those offered by the Roofing Industry Educational Institute (RIEI). USPS has sponsored one RIEI course for USPS staff members.

A major source of information is attendance at vendor seminars. An attraction of these courses is that they are often provided at the USPS facility or at least locally. A limitation is that they may lack objectivity which is a fact recognized by many offices.

3. RECOMMENDATIONS

This section of the report presents recommendations to USPS for improving its roofing practices. The recommendations are based on the review of USPS current roofing practices [4], and the review of roof management programs undertaken by major organizations, both public and private, to help assure that their roofs provide satisfactory long-term performance [5].

Three options are given as recommendations which include:

1. development of a total roof management program,
2. adoption of some pertinent practices included in roof management programs to provide improved control of USPS roofing, and
3. implementation of individual steps to modify current USPS practices.

The three options are listed in order of their complexity, level of effort, and cost which would have to be expended to implement the action. For example, the development of a total roof management program is the most complex and would require commitment of many individuals within USPS, as well as outside, with expertise in roof management programs. Moreover, once in place, a means must be implemented to maintain the program current. Conversely, individual small steps taken to modify roofing practices might be, in many instances, adopted quickly by appropriate personnel within the USPS system. Sufficient data are not available to estimate the cost-effectiveness of implementing the three options. As discussed in the report on roof management

programs [5], increased costs of new roofing done under a management program may be in the range of 5 to 25 percent above the costs for roofing conducted without a management program. As a step towards estimating the cost-effectiveness of conducting a USPS roof management program, a study could be conducted to compare the costs and roofing performance experienced within two FREBOs. In this case, one FREBO would use only roofing specialists for the design and construction of its roofing, while the other would do in-house design or use general A/E firms.

It is recognized that there is redundancy in the options. For example, the individual steps listed in option 3 would be included as necessary actions undertaken in the development of a total roof management program. Nevertheless, the options were listed in this manner so that USPS could begin to act on the individual steps if the resources would not allow implementation of a total roof management program.

The USPS is already conducting its roofing practices in many offices in a manner which has a number of advantages or strengths. However, such practices are not universally in place throughout the system. It is intended that these strengths should be considered in developing steps to improve USPS practices and incorporated in actions taken.

It is again noted here that many of the aspects of current USPS roofing practice were found quite acceptable and success-

ful. Nevertheless, improvements can be implemented which is the intent of providing recommendations.

3.1 Option 1 -- Total Roof Management Program

This option is the development of a total roof management program for the USPS. Major objectives of roof management are to increase control over the organization's roofing design, construction, and maintenance, and to define the risks associated in carrying out these functions. Mechanisms for providing the control are incorporated in the program.

A roof management program should be developed based on the four elements essential to roof management: (1) the roofing system criterion, (2) the quality assurance plan, (3) the quality control phase, and (4) the assignment of responsibility.

A model for the development of a roof management program for the USPS could be that developed by the U.S. Air Force [10].

However, in this case, the plan should be designed to meet the specific needs of the USPS. In particular, practices in the U.S. Air Force program which limit the types of roofing materials and systems could be altered to suit the USPS needs. Likewise, mechanisms for providing on-site inspection of roof installation could be incorporated to be specific to USPS roofing practices.

A roof management program for USPS would be extensive. Documents would need to be prepared to define the roofing system criterion for USPS including master specifications and details for design, acceptable materials and systems, acceptable installation

practices, repair and maintenance techniques, contracts and warranties. Mechanisms for quality assurance and quality control would need to be established including procedures for review of specifications, materials acceptance, and proper installation of new, repair, and remedial roofing. It is noted here that the inclusion of master specifications and details in the program would not necessarily mean that USPS would develop their own documents. Rather, industry documents such as the National Roofing Contractors Association "Roofing and Waterproofing Manual" might be used in part for the program.

An important aspect of the development of a roof management program is the assignment of responsibility to assure that the program and the steps and procedures incorporated in it are carried out as intended. Current USPS practice does not, in most circumstances, assign responsibility for roofing to specific individuals within the various levels of the USPS organization structure. In general, roofing responsibility is spread among a number of individuals without coordination. The roof management program should address this limitation and include steps for assignment of responsibility.

Another facet of responsibility assignment included in a roof management program is the determination of clearly-defined procedures for indicating the party responsible for the long-term performance of the roof. Some existing roof management programs have taken steps to tie together the responsibility for design, materials, and installation with the intent that there should be

a single responsibility for these three areas of roof construction practice. A program developed by USPS should consider a mechanism for assigning a single responsibility.

3.1.1 Levels of Concern in Roof Management Planning

The majority of roof management plans reviewed in this study concentrate on quality assurance and quality control of new roofing. This finding can be rationalized if it is considered that roofing construction should be satisfactorily completed to provide acceptable long-term performance. Moreover, a properly designed and constructed roof should develop few problems requiring extensive repair during its service life. However, USPS has a vast inventory of buildings of varying ages whose proper maintenance and repair are equally important. Therefore, a roof management program should address not only the proper construction of new roofing, but also the performance of that already in place. Inadequate routine inspection, and lack of timely maintenance and repair of existing roofing, were found to be among the limitations of current USPS practice.

It is considered that the roof management program for USPS should consider five levels. The plan should describe the mechanism for attaining quality roofing for each of these areas:

Level 1. New construction. The components of the roof system are installed at the time of building construction.

- Level 2. Reroof existing building. Generally, the non-structural portion of the roof system is removed and discarded. Repairs are made as necessary to the structural components and a new roofing system is applied.
- Level 3. Recover existing roof. The existing roof is repaired and restored to an acceptable condition to receive a new cover, and a new membrane system is put in place. A determination must be made that moisture has not penetrated the existing system to the point that it is an unacceptable substrate for the new cover. The recover operation usually involves new insulation as a separate layer and a new membrane with appropriate surfacing.
- Level 4. Repairs to existing roof. This action is required after a problem occurs or a major defect is discovered during roof inspection. Remedial action is taken to bring the roof to a serviceable condition. In many cases, this involves less than the total area of the roof.
- Level 5. Roof maintenance. These are routine actions carried out promptly to prevent problems and extend the service life of the roof.

3.1.2 Plan Levels

The roof management program should be developed to address the hierarchical organization of the USPS from its Headquarters to the individual Post Offices. Thus, it is convenient to consider five levels at which the program would be administered and implemented: (1) Headquarters, (2) Regions including FREBOs, (3) Districts including BMEOs, (4) Management Sectional Centers, and (5) Post Offices. A key element is the assignment of responsibility at each of these levels.

Level 1. Headquarters. The program should describe, in general terms, policies concerning roofing as well as the requirements of all USPS roofs. At this level, procedures and guidelines for specifying, constructing, and maintaining roofs would be established to assist the lower levels in the hierarchy. This level would address such items as bidding, warranties, guarantees and the like. In addition, the mechanism for the design and construction of roofs by Headquarters staff would be formalized.

Level 2. Regions. This portion of the program would address the roofing needs of the individual regions and FREBOs in specific terms, especially as roof design, materials and construction vary

among the five Regions. With regard to new construction and major renovation, the program at this stage should provide for the prequalification of manufactured materials, contractors, roofing specialists, quality controllers, inspectors, and testing laboratories for determining the quality assurance and control of USPS roofing. It would provide the mechanism for material and design selection, as well as the on-site quality control of the roof installation. The administrative duties of the Regional staff regarding roofing would also be defined.

Level 3. Districts. The procedures at this level would also be specific and primarily aimed at the actions undertaken to provide for necessary maintenance and repair. Guidelines and specifications for maintenance and repair would be established, as well as criteria for the selection of contractors who provide maintenance actions for USPS. The responsibility for establishing procedures for record keeping would fall at this level. The administrative duties of interfacing the FREBOs and BMEOs, and also the MSCs and BMEOs would be defined.

Level 4. Management Sectional Centers. The duties and actions required of the maintenance officers for inspection and repair of roofs would be addressed at this level. Included here would be items such as scheduling of inspections, training, inspection techniques and procedures, and reporting.

Level 5. Post Offices. This level involves varied tasks depending upon the size of the building. For those buildings where maintenance staff are available to conduct periodic maintenance inspections, the program should address these activities. For all buildings, the program should address the steps to be taken in cases of emergency (e.g., leaks, blow-offs) to assure that prompt corrective action is taken. Finally, the program should address steps to be taken to raise the awareness that the roof must be properly maintained and not abused, if it is to provide satisfactory long-term service.

3.2 Option 2 -- Pertinent Practices Incorporated in Roof Management Programs

The second option of actions to be taken to improve USPS roofing performance is to include in its existing roofing program some pertinent practices which are incorporated in well established

roof management programs. However, this option falls short of considering the development of a total roof management program. It is considered that this option might be implemented in the short-term as a step towards developing option 1.

Option 2 is based on the review of current USPS roofing practices and the identification of some of its advantages and limitations. These advantages and limitations are considered in light of those practices which have been included in successful roof management programs. The recommendations in this option have two parts. The first deals with design and construction of new roofing, as well as major repair and renovation of existing roofs. The second concerns the maintenance and repair of existing roofing. This division is consistent with current USPS practice whereby Headquarters and the FREBOs are primarily responsible for design and construction, while the BMEOs and local maintenance officers are responsible for maintenance and repair.

3.2.1 Design and Construction

The primary recommendation regarding design and construction is that the USPS initiate a uniform policy of using roofing specialists to assist its project managers in roofing design and construction. This recommendation is based on the current limited practice of using roofing specialists at Headquarters and at some FREBOs. Where the practice is already in use (Headquar-

ters and some FREBOs), it should be continued with consideration of improvements given below.

The review of USPS practices indicated that, at the limited number of FREBOs that have used the practice for a few years, much success has been attained. Roofs constructed under the practice have performed satisfactorily without premature major problems. Those FREBOs currently using the practice anticipate that the added initial costs of roofing will be offset by increased long-term performance.

Roofing specialists should be used for three actions:

1. To provide design review for new construction and actual design for remedial roofing. This practice has the benefit that the roofing specialist may use his/her expertise to define and provide acceptable design including material selection for USPS. It precludes the necessity of USPS staff preparing guide specifications, details and the like which would be part of a total roof management program.
2. To provide inspection during construction and assure that proper steps regarding materials handling and storage are followed. This practice has the benefit of removing the burden of inspection from a general A/E or USPS staff member who may not have adequate experience in monitoring roof construction.

3. To provide investigation of roofing problems and prepare recommendations for their solutions. This practice has the advantage that an individual knowledgeable in roofing technology recommends solutions to problems.

Although the practice of using roofing specialists has been successful to-date for the USPS, some actions for improvement are suggested as follows:

1. The USPS should assign a roofing coordinator at Headquarters and at each FREBO to work with the roofing specialist. Even when roofing specialists are used, USPS has ultimate responsibility for its roof design and construction, and at each level USPS should have someone who can be delegated that responsibility. The roofing coordinator should be experienced in roofing technology and active in the industry in order to keep abreast with technological changes. Steps for being active might include participation at conferences, seminars, training courses, and standardization committees such as ASTM.
2. USPS should develop uniform criteria for the selection of individuals who are hired under contract as roofing specialists. This suggestion is based on the premise that the benefits to USPS in using the assistance of roofing specialists are limited by the level of expertise of the specialists. Some FREBOs currently using this practice have expressed

concern that they have had under contract individuals who lacked desired qualifications.

3. USPS should provide guidelines for acceptable materials and systems and limitations on their use. In addition, alert bulletins on systems and designs which have given difficulties should be provided to the offices. This suggestion is based on the realization that USPS has many thousands of roofs in service and that feedback on their performance would provide valuable information to help assure the success of future design and construction. Also, industry trends regarding technological changes should be described.

3.2.2 Maintenance and Repair

USPS should take steps to provide improved maintenance and repair of its roofing. This recommendation should not be construed as implying that the current practices are entirely unsatisfactory. Rather, the recommendation is based on the finding in the study that in a number of instances, maintenance and repair procedures were conducted in less than a satisfactory manner. Existing maintenance and repair procedures were listed among the limitations of current USPS practices. Significant here were the concerns regarding local preventive maintenance inspections, and the time that sometimes elapses between the discovery or report of a problem, and its solution.

One step to be taken is that each BMEO should be assigned a roofing coordinator to track the inspection of roofs and assure that problems, when observed, are corrected without undue delay. The majority of the BMEOs do not have one individual responsible for roofing activities within the office. Moreover, the computerized data base management system currently being brought into use by the BMEOs should be revised to incorporate information concerning roof construction, age, and the specifics of problems discovered during inspections. Such information might be used for periodic review of the performance of USPS roofs including the successes and the failures. In addition, it could provide the basis for revision of a listing of acceptable materials and systems used by USPS, or for alert bulletins on materials performance made available to FREBO staff.

To improve maintenance and repair practice within USPS, three alternative suggestions are included here:

1. Improve local maintenance practice. The first line of inspection and maintenance of USPS roofing is the local maintenance officer from the MSC or Post Office. Inspection and maintenance procedures for these individuals should be improved. Although the BMEO staff members are in general adequately trained in roofing, they inspect each roof only every 2 to 3 years, unless problems develop and their assistance is needed. Training of local inspectors should be improved to increase both the knowledge of the inspector, and the awareness of the necessity to provide adequate periodic inspections of the roof and timely repairs of observed defects.

The inspectors should be provided with improved tools for conducting inspections. One item is to have available a detailed inspection and repair manual instead of the current checklist which is only intended for those who have some knowledge of roof inspections. The manual should include information on all types of roofing which USPS uses and should update the current manual concerning built-up roofing. If work orders are to be prepared by maintenance personnel, then the "short form specifications" should be updated.

Another item is to provide a uniform set of criteria for the selection of term contractors who conduct repair work for the maintenance officers (and in a broader sense, the BMEOs and FREBOs). This suggestion is based on the finding that in some instances, term contractors were inadequately qualified. These criteria should qualify the contractor on the basis of ability, experience, past performance, and training, and not on the basis of cost alone. For conducting minor local repairs where the assistance of a trained designer is not warranted, the help of a qualified roofing contractor can be valuable to the local maintenance officer.

Also included in this category is a review of current contracting procedures. The intent is to determine whether the procedures may be revised to decrease the time required to let a contract for repair after a defect in a roof is discovered.

2. Use of inspection and maintenance contracts. One aspect of roof management programs which has been increasing in recent years is the use of contractors who specialize in the maintenance and repair of roofs. These firms can provide record keeping, periodic inspection, recommendations for immediate repair as necessary, and cost estimates for long-term maintenance and eventual reroofing. Although there are obviously costs associated with contracting

for such services, their use helps assure that timely inspections are conducted by trained professionals. Moreover, it also relieves the building owner of the responsibilities to train inspectors to inspect the myriad of different roofing systems that are currently available and to prepare and keep current the accompanying manuals.

It is thus suggested that USPS undertake an exploratory study to use the services of a maintenance and repair contractor for a number of its buildings. During the study, the cost benefits to USPS and improvements in roof inspection practices should be ascertained. Criteria would need to be developed to assure that the selected maintenance contractor(s) was suitably qualified.

3. Include a maintenance contract in the construction bid. Another suggestion for improving USPS roof maintenance practice is to include a maintenance clause in the construction contract for the roof. For example, the U.S. Air Force program has incorporated, as part of the original construction contract, a performance agreement that the roofing contractor maintains the serviceability of the roof for 5 years after completion [10]. USPS could explore a similar mechanism. Or, it could investigate the use of the services of a firm which specializes in total roof management. In this case, the firm would accept single source responsi-

bility for design and construction of the roof, and also agree through contract to maintain its serviceability for a specified period of time (perhaps up to 20 years).

Because the inclusion of a maintenance clause in the construction contract offers long-term benefits of overcoming the current limitations in its practice of always providing timely maintenance, it is suggested that a preliminary study be conducted. The study should explore both the use of a maintenance clause in the construction contract and use of a firm which would accept total responsibility for design, construction, and serviceability.

3.3 Option 3 -- Incorporation of Individual Steps to Improve USPS Practices

This section lists individual steps to improve USPS roofing practices. The recommendations are based on the review of USPS current practices and the identification of limitations in them. This recommendation is given so that USPS may review each of the individual items given and select those which it considers best in view of staff or funding limitations, or current construction policy. In general, the recommendations given here follow the outline of topics summarized in Section 2.

o Design

- prepare a uniform set of design guidelines for use by A/Es who provide roofing services to USPS; this has special significance in those cases where the A/Es do not have specialization in roofing; USPS may not need to develop the guidelines in-house, but might use industry documents such as those prepared by the National Roofing Contractors Association, or the Sheet Metal and Air-Conditioning Contractors National Association (SMACNA).

- develop a knowledge-based expert system to provide design guidelines to those providing design of USPS roofs.

- continue to use roofing specialists to assist in the review of design for new construction and to provide design for existing construction, as is currently practiced at Headquarters and some FREBOs.

- develop a uniform policy among all FREBOs to use roofing specialists (as is current practice at some of them) to provide assistance with:
 - a. design and specification review and preparation,
 - b. inspection of roofing installation, and
 - c. investigation of reported problems and recommendations for solution.

-- develop criteria for the selection of roofing specialists contracted to assist USPS design personnel.

-- investigate the use and cost effectiveness of roof management programs offered by firms which provide single source responsibility for design, construction, and serviceability of roofing.

o Materials

-- provide a list of materials acceptable for USPS roofing, design guidelines for their use, and information concerning limitations for use; criteria for placing given materials on the list would need to be developed.

-- provide feedback to USPS roofing designers on the performance of materials and systems for USPS roofing; prepare guide bulletins on materials performance.

o Construction and Workmanship

-- improve workmanship during construction through the development and use of continuous inspection for new construction, re-roofing, and major repair or renovation.

-- improve workmanship during construction through the development and use of a uniform set of criteria for selecting roofing contractors; the intent is to preclude

the use of marginal contractors for USPS roofing; the criteria may be based on experience, past performance, training, and financial responsibility.

-- develop a uniform set of criteria for judging acceptable workmanship; included here is consideration of such items as tolerances in membrane construction and the use of test sampling of the system under construction; a starting point could be the NRCA document "Quality Control in the Application of Built-Up Roofing" [6].

o Responsibility

-- assign a roofing coordinator at Headquarters to coordinate design and construction done at this level.

-- assign a roofing coordinator at each office of the lower levels where major design and construction, as well as maintenance and repair, are carried out; this has particular significance for the FREBO and BMEO offices; the duties of the coordinator should be developed based on those incorporated in roof management programs; the intent is to improve USPS control of its own practices.

-- develop communication between the roofing coordinators from each of the offices; it may be feasible to hold an annual meeting dedicated to roof performance.

-- develop contract documents in a manner to define clearly the responsibilities of each party to the roofing contract; included here would be a mechanism for determining single source responsibility for the roof system which the USPS purchases; in addition, all roofing components from the deck up should be purchased from a single manufacturer who takes responsibility for the entire assembly; the intent is that USPS has a single source of recourse if problems arise with the roof within the warranty period.

o Design Documents

-- revise "short form specifications."

-- provide roofing personnel with reference documents developed within the industry such as the U.S. Air Force, ARMA, NRCA, SMACNA, and SPRI manuals (see Appendix).

o Maintenance Inspections

-- improve inspection procedures conducted in-house through better training of local inspectors and the development of better inspection manuals and guides; increase the awareness of local inspectors on the importance of periodic maintenance.

- assure that routine local inspections are conducted at least annually as presently required by USPS directives; it is noted that industry recommendations call for routine inspections every 6 months.
- develop an inspection manual for use on the roof.
- revise current USPS inspection checklists; they should be expanded to address all roofing systems; they should be redesigned to provide instruction to those who may not be fully trained in conducting roof inspections.
- develop a computerized data management system for use by the maintenance coordinator for tracking the inspection of roofs; the system should address items such as the scheduling of inspections, when they are done, when they are due, and which roofs are overdue.
- develop a uniform policy regarding the use of NDE equipment to complement on site inspections now that USPS has discontinued the training of BMEO personnel in the use of nuclear meters; continue to encourage inspectors to use NDE techniques, whether in-house or under contract, where warranted.

-- develop criteria for assisting inspectors in assessing the condition of existing roofing, and decision makers in deciding whether a roof should be repaired or replaced; consideration should be given to the development of a knowledge-based expert system to assist those in the assessment of roof condition.

o Maintenance and Repair

-- improve procedures to assure that roofing repairs are completed in shorter periods of time than is done with present practice.

-- continue present practice of using, as warranted, outside expertise to assist in the investigation of roofing problems; within the maintenance offices, increase an awareness that the MTSC is available to provide information and assistance.

-- provide improved documents for use by maintenance personnel in cases where they prepare the work order for needed repairs.

-- expand the recently-initiated data-based management system for keeping records regarding roof repairs and work in progress; items which should be added to the data base include the type of roof system and its components,

its age, dates of inspection and the results, types of needed repairs (if any) and causes to which the defects are attributed; when a roof is built, pertinent information should go into a newly-created file.

-- improve maintenance and repair practices by investigating the use of roof maintenance contracts with contractors specializing in the business.

-- improve maintenance and repair practice by investigating the incorporation of maintenance clauses in the original construction contract or by using the design and construction services of a firm which would provide a single source guarantee for the performance of the roof over its warranty period.

o Maintenance Guidelines, Bulletins, and Other Documents

-- increase the awareness of the USPS maintenance staff of the maintenance documents which USPS has available.

-- provide improved documents on roof repair techniques; the documents should include reference to all types of roofing systems and their scope should be expanded to be useful to those who have knowledge in general building repair and not specific expertise in roofing; consideration should be given to the use of a computerized system

to assist in providing repair information for maintenance personnel.

-- provide maintenance personnel with industry documents such as developed by the NRCA.

o Training

-- encourage the training of those involved with USPS roofing, particularly the individuals who take little or no training; emphasis should be placed on the newer materials and systems, since USPS personnel have reported troubles in keeping abreast of them.

-- expand, as intended, the roofing course under consideration by the MTSC.

-- continue and expand the use of industry courses such as RIEI, NRCA, and universities.

4. SUMMARY

This study was conducted at the request of the U.S. Postal Service (USPS) to provide technical support to improve the quality of its low-sloped roofing. The USPS is among the Nation's major users of industrial and commercial buildings and has direct responsibility for the design, construction, and maintenance of more than 100 million square feet of roofing. Two major tasks were carried out to provide the technical support: 1) a review of USPS current roofing practices, and 2) a review of roof management programs used by other organizations in the public and private sectors. A comparison of USPS practices with the elements of effective roof management programs provided the basis for recommendations to USPS for improving its roofing practices.

This report presents the final results of the study. Included are a summary indicating the trends in current USPS roofing practices and the recommendations to the USPS. Three options as to steps which USPS may take to improve its roofing are suggested. The first option is to develop a total roof management program. The second is to adopt in its program some pertinent practices which are included in roof management programs. In the third option, a list of individual steps to be considered to reduce the limitations identified in current USPS practices are given. The study provided NBS an unusual opportunity for identifying measurement research needs related to improved roofing performance for organizations having large inventories of buildings.

5. REFERENCES

1. Griffin, C. W., "Manual of Built-Up Roof Systems," 2nd Edition, McGraw-Hill, New York, Chapter 1 (1982), pp. 1-6.
2. "Opinion of Building Owners on the Construction Industry," Report to Wagner-Hohns-Inglis, Prepared by Fleishman-Hillard, Inc. (September 1983), 53 pages.
3. Appelhans, P., "Litigation Center Growth Continues," The Roofing Spec (March 1980), p. 40.
4. Rossiter, Walter J., Jr., Cullen, William C., and Mathey, Robert G., "U.S. Postal Service Roofing Practices," National Bureau of Standards (U.S.), NBSIR 85-3275 (November 1985), 100 pages.
5. Rossiter, Walter J., Jr., Cullen, William C., and Mathey, Robert G., "Roof Management Programs," National Bureau of Standards (U.S.), NBSIR 85-3239 (November 1985), 60 pages.
6. "Quality Control in the Application of Built-Up Roofing," National Roofing Contractors Association, Chicago, IL, (1985).
7. "Commercial, Industrial, and Institutional Roofing Materials Guide," National Roofing Contractors Association, Chicago, IL, Vol. 6 (February 1985).
8. "Roofing and Waterproofing Manual," National Roofing Contractors Association, Chicago, IL (1985).
9. "Manual of Roof Maintenance and Roof Repair," Asphalt Roofing Manufacturers Association, Rockville, MD/National Roofing Contractors Association, Chicago, IL (1981).
10. "Built-Up Roof Management Program," Air Force Manual AFM 91-36, Department of the Air Force (3 September 1980).

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APPENDIX. SELECTED ROOFING INDUSTRY DOCUMENTS FOR REFERENCE

This appendix lists some industry documents which provide guides for the design, construction, or maintenance of roofing systems.

- o U.S. Air Force Manual AFM 91-36, "Built-Up Roof Management Program."
- o Air-Conditioning and Refrigeration Institute/National Roofing Contractors Association/Sheet Metal and Air-Conditioning Contractors National Association, "Guidelines for Roof Mounted Outdoor Air-Conditioner Installations."
- o Asphalt Roofing Manufacturers Association, "A Guide to Preparing Built-Up Roofing Specifications."
- o Asphalt Roofing Manufacturers Association/National Roofing Contractors Association, "Manual of Roof Maintenance and Roof Repair."
- o National Roofing Contractors Association, "Commercial, Industrial, and Institutional Roofing Materials Guide."
- o National Roofing Contractors Association, "Handbook of Accepted Roofing Knowledge."
- o National Roofing Contractors Association, "Quality Control In the Application of Built-Up Roofing."
- o National Roofing Contractors Association, "Roofing and Waterproofing Manual."
- o Sheet Metal and Air Conditioning Contractors National Association, "Architectural Sheet Metal."
- o Single Ply Roofing Institute, "Single Ply Roofing: A Professional's Guide to Specifications."
- o Urethane Foam Contractors Association, "Design Considerations and Guide Specifications."

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