TENNESSEE VALLEY AUTHORITY

NUCLEAR MANAGER'S REVIEW GROUP

NMRG REPORT NO. R-86-02-NPS

Review of Maintenance at Browns Ferry, Sequoyah, and Watts Bar Nuclear Plants

Summer 1986

(Sept 22, 1986)

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I. Introduction and Scope

On April 10, 1986, the Manager of Nuclear Power requested the newly formed Nuclear Manager's Review Group (NMRG) to perform a comprehensive review of corrective (CM) and preventive maintenance (PM) at Browns Ferry (BFN), Sequoyah (SQN), and Watts Bar Nuclear Plants (WBN). The requesting memorandum is attached. This was the first review assignment for the NMRG after its formation from the Nuclear Safety Review Staff (NSRS) and the assignment of a new NMRG Director.

This review of maintenance offered an opportunity for the NMRG to perform a substantive assessment of one of the most important performance areas affecting TVA's nuclear plants and to demonstrate the use of improved, performance-based review techniques to focus review efforts in the most significant areas. Maintenance is widely recognized within the nuclear industry as an area in need of improvement.

Of sixteen notable accidents at nuclear power reactors that have occurred in the U.S. and abroad, maintenance was a significant cause or contributor to eight. The Nuclear Regulatory Commission (NRC) has recently strengthened its inspection of maintenance and is considering other actions to improve maintenance and strengthen regulatory involvement in maintenance-related matters. The Nuclear Utility Management and Human Resources Committee (NUMARC) formed a working group to develop appropriate industry-wide improvement initiatives in maintenance. This on-going activity is supported, in part, by the Institute of Nuclear Power Operations (INPO). INPO is also increasing its attention to evaluating maintenance and supporting maintenance improvements.

The NSRS also recognized the importance of nuclear plant maintenance. They performed a review of the maintenance program at WBN, BFN, and SQN during February and March of 1985. The results were published in NSRS Report R-85-03-NPS on July 5, 1985. That review produced eight recommendations for improvement, mostly in the postmaintenance testing (PMT) area. It did not, however, delve deeply into the implementation of maintenance policies and programs at the working level.

Substantive preparation for this review began on April 21, 1986, when the NMRG staff reported to their new offices in Chattanooga. Selection of review team members and leaders was one of the first activities. All NMRG personnel not already committed to other activities were assigned to the review. Leaders for the review were selected by a screening and interview process. All NMRG personnel assigned to the review were considered, and the leading candidates were interviewed by the Director, NMRG, and two other senior, operationally experienced nuclear power managers. Based on the results of the interviews, the Director, NMRG, selected team leaders for plant teams at WBN, SQN, and BFN, a small corporate team, and an overall project leader.

Though NMRG members had extensive experience in conducting programmatic reviews, they were not well experienced in maintenance or in evaluation of maintenance work. Therefore, seven loanee evaluators were obtained from the maintenance organizations at four plant sites and the corporate maintenance support organization. These loanees held maintenance engineering and supervisory positions from the General Foreman to the Maintenance Superintendent level. Their knowledge and experience in maintenance contributed substantially to the quality of the review.

Including the seven loanees, 25 persons were assigned to the review. Individuals were assigned to site teams so that each team had a mix of loanees and NMRG personnel, and each had expertise in the electrical, mechanical, and instrumentation disciplines.

In order to help this first NMRG review to produce results recognized as useful by line managers, it was structured so that the results would reflect, as closely as possible, the actual performance of maintenance at the sites. New review techniques, similar to INPO's performance-based evaluation methods, were used where possible. These utilize direct observation of maintenance activities to identify performance problems at the working level and subsequent follow-up to determine the extent and causes of the observed performance problems. All team members were trained, in a course presented by an INPO evaluation team manager, on effective observation and follow-up techniques.

As a basis for the review, the team selected applicable documents used by INPO in evaluating maintenance and providing assistance to utilities in improving maintenance. They were INPO's "Performance Objectives and Criteria for Operating and Near-Term Operating License Plants," "Performance Objectives and Criteria for Corporate Evaluations," and "Guidelines for the Conduct of Maintenance at Nuclear Power Stations." These publications were developed by INPO with substantial input from nuclear utilities. They are widely accepted within the nuclear utility industry as appropriate standards of excellence for maintenance. The chapter topics in the maintenance guidelines were broken into sets, or performance areas, and individuals were assigned responsibility for evaluating performance in each of the selected areas. Identical sets were used for each plant team. Under this arrangement, individual members worked with their own team on the assessment of their assigned site and with members of other teams on the assessment of common performance areas at the three sites. Each of the performance area groups was assigned responsibility for preparing the answers to selected questions from the memorandum requesting the review. Appropriate performance area groups were also assigned follow-up responsibility for each of the open recommendations from the NSRS report on maintenance (R-85-03-NPS) prepared in 1985.

During the preparation period, team members studied applicable INPO publications, procedures, and other documents relevant to their assigned areas. More structured evaluation plans were developed for the onsite phase.

Field evaluations at the nuclear sites began on May 19, 1986. During the first week, team members concentrated on observing maintenance activities in progress. A variety of activities, covering most facets of maintenance, was observed at each site. These included PM and CM, establishment of clearances (tag outs), planning and scheduling (P&S), parts procurement, and testing.

To the extent possible, observations were performed by two team members, at least one of which had expertise in the discipline being observed. The results of observations were recorded and distributed to each team member daily so that all team members were aware of the problems being observed and could offer suggestions and adjust their own evaluation work appropriately. Team meetings were conducted at the end of each day to discuss progress and help prepare team members for the next day's activities.

Normally on a daily basis, the team leader briefed the plant manager or his designated contact on progress of the review and the results to date. These plant contacts were requested and encouraged to give feedback to the team in cases where results did not seem correct or where the team might need additional information to understand an issue fully. During this week the Director, NMRG, and project leader separately visited each site to observe and guide the review. They participated in observations, reviewed and critiqued potential findings and observation results, and provided advice and assistance as needed.

Following the first week onsite, the teams returned to the Chattanooga office for one week to compare notes and prepare for follow-up evaluation work at the sites.

The teams returned to the sites on June 2, 1986, to follow up on the problems noted during the first week and explore new areas related to findings at the other sites. Efforts were focused on problems that interfered with the correct and efficient performance of maintenance, or impaired effective management and monitoring of work. Interviews, document reviews, and additional observations were used to gain more understanding of the nature, extent, and causes of the problems. Though the focus of the review was on the overall effectiveness of maintenance and support for maintenance, adherence to appropriate regulations and commitments was also considered. The Director, NMRG, and project leader separately visited each team to review their progress and critiqued their findings. BFN and SQN follow-up activities extended for two weeks, but WBN follow-up required only one week. Additional corporate review was also performed at this time.

Upon return to the NMRG offices, drafting of the review report commenced immediately. Findings and responses to the questions in the requesting memorandum were drafted by the cognizant performance area groups and reviewed by a select group composed of the team leaders, the project leader, one of the senior loanees, and the Director, NMRG. As revisions were made or questions identified during their review, the cognizant team members were consulted to ensure that the resulting report contents accurately reflected the results obtained in the field. Since this was

a new process for the NMRG, several iterations were required to draft the findings accurately. During this process, the originators of the findings were consulted to ensure that the findings remained fair and accurate in their opinion. When the group of team leaders was satisfied with the report, copies were distributed to all review team members and a meeting was convened to discuss the contents and, once again, to ensure that the report fairly and accurately presented the results of the review and that no important information had been omitted. All comments received on substance or fact were incorporated.

Throughout the review process, interaction between evaluators, teams, team leaders, and NMRG management was encouraged to help ensure that potential problem areas were adequately investigated, available resources were used effectively, and that the resulting findings were a fair and accurate reflection of the facts. This emphasis on teamwork will be continued in future NMRG reviews.

Exit meetings were held at the sites on July 28 and 29, 1986, and with corporate managers on July 30, 1986, to discuss the results of the review. Only minor adjustments to the draft report resulted from those meetings.

The draft report was forwarded to the Manager of Nuclear Power on August 15, 1986. It was returned to the Director, NMRG, on September 12, 1986, with a request that appropriate recommendations be added. Recommendations for corrective actions are now included.

II. Management Summary

The findings and recommendations resulting from this review are included in section III. They are grouped into fifteen performance areas that correspond closely with those in the INPO Guidelines for the Conduct of Maintenance at Nuclear Power Stations. This grouping is used for clarity and is not intended to indicate which organizations should be responsible for corrective actions.

Answers to the questions contained in the reqesting memorandum are contained in Appendix A. Where appropriate, these answers reference applicable findings in section III.

Appendix B is the result of the follow-up review of outstanding recommendations from NSRS Report Number R-85-03-NPS, "Review of Nuclear Power Maintenance Program." Two findings in this report, I-1 concerning postmaintenance testing and O-4 concerning quality assurance surveillance activities, address continuing problems first noted in that report. One additional recommendation from that report (R-85-03-NPS-07), concerning common mode failure, needs additional review to determine if closure is appropriate. Since corrective action was found adequate or a related finding was included in this report, all recommendations in that report (except R-85-03-NPS-07) are now closed.

Though findings throughout this report are identified with specific stations, the corrective action for many of the findings will require substantial effort from the corporate organization. Where appropriate, the recommendations indicate the need for corporate involvement. Cognizant managers can best determine appropriate corrective actions and implementation schedules after a thorough review of the findings and recommendations. Many of the findings had been previously recognized by the responsible line managers, and corrective actions are in progress. As reflected in the findings and recommendations, however, adjustments to some current corrective actions will be needed in order to fully address the problems noted and to improve coordination of improvement efforts at the sites.

Findings are identified to the sites at which each was noted, and as appropriate, amplifying information is provided for each site. However, because different teams were used at each site and because the problems evident from observation of work activities were somewhat different at each site, findings may also be applicable to sites other than those specifically noted. Managers are urged to consider applicability of each of the findings to their own sites and to formulate corrective actions appropriately.

In this report, the term "preventive maintenance" is used in the broad context. It includes all those regularly scheduled activities that are performed to monitor the condition of equipment and prevent or retard equipment degradation, regardless of which organization is responsible

for the individual activities. Also, in this report the term "corporate" denotes all Office of Nuclear Power (ONP) organizations not reporting to the site directors.

Time constraints on the review precluded full investigation of some identified problems, particularly those in support programs and activities. In these cases, the findings reflect the information acquired by the team, and further investigation may be needed to adequately formulate corrective actions.

It is the opinion of the review team that significant improvements have been made in maintenance at the nuclear sites, particularly in P&S, over the past several months. However, as illustrated by the findings in section III, substantial improvements are still needed in order for maintenance at the nuclear sites to approach excellence.

The most significant improvements needed, based on the collective interpretation of the findings of this review are as follows:

- Aggressive correction and prevention of hardware problems. Responsibility for controls and checks to ensure activities are performed properly are diffuse, resulting in multiple opportunities to impede timely progress. Unfortunately, there is often a lack of aggressive, coordinated effort to solve the fundamental issues impeding timely correction of hardware problems. A lack of clear accountability for solving specific hardware problems and inordinate attention to administrative concerns may be contributing factors.

- Corporate involvement in nuclear maintenance. Corporate responsibilities relative to nuclear maintenance are not clearly defined. Though corporate direction is needed in several areas, an especially urgent need exists for support and coordination of current site improvement efforts from the corporate offices.

- Implementation of challenging goals and objectives for maintenance. Maintenance performance goals have not been established at the corporate level, and in many relevant areas, at the site level. Maintenance performance monitoring efforts are not providing needed information to key managers.

III. Findings

A. CORPORATE INVOLVEMENT

The review of corporate[1] level involvement in the maintenance program was based exclusively on interviews with top level management. At the time of the review, the ONP organizational structure was not totally approved. In addition, the procedures (policies, directives, and standards) of ONP were in various stages of completion. These documents are needed to define the approved methods of doing business. The information obtained during the interview process was compared with the INPO 85-029[2] objectives and criteria that are applicable to a corporate maintenance program. It is important to note that some findings may be a result of a lack of program redevelopment following the organizational change away from the owner-operator concept.

Finding A-1

Corporate responsibilities regarding maintenance lack definition and direction. An ONP policy for conduct and support of maintenance at the sites has not yet been established. A draft policy exists, but it has received only limited distribution and contains significant weaknesses, such as undefined corporate involvement in monitoring and support of maintenance. It appears that support for maintenance from a hardware standpoint including component and specialized technical expertise was being assigned to Division of Nuclear Engineering (DNE). It was not clear, however, that other important maintenance program matters not so directly associated with hardware would be adequately addressed. Corporate responsibilities for support and coordination of human resource management efforts such as P&S, training, staffing, and performance monitoring of the maintenance organizations do not appear to be adequately addressed. Oversight plans of the technical assessment group are redundant to the efforts of other groups and place less emphasis than appropriate on providing support and coordination services for improvement efforts at the sites.

Performance goals for maintenance have not been established. Directives and standards to clearly define the responsibilities of the different organizations for maintenance have not been completed.

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1. For the purposes of this section, "corporate" is defined as any part of the utility organization not reporting to a site director.

2. INPO 85-029, "Performance Objectives and Criteria for Corporate Evaluations," August 1985.

At least a quarter of the corporate managers interviewed stated they did not have a clear understanding of their role in maintenance. Those managers appear in the organization chart from the group head level to the division director level, and all appear to have significant maintenance support roles. Since the change away from the owner-operator concept, the roles of several corporate organizations for support and coordination of maintenance have not been clearly defined. Some managers have attempted to define their roles through interpretation of the Nuclear Performance Plan.

Recommendation:

Strengthen the corporate involvement in maintenance by appointing a senior level manager, experienced in maintenance, to direct and coordinate TVA's nuclear maintenance program. Assign that person appropriate responsibility, authority, and organizational position to permit effective establishment of needed policies, directives, and standards governing maintenance efforts. Use this position to promote development and use of common maintenance management and monitoring programs at the nuclear sites, and strengthen the corporate role in directing, supporting, and coordinating human resource management efforts in the maintenance area. Involve knowledgeable site personnel in efforts aimed at standardizing maintenance management methods to help ensure that revised programs function effectively.

Finding A-2

Performance indicators used to gauge the effectiveness of Preventive Maintenance and Corrective Maintenance activities at the sites are not representative of the actual effort expended or as useful as possible. Differences in maintenance work classification at the three sites produce indicators that cannot be easily or meaningfully compared between sites, combined to reflect overall Tennessee Valley Authority (TVA) performance or compared with the industry performance indicators collected by INPO. These indicators are used at the sites and in monthly reports to the corporate office.

The scope of activities considered to be PMs is not completely or uniformly defined at the sites. Examples of PM activities not reported in performance monitoring data bases include predictive analysis, Division of Power System Operations (DPSO) testing and calibrations, and (at WBN) some periodic instrument calibrations.

Though the number of Maintenance Requests (MRs) at each site is monitored and reported to reflect the magnitude of the maintenance effort, that number is not representative of the CM effort on process equipment and does not fit the scope preferred by INPO. MRs are used to request CM and also to authorize a variety of other work. Examples of other uses for MRs include PMs at WBN, work on non-process equipment, and requesting maintenance personnel support for activities such as Surveillance

Instruction (SIs), refueling, and modifications. Separate MRs are often but not consistently used for individual support activities (e.g. disconnecting electrical leads, erecting scaffolds, and installing temporary lighting) in addition to the basic corrective maintenance activity. As a result, the number of MRs completed or in backlog has limited value for comparison between TVA sites and with other utilities, and for meaningful analysis.

In part because of these problems, and in part because corporate managers have not clearly identified the maintenance performance indicators desired in regular reports, monthly site performance reports do not provide needed information in a form that is readily usable by managers. Though a variety of information, including the performance indicators discussed above, is included in the reports, any analysis of that data is left for upper management to perform. Senior managers often do not have the time or in-depth knowledge necessary to perform their own evaluation. As a result, they are not making effective use of the data. Most corporate managers stated that they were not familiar with the information contained in the monthly reports or the maintenance workload at the sites.

Recommendation:

Develop standard definitions for performance indicators, consistent with INPO definitions, to help gauge the effectiveness of site PM and CM efforts. Improve the selection and analysis of maintenance data included in regular site performance reports and develop more useful summary reports for corporate managers. Include performance information for all scheduled equipment monitoring and maintenance activities. Implement consistent use of MRs to authorize work at all of the sites, and define appropriate categories of maintenance work for tracking and monitoring purposes. Categories of maintenance work could include CM on plant process equipment, CM on other equipment, support work for other activities, and modification work. Involve knowledgeable site personnel in this effort.

Finding A-3

Some maintenance program improvement efforts lack needed corporate guidance and coordination. Currently, each of the sites independently identifies and pursues most of its own maintenance program developments and improvements. Two example areas illustrate the lack of needed corporate involvement in maintenance program development.

First, no corporate guidance exists for the overall PM program. The PM program at BFN is different from those at SQN and WBN, which are similar, but still have some differences. Those differences include the types of equipment included in the program and the methods of initiating and controlling the

maintenance; some are done under MRs and others are done under Maintenance Instructions (MIs). No guidelines are available as to what equipment should be included in a PM program. Each site uses a different set of criteria, and some important pieces of equipment such as Essential Raw Cooling Water (ERCW) pumps and motors have been omitted. BFN expressed reluctance to involve the corporate office in development of a uniform PM program because that would delay needed improvements.

Second, within the past two to three years, the sites have made significant improvements in maintenance P&S. To a degree, these improvements have resulted from the support and coordination efforts of the Industrial Engineering (IE) organization in Knoxville. Though the current IE effort has been completed, there are still significant improvements in P&S needed at each site, and there are unnecessary differences in the way P&S is accomplished at the sites. Examples of these differences include availability and use of information resources, work prioritization, work authorization, and work tracking methods.

Recommendation:

Strengthen corporate direction and coordination of maintenance program improvement efforts at the nuclear plant sites and standardize programs except where hardware differences or hardware application differences require otherwise.

Develop and implement corporate guidance for the scope, content and management of the PM program. Consider expanding the BFN PM development effort to include all the sites and encompass all regularly scheduled monitoring and maintenance efforts. Note that some corporate PM development efforts are apparently in progress in the Operations Engineering Section of DNE.

Strengthen corporate efforts to standardize and improve P&S at each of the sites. Consider the detailed recommendations and supporting information provided in the Nuclear Plant Operational Support Systems (NPOSS) Review Phase II Report No. 6.0, Routine Activity Planning and Scheduling Functional Area (Maintenance Management), prepared by the TVA Industrial Engineering Staff and dated June 1986.

Involve knowledgeable site personnel in these improvement efforts to help ensure development of effective improvements and coordination of standardization efforts with site-specific improvement efforts that need more immediate attention.

Finding A-4

Root cause analyses are not performed for some potentially significant failures.

Root cause analyses are performed for Critical Systems, Structures, and Components (CSSC) equipment failures that result in a Licensee Event Report (LER) at BFN and SQN. A policy or

directive is needed, however, to define other appropriate criteria for requiring prompt failure evaluations of specific plant events. Ground rules and requirements are also needed for periodic review and trending of maintenance history to identify repeated failures that should be analyzed.

Browns Ferry

A review of MRs revealed repeated failures and repairs of the auxiliary compressor for the emergency diesel generators. Although considerable analysis was performed, the root cause was not determined in a timely manner. For years, High Pressure Coolant Injection (HPCI) system problems were simply repaired, and the root causes were not corrected. Only after a NSRS investigation and report, were HPCI problems evaluated for root cause.

Sequoyah

There have been many problems with the ERCW pumps related to leakage. No root cause analysis has been done in order to correct the problem. Instead, the pumps have been repaired each time failure occurs. There have also been repeated problems requiring corrective maintenance on the diesel generator governors and the control air moisture traps. Neither of these two problem areas have been evaluated for root cause.

Watts Bar

Examples of occurrences for which root cause analysis had not yet been performed include: a diesel generator malfunction due to a potential transformer connection, and repeated malfunction of an auxiliary feed water pump trip throttle valve discovered by an MR history review.

Recommendation:

Expand the use of root cause analyses to aid in prevention of potentially significant equipment failures. Establish standard criteria for use at all sites for selecting a broader range of equipment failures for root cause analysis. Consider the selection criteria for potentially significant events described in INPO publication 86-017, "Significant Event Evaluation and Information Network (SEE-IN) Program Description." Periodically analyze equipment history records for adverse trends or repetitive failures that should be analyzed.

Finding A-5

Identification of an acceptable substitute for teflon tape has not been aggressively pursued.

Teflon tape is restricted from use as a lubricant and sealant for threaded pipe connections in certain system applications and

environments. A non-conformance report at WBN identified its improper use in restricted applications in April 1985. A subsequent NSRS investigation, completed in September 1985, resulted in the identification of the issue as generic to all plants. Based on information obtained during interviews, the only approved substitute which completely satisfies the applicable technical requirements is too brittle and too thick for some required applications.

DNE has reportedly been assigned the lead in resolving the generic issue, but coordination between site and DNE personnel to resolve the issue has not been effective. Different interim actions are being taken at the three sites, and resolution of the generic issue is not proceeding expeditiously. Currently, WBN restricts use of teflon tape in the reactor and auxiliary buildings; SQN analyzes specific applications but does not otherwise restrict its use. BFN is prohibiting withdrawal of teflon tape from Power Stores until the issue is resolved even though applicability of the generic issue to BFN is not clear. Tests for additional substitute materials and relaxation of radiation and temperature limits on teflon tape are planned, but are not in progress at this time. Communication between the cognizant DNE personnel and site personnel on the issue is poor. For example, site personnel were not correctly informed of the status of testing on substitute materials, and DNE personnel were unaware of the inconsistencies in restrictions on the use of the teflon tape at the three sites.

Recommendation:

Assign responsibility for identifying acceptable alternatives to the use of Teflon tape and follow up to ensure timely completion of the effort. Implement uniform controls over Teflon tape use at all the nuclear plant sites.

Finding A-6

No specific requirements exist for protecting the health of TVA employees while working on domestic sewage facilities.

No protective clothing was worn by SQN employees repairing a broken sewer line. The general foreman was not aware of any requirement for protective clothing such as rubber gloves and waders. A review of TVA documents and discussions with corporate organizations did not reveal any requirement, procedure, or responsibility for the protection of employees working on sewage facilities. This void in protection of employee health apparently occurs at all sites.

Recommendation:

Establish and promulgate guidance for protection of personnel working on raw sewage systems.

B. MAINTENANCE DEPARTMENT ORGANIZATION AND ADMINISTRATION

There were no specific findings in this area. Findings in several other areas, however, address performance problems that are related to organizational and administrative problems.

C. TRAINING AND QUALIFICATION OF MAINTENANCE PERSONNEL

Finding C-1

The lack of structured training for planners has contributed to planning problems. Planners are principally learning their jobs through unstructured on-the-job training, relying primarily upon their experience as craftsmen.

Specialized training for planners is needed in such areas as use of the Equipment Information System (EQIS) and Materials Management System (MAMS), plant systems, preparation of work instructions, PMT, and as appropriate, supervisory and management skills. Sections G, H, and I contain examples of planning problems that can be associated with training weaknesses.

Recommendation:

Develop and implement a structured training program for maintenance planners. Include classroom instruction and structured on-the-job skills development and demonstration. Include the following elements in that program:

1. EQIS
2. MAMS
3. Plant systems
4. Preparation of work instructions
5. PMT

When feasible implement standardized training for all the sites at Power Operations Training Center (POTC). In the interim, provide site-specific training on elements most critical to the quality of current maintenance efforts, such as determining appropriate PMT.

D. MAINTENANCE FACILITIES, EQUIPMENT AND TOOLS

Finding D-1

Maintenance shops and office spaces are inadequate to efficiently perform work. Time delays have occurred, and safety hazards have resulted. Contributors to the problem include increases in personnel and activities at the sites beyond design expectations. Though the review schedule did not permit a comprehensive review in this area, the problem is considered significant and widespread. Example problem areas are as follows:

At all sites, portions of work and storage spaces are now utilized for offices or lunchrooms, resulting in limited space in mechanical and electrical shop areas for equipment maintenance and material staging.

Browns Ferry

- A designated hot tool room does not exist. Hot tools and equipment are stored in various lockers and locked storage rooms without inventories or segregation by types. As hot tools and equipment are requested, the tool room attendant must leave the outage tool room and search each location, an inefficient process that contributes to delays.

- Switchyard breaker maintenance cannot be conducted during inclement weather due to a lack of appropriate facilities.

- The P&S Office is overcrowded; desks, filing cabinets, and drawing racks restrict egress paths.

- A new maintenance office building is under construction. That building should allow recovery of some usable work space in the mechanical and electrical shop areas, but additional facilities are needed.

Sequoyah

- Carpenters are using space in the construction buildings about 1/4 mile outside of the plant access gate. Other crafts also utilize these construction buildings from time to time. This remote location leads to inefficiencies in the use of craftsmen's time.

- Spaces in the main machine shop area and electrical shop are being used for welding booths, decreasing the available space for normal shop work.

- Portions of the main machine shop have been designated for small tool repair, requiring relocation of equipment and congestion in the remaining areas.

- Though plans developed to add additional space appear comprehensive and well thought out, they have not been finalized or budgeted.

Watts Bar Nuclear Plant

- An insulators' shop has been established in a wire cage in the turbine building, but the cage is not large enough. Some heavy equipment must be moved out of the cage to be used or to allow access to other equipment. This problem has been recognized for about two years.

- o Switchyard breaker maintenance cannot be conducted during inclement weather due to a lack of appropriate facilities.

- o The carpenter shop is too small for some work performed.

Recommendation:

Implement plans that have been developed by the sites to alleviate the problems noted.

E. TYPES OF MAINTENANCE

Finding E-1

Some needed PMs are not included in any program governing PM activities. Some equipment requiring PMs has not been so identified. The scope of PMs on some identified equipment has not been evaluated for adequacy and completeness. Various methods have been used to identify equipment needing PM and to determine the appropriate PM for each piece of equipment. Vendor manual PM recommendations have not been uniformly implemented, and variations from the recommendations have not been well documented. As a result, PM program development efforts to date have not been completely effective. The absence of a reliable, useful master equipment list that identifies all systems and equipment for each site may have contributed to the problem. Efforts are underway at each site to improve PM programs, but those efforts are individual and lack needed corporate support and coordination.

Browns Ferry

Management was attempting to contract with an outside consultant to upgrade the current program and consolidate preventive activities in a comprehensive PM program. This program is intended to include all equipment important to safety, operability, and reliability. The effort is projected to take one year after the contract is awarded.

Sequoyah

Several components important to safe and reliable operation are not included in the PM program. Examples include component cooling motors, condenser hotwell pumps/motors, and ERCW pumps/motors.

Management has initiated a program to systematically identify equipment on the CSSC list that is missing from the PM program. The scope of this effort, however, does not include a systematic review to identify non-CSSC equipment important for reliable operation missing from the PM program.

Watts Bar

The current PM program was established from tentative transfer packages used to transfer of cognizance for complete systems and/or components from construction to operations. Those packages were used to identify equipment within the transfer boundary that needed PM, and to establish appropriate PM for that equipment. This method did not ensure that equipment changes occurring due to subsequent modifications and final transfers were evaluated for impact on the program.

Management stated that they have plans to systematically update and restructure the PM procedures over the next two years. Plans are being made to contract with the same consultant as BFN to assist with the upgrade effort. The effort is to include identification of all equipment and PMs that have been omitted from the program. Some work has been initiated; however, implementation plans for accomplishing this work were not documented, tracked, or scheduled. A draft plant instruction has recently been developed as part of this effort to describe the PM program. A review revealed that this instruction did not address the following:

a. Long-term maintenance of the PM program to ensure that it remains current and effective, including periodic review for completeness.

b. Additions of equipment to the program by means other than tentative transfer; e.g., Engineering Change Notices (ECNs).

c. Documentation, for historical purposes, of changes to the PM list.

d. Adjustments in PM frequencies based on equipment performance.

e. Technical evaluation and management approval of changes in approved frequencies and activities.

Recommendation:

Assign responsibility for PM program development and improvement to a capable manager at each site. Charge these managers with the responsibility for directing site-specific improvements in PM and coordinating with designated corporate managers on development of a uniform nuclear plant PM program. Provide these managers with resources needed to support a timely upgrade of PM efforts. Review available lists of equipment and the current lists of PM activities to identify equipment important for safe and reliable operation that is not receiving appropriate PM.

Establish appropriate PM activities based on available vendor recommendations, equipment service history, and other available sources of information such as Nuclear Performance Reliability Data System (NPRDS). Document, for future reference, reasons for decisions to deviate from vendor recommendations, if any. Consider developing corporate guidance for the type and frequency of PM on equipment used at more than one site. Ensure that modification procedures contain provisions for updating the PM program as necessary.

Finding E-2

At WBN and BFN, some PM activities are not controlled under the present PM program and are not subject to the same levels of approval for waivers, deletions, additions, or changes in established frequencies. Activities not addressed in the scope of PM procedures include periodic Instrument Maintenance Instructions (IMIs) and some MIs at WBN, and periodic predictive monitoring activities.

The PM schedule is reviewed and deferrals are approved by the Maintenance Superintendent as required. However, deferrals at WBN of periodic calibrations, some MIs, and IMIs are not reviewed above the group supervisor level because they are not considered PMs by current site procedures.

At BFN and WBN all predictive analysis activities are outside the control of the PM program.

Recommendation:

Develop and implement uniform procedures for waivers, deferrals, deletions, and changes in PM activities.

Finding E-3

At SQN, required management approvals have not always been obtained for waivers, extensions or deferrals of PM activities past due for performance. Eleven of the approximately 140 PM activities past due for performance as of June 3, 1986 were reviewed. Six of these eleven PM packages reviewed had not received management approval for deferral, and no clear need for the deferral was indicated. Instructions require management approval for all PM deferrals or cancellations and documentation of the reasons for deferrals or cancellations.

Recommendation:

At SQN, strengthen measures to ensure that waivers and extensions or deferrals of PM activities are approved and the reasons documented before due dates are passed.

Finding E-4

At WBN, Quality Control (QC) verification of oil additions to CSSC equipment is not complete and does not meet the intent of the Nuclear Quality Assurance Manual (NQAM). The NQAM requires that Plant Quality Assurance (PQA) ensure the correct oil type and amount is added to CSSC equipment. A PQA staff instruction letter requires that QC inspectors verify that the containers used for oil addition are marked with the type of oil specified in the work instruction and that the proper amount is added. It does not require QC verification that the correct oil type is placed into the marked container.

Recommendation:

At WBN, improve the PQA method used to verify proper oil additions to CSSC equipment by including verification of proper oil transfer to the containers used for oil addition. Consider deleting the NQAM requirement for QA verification of oil addition and placing responsibility for this action with line management.

Finding E-5

At SQN no mechanism exists within the PM program to identify the individual PMs that are required by regulatory agencies, corporate policy or other commitments. Subsequently, inappropriate revision or deletion of the PM is not prevented, and commitments to perform certain PMs may be missed.

Recommendation:

Develop and implement uniform methods of identifying PM activities that are constrained by regulations, policy, or other commitments. Maintain documentation or reference to those restraints to ensure that subsequent changes are consistent with the restraints. Include identification of applicable restraints in the PM upgrade effort discussed in finding and recommendation E-1.

F. MAINTENANCE PROCEDURES

Finding F-1

Work instructions/procedures were not always followed at all three sites. Weaknesses in procedural adherence have been identified as recurring problems at all three plants, and previous corrective efforts have not been fully effective. In a number of cases, deviations from approved procedures were considered acceptable and even routine at the working level. Examples include the following:

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- A Hold Order Tag was violated when a valve motor operator was removed with a Hold Order Tag attached to the handwheel.

- The following Radiation Work Permit (RWP) procedural violations occurred: (1) one man logged time out and dose for others; furthermore, he failed to consult with those individuals to determine the dose to be logged, and (2) the applicable RWP was removed from the area before everyone had exited and logged their exit as required.

- Though management stated that attention is being given to the procedural adherence problem and violators have been penalized, those actions have not been fully effective.

Sequoyah

- In performing a generic procedure applicable to several models of similar equipment from one vendor, some procedural steps were skipped, and data sheets were not completely filled out. Though skipped steps appeared not to be applicable to the specific model being worked on, the applicability of these steps should have been determined by the test coordinator, not the craftsman, as occurred in this case.

- On occasion second party verifications were not performed properly. For example, the second person did not visually verify some wire terminations as required.

Watts Bar

- PM work instructions for a safety-related pump motor stated "Flush out each bearing oil reservoir with kerosene before replacing oil." This step was not performed; craft stated that they had verbal approval from the general foreman to not perform that step. The instruction also included a step to lightly coat each plug with approved (Permatex) compound. The craft did not have Permatex, did not perform the step, and stated it was unnecessary because the plug is removed every three months.

- A draft copy of a procedure used for switchyard work did not have appropriate approval signatures on the cover sheet.

- Steps in several instructions were skipped and performed out of sequence. Hold points were signed off by foremen without observing the completed work as required.

- o Signoffs were not made as the work progressed, but were made after the work was completed.

- o Maintenance procedures provided with MR work packages are not always referred to by the craft at the job site when appropriate.

Recommendation:

Improve adherence to procedures by implementing a variety of improvement actions. Consider the following measures:

1. Establish a clear, realistic policy for adherence to procedures. Where close adherence to procedural guidance is needed, require and insist on adherence. Where the intent of procedures can be safely accomplished without strict adherence to available procedural guidance, consider permitting flexibility from strict adherence (e.g., permitting performance of steps out of sequence, omitting inapplicable steps, or completing steps by alternate means).

2. Train maintenance personnel in the policy for procedural adherence, the reasons why procedural adherence is important, and the possible consequences of inadequate adherence.

3. Increase supervisory monitoring and coaching of maintenance work, emphasizing procedural adherence among work crews, and identifying areas where action is needed to support appropriate adherence.

4. Strengthen assistance to procedure users in resolving problems that encourage unauthorized deviations from procedures.

Finding F-2

Some instructions were not clear, were not concise, and did not contain the information necessary for users to understand and perform work activities effectively. Some instructions did not include appropriate human factor considerations to promote-error-free performance. The mechanisms used to obtain feedback on instructions have not been effective due to limited use of feedback sheets by users. Examples of problems noted include:

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- o The site is involved in a major review and rewrite of maintenance instructions. The initial procedure produced by this process is a significant improvement over those currently in place. The rewrite effort is projected to take about ten years with present methods

and resources. Though critical procedures are being given priority, the planned completion is not timely. Management stated that efforts to shorten the time required to complete the program are in progress.

Sequoyah

- Selection of lubricants or methods of lubricating were sometimes not specified in instructions.

- Some motor maintenance MIs that require lifting of power leads do not require a check for proper rotation of the motor after reconnection.

- Incorrect material for electrical terminations on class 1E motors was specified in some instructions.

- Many work instructions require reference to and use of additional instructions and data sheets. In some cases a series of references results. This contributes to inefficiency and increases the possibility of human errors in field performance. Maintenance management has recognized this problem and has addressed it in the Nuclear Performance Plan, Volume II.

Watts Bar

- Plant instructions require step-by-step performance unless otherwise noted. In some cases, procedures were unnecessarily restrictive, requiring step-by-step performance when sequence was not important or when users could readily determine applicability of selected steps.

- Installed pump flange bolts were torqued to higher values in two passes. The work instructions with the MR did not specify the number of passes to make or refer to other instructions providing this information. A section instruction letter, not present at the worksite, specified three passes from initial to final torque at 50 percent, 75 percent, and 100 percent increments respectively. The initial torque used was only 36 percent.

- A craft worker moved a control switch from auto to manual to start a diesel generator compressor to check the oil pressure, but did not obtain approval from plant operators. The craft returned the control switch to auto after the check. The MI used instructed that the oil pressure be checked, but did not instruct the user to start or stop the compressor.

- Some hold points contained in instructions did not clearly describe the actions to be verified.

- Duplicate entries/signoffs for the same activity were sometimes required at different locations in data packages.

- Some SIs were very cumbersome to use. It was necessary to refer repeatedly back and forth between the surveillance instruction, data sheets, and other referenced procedures.

Recommendation:

Significantly strengthen feedback methods used to identify and correct procedural errors or omissions that interfere with correct performance of maintenance. Consider providing more direct technical support to maintenance crews during and immediately following completion of specific jobs to ensure that needed procedure changes are identified and processed. Increase supervisory monitoring of maintenance work in progress, and give particular attention to procedure adequacy and adherence. Continue and consider expediting current plans to develop new, improved procedures and to thoroughly check them for adequacy before implementation. Include, when possible, dry runs of draft procedures.

For the long term, consider implementing simplified procedure approval and revision processes similar to those employed by other utilities that have eliminated the requirement for PORC review of all but a few procedures and revisions.

Finding F-3

Procedure revisions at SQN are not being processed in a timely manner because of delays in the word processing center. A total backlog of 354 draft procedures, including maintenance instructions, is awaiting typing, 44 of which were submitted for revision prior to December 30, 1985. Since March 1986, word processing has gone from one to two shifts, and unit supervision stated that additional equipment, space and personnel will be necessary to reduce the backlog. Other documents being typed by word processing are given priority, contributing to the procedure backlog. Examples include the morning operating report, biweekly summary of activities, monthly operating report, section instruction letters and employee concern responses.

Recommendation:

At SQN, establish an acceptable turnaround time for procedures being typed, then provide resources necessary to meet that time. Consider transferring non-procedural word processing to others.

Finding F-4

Improvements are needed in the method used to prepare WBN SIs for use in the field. Some approved SIs cannot be successfully completed as written. Currently, errors are being discovered and corrected one at a time during initial performance of each SI for credit. Since cognizant engineers and approval personnel are not readily available at the work site, each change requires one to three hours to complete. The result is that some instructions that could normally be accomplished in one shift are taking over a week to complete. Though dry-run methods are available that would permit identification and correction of all errors in a single walk-through performance of each SI, these procedures are not being used.

Recommendation:

At WBN, shorten the time required to verify the usability of new and revised SIs by using the existing dry run method to identify all procedural problems during a single walk-through. Perform the walk-through with engineers in attendance to determine and verify appropriate corrections prior to performing the procedures for credit.

G. PLANNING, SCHEDULING, AND COORDINATION OF MAINTENANCE

Finding G-1

At BFN, maintenance was often scheduled and work authorized to start before prerequisite conditions were satisfied and the job was ready to be worked. Attempts to begin that work resulted in a significant loss of productivity. The following examples were observed:

- Work was initiated on equipment using a procedure in which deficiencies had been identified, but the needed revision had not yet been made. The work was delayed while awaiting the needed revision.

- Maintenance was substantially delayed when workers discovered, upon arrival at a job site, that equipment required to be operational as a prerequisite was tagged out. Workers stated that delays of this nature were very common.

- A scaffold scheduled to be erected was not completed on time. The delay was not reported to the cognizant maintenance foreman, and the maintenance crew discovered that the scaffold was not installed only after assembling their tools and equipment and reaching the job location.

Maintenance scopers identify, in advance, job prerequisites and support requirements for the P&S unit, which is responsible for initiating and scheduling the needed support and prerequisites.

The scoping function has contributed to noticeable improvements in productivity. Additional effort is needed, however, to ensure that jobs are actually ready to be worked before work crews are dispatched.

Recommendation:

At BFN, strengthen the planning and scheduling role to include ensuring, in coordination with foremen, that systems and equipment are available for work, prerequisite conditions are met, and needed support from other disciplines is provided when maintenance work crews are dispatched on a job. Schedule work further in advance and adhere to work schedules so that prerequisites and necessary personnel support can be scheduled reliably.

Finding G-2

At SQN, delays in initiation of approved work packages may result in work not being performed to the current revision of maintenance instructions and drawings. Some approved MR packages, which included procedures and drawings, have been planned and available for work for several months prior to the start of work. The work control system requires the cognizant foreman, rather than the planners, to ensure that work package contents are current prior to initiating work. Although no active work packages were observed that did not have the current revisions, several work packages had been completed using expired "controlled for use" drawings, and one active work package contained two revisions of one instruction. One other active work package reflected inappropriate support requirements. The original work package did not require a scaffold or RWP, but when the work was initiated, both were required.

Recommendation:

At SQN, strengthen measures to ensure that work packages are updated before beginning work if a significant delay has occurred since preparation. Consider using scopers and the planning and scheduling staff, instead of only foremen, to update the packages as necessary.

Finding G-3

At BFN, some In-Service Inspection (ISI) corrective action work is not coordinated effectively and completed in a timely manner. Over 100 ISI-related MRs were identified that were being held for engineering evaluation and had not been entered into the MR system. This results in an inaccurate MR backlog and can result in corrective actions for identified deficiencies not being completed or being unnecessarily delayed. Most of these MRs were approximately a year old and were for such work as weld repairs and replacement or tightening of lock nuts.

Recommendation:

At BFN, persue CM actions resulting from ISIs in a more timely manner. Ensure all CM MRs resulting from ISI activities are promptly placed on the tracking system so that they are processed to completion.

Finding G-4

At all three sites, the scheduling of different types of maintenance (PM, CM, predictive maintenance, SIs, MIs, IMIs, etc.) is not coordinated to minimize equipment downtime, eliminate excessive PMT, minimize radiation exposures, and improve productivity. No effective mechanisms or programs are currently in place to identify maintenance activities that should be performed at the same time. Currently, the proficiency of individuals within the planning organization is the principle mechanism or the only mechanism for identifying related work on given equipment or in the same area.

WBN and SQN have recognized these scheduling shortcomings and are presently considering improvements. WBN plans to address this in a new maintenance program on the PRIME computer. However, no implementation schedule was available for this new program.

BFN also has recognized these scheduling shortcomings and has a computer-assisted program in place to assist in common work scheduling for any specified piece of equipment. Planning activities were observed that demonstrated this capability. However, this program does not include a method of grouping by work type, equipment type, or location.

Recommendation:

Implement an improved planning and scheduling system that includes the capability to identify all anticipated work by the applicable system, location, type of work, and other attributes that may aid in scheduling common work together. Utilize this system to schedule like maintenance activities together to eliminate unnecessary testing, radiation exposure, equipment down time, and wasted effort for maintenance crews.

Finding G-5

Determination of the appropriate quality classifications for MRs requires excessive effort and time, and is prone to errors. At WBN, an average of 20 minutes for each MR was expended by planners to determine quality classifications. The classifications include, for example, CSSC applicability, Code of Federal Regulations 10 CFR 50.49 (Environmental Qualification (EQ)) applicability, class 1E designation, and "limited quality assurance (QA)" applicability. There are a number of lists that

must be consulted by the planners to determine quality classifications. These include: CSSC list, Q list, cable and conduit schedule, 50.49 lists, and drawings.

At SQN a difference between a 10 CFR 50.49 index and information in the equipment folder (individual binder) was found after MR work was initiated. Though 10 CFR 50.49 requirements were applicable, an error in the index and the 50.49 list caused the work to be improperly classified as 50.49 requirements not applicable.

At WBN, planners use an uncontrolled copy of a conduit list obtained from DNE in Knoxville, and 50.49 lists used were not controlled. There are a number of inconsistencies between the lists, some of which have been documented by Corrective Action Reports (CARs). It appears that EQIS, if fully developed and controlled, could aid significantly in improving this process.

Recommendation:

Consolidate the variety of existing equipment classification lists into a consolidated equipment listing for each site showing all the applicable quality, regulatory, or other classification needed to ensure that work is planned and executed to the appropriate standards. Include the lists mentioned in the finding. Establish controls over the content of the listing so that it can be used reliably as an authoritative source. Assign a responsible corporate manager responsibility for the effort and assign qualified support from DNE, Division of Nuclear Quality Assurance (DNQA), and the sites to help ensure the end product is accurate and readily usable for all potential users. Consider establishing this list on the EQIS computer program.

H. CONTROL OF MAINTENANCE ACTIVITIES

Finding H-1

Minor design changes needed to support plant maintenance and operation are not being accomplished in a timely manner. As a result, temporary alterations have been used to make permanent modifications. Maintenance managers and supervisors interviewed at all sites stated that the minor modification process is not effective in meeting maintenance needs.

The plant staffs do not engineer any changes affecting design-controlled drawings. Minor changes currently must go through the normal process for requesting (Design Change Request (DCR), Field Change Request (FCR), authorizing (ECN), and implementing changes (via workplans). In this process, minor changes compete in priority with the total modification backlog. The process in place for making minor modifications does not provide the expedient handling needed. An expedient process is possible without adversely impacting the necessary change controls.

DNE has recently located large project engineering staffs on the sites to expedite design changes. The effort has not been fully effective because these staffs are reportedly not permitted to authorize changes without approval of engineers in the Knoxville office. Examples of minor modifications processed through the full design change process, where that may not be necessary, include revision of a drawing dimension to permit metallurgical sampling of an installed bolt; revision of drawings to correct discrepancies; installation of a deck plate for personnel safety over a maintenance rail installed in the floor; and change of recorder pens from capillary type to felt type. Some DCRs involving substitution of parts have taken several years to process.

More than half of the temporary alterations presently in place are pending action to be made permanent; 121 of 151 at SQN, 218 of 358 at BFN, and 71 (and possibly more) of 240 at WBN. These kinds of temporary alterations place additional and redundant demands on plant and DNE resources and complicate configuration management. Temporary alterations pending action to be made permanent include three for meeting Technical Specification requirements, several industrial safety items, and one with a related DCR 9-1/2 years old.

Recommendation:

Establish an expeditious process within DNE for approving and implementing minor design changes needed to support plant operations and maintenance. Include provisions for simplifying selected portions of the design change process when appropriate. Ensure that the expeditious process continues to give adequate attention to required safety reviews. Provide for processing and approval of minor design changes on site. Consider establishing a grading system for modifications based upon safety significance and complexity and assigning approval authority to DNE Knoxville, DNE site, or maintenance engineering as appropriate, with emphasis on handling modifications at the lowest qualified level. Continue current efforts to reduce the number of outstanding temporary alterations. Monitor results of improvement efforts to determine if minor design changes are being processed in a timely manner and whether or not temporary alterations continue to be used for permanent changes.

Finding H-2

No uniform and effective priority system exists for managing MR work classified as routine at BFN.

The routine priority is used for a large majority of the maintenance work performed. Within that priority, no uniform, approved method identifies the most important or urgent work. One of three P&S scheduling units uses numerical codes in the MR

tracking system to relate maintenance activities to plant schedule milestones. Though this effort helps prioritize and schedule work, it is done only on a limited basis.

Recommendation:

Establish a uniform priority system for maintenance work at all the sites. Provide enough different priorities that planners and schedulers can effectively coordinate their efforts with minimum involvement by line managers and supervisors after prioritization. Provide for considering plant schedules when assigning priorities.

Finding H-3

At BFN and WBN, some MRs are signed off as complete without actually completing the work needed, and without initiating separate identifiable action to ensure that the stated deficiencies are corrected. Examples include the following:

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- Two MRs were closed out even though the specified PMT was not performed. The required PMT steps in the procedures could not be performed and this fact was appropriately documented by the craft on the MRs. The MRs were subsequently signed off as complete, and no actions were taken to ensure that the PMTs would be performed at a later date.

- Work performed under one MR to correct reported valve leakage was not successful. The description of work performed stated the valve continued to leak and needed to be replaced. The MR was signed off as complete, and no other MR could be found that would replace the valve or correct the leakage.

- An MR for a pressure gauge indicated that an accurate pressure measurement could not be obtained. The PMT specified was to verify proper operation. The description of the work performed on the MR stated that snubbers were needed on the gauges. There was no indication available that snubbers had been requested or that the initial problem was corrected.

Watts Bar

- A PM was being performed on a safety-related pump motor. The PM work instruction specified PMT to verify proper operation by ensuring that no leaks occurred and the oil level was maintained with the motor running. The PMT was not performed, and the PMT portion of the MR

was N/A'd. The hold order associated with the PM was released; the craft signed off the maintenance work as complete; and operations signed off all work/testing as complete.

Recommendation:

Strengthen adherence to the requirements stated on MRs and re-emphasize to supervisors the need to follow up on deviations or problems noted by the work crews. Strengthen the MR closeout process to ensure that appropriate follow-up action is, in fact, taken. Consider using the P&S staff or system engineers to review completed MRs and initiate follow-up to ensure satisfactory correction of the reported problems.

Finding H-4

At BFN and WBN, available manpower is sometimes not effectively utilized. Unnecessary personnel are often assigned to simple tasks, and subjourneymen are seldom permitted to perform work other than as a helper or laborer.

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On some occasions, planned contingency work was not available for crews that were unable to proceed with their normally planned work. Significant idle time resulted.

For some of the activities observed, 25 to 50 percent of the manpower assigned was not needed or utilized to perform the work. Interviews revealed it was general practice to use no less than two persons on any job, even for jobs that could clearly be done easily and safely by a single person.

Watts Bar

Two journeymen and one subjourneyman were assigned to disassemble a small valve. The two journeymen alternately worked on the valve while the subjourneyman only observed.

Two journeymen and one subjourneyman were assigned to replace three quarts of oil in a pump motor. Only one person at a time worked on the motor while the others handed tools, rags, or oil as needed.

Recommendation:

Maintain a backlog of planned jobs ready to work on short notice, and assign these to crews that complete work ahead of schedule or that are unable to proceed on scheduled tasks. Implement work assignment guidelines that will ensure adequate numbers of workers are assigned, considering the nature of the work and worker safety, but preclude assignment of excessive or unnecessary manpower.