



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

NOV 07 1990

MEMORANDUM FOR: Edward G. Greenman, Director  
Division of Reactor Projects, Region III

FROM: Jack W. Roe, Director  
Division of Licensee Performance  
and Quality Evaluation, NRR

SUBJECT: ASSESSMENT OF OVERTIME AT ZION NUCLEAR POWER STATION,  
UNITS 1 AND 2

Enclosed for your information and use is the NRR/DLPQ report assessing overtime worked by personnel at Zion Nuclear Power Station (Zion), Units 1 and 2. This assessment was undertaken in response to concerns for increased probability of personnel error resulting from cumulative fatigue effects. High amounts of overtime were previously noted by Region III inspectors and documented in a Diagnostic Evaluation Team (DET) report (August 1990). The concern for personnel errors resulting from cumulative fatigue effects was based upon both the high amounts of overtime and the unusual duration of the overtime schedules; personnel at Zion have been working on an outage schedule for most of the period from September 1989 to September 1990.

The specific objectives of the overtime assessment were (1) to review the amount of overtime worked by plant personnel with respect to the potential for personnel errors, and (2) to identify the factors contributing to the excessive amounts of overtime. The review was conducted onsite during the week of September 10 to 14, 1990, by two members of the Human Factors Assessment Branch (LHFB), NRR. These NRC staff members received support from a member of the resident inspection staff at Zion. Inspection activities focused on overtime worked during the period of September 1989 to September 1990 because of the extensive use of outage schedules.

The NRC team performed the following three-part examination of overtime in the operations, maintenance, health physics, and chemistry departments: (1) a significant number of the plant staff and management were interviewed. The interview focused on their experiences and observations concerning overtime, fatigue-related errors, and the reasons that personnel had worked excessive amounts of overtime; (2) documentation of the licensee's policies and practices concerning the control of overtime was reviewed; and (3) events and general operating experience at Zion during 1989 and 1990 were examined with respect to the overtime worked by the personnel involved in the event (i.e., the team identified events involving human performance and reviewed the schedules worked by the individuals involved in these events for the 28 days before the event).

The team examined 48 events and concluded that the data was not sufficient to determine if personnel errors occurred or increased in frequency because of the effects of cumulative fatigue. However, the team did confirm observations made by the regional staff and the DET that plant personnel had worked excessive amounts of overtime. Within the departments examined, individuals in the

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following positions worked the most overtime: nuclear station operators; equipment operators and attendants; auxiliary operators; and radiation protection technicians. In over 60 instances, individuals in the operations department worked more than 90 hours in a week, and regularly exceeded the working hour guidelines transmitted in Generic Letter 82-12, "Nuclear Power Plant Staff Working Hours," and contained in Zion's administrative procedures.

In addition, the team identified numerous deviations from Zion's administrative procedure for controlling working hours with respect to the approval, tracking, and reporting of overtime. These deviations may be violations of 10 CFR 26.20, which requires licensees to establish and implement policy and procedures that address, among other factors, fatigue, so that there is reasonable assurance that nuclear power plant personnel are not impaired in their ability to safely and competently perform their duties.

Research on extended working hours suggests that the performance of individuals working such hours can be expected to degrade. Because individuals in these positions routinely perform safety-related duties and may be required to respond to a plant emergency, the practice of allowing such excesses in overtime cannot be considered prudent with respect to protecting public health and safety. Fatigue can degrade an operator's ability to rapidly process the complex pattern of information that is presented in an offnormal plant condition. Consequently, the ability to respond in a timely fashion may be jeopardized and errors in responding are more likely to occur as a result of lapses in short-term memory.

The team identified the following root causes for the amount of overtime that had been worked:

- (1) Outage scheduling was unrealistic with respect to meeting the intent of the guidelines (i.e., to prevent situations where fatigue could reduce the ability of operating personnel to keep the reactor in a safe condition) transmitted in Generic Letter 82-12 and contained in Zion's administrative procedures for the control of overtime;
- (2) Positions were staffed at minimal levels because of inadequate forecasting and support of personnel needs; and
- (3) Collective bargaining agreements that:
  - (a) allowed individuals to volunteer for excessive amounts of overtime; and
  - (b) required the licensee to make overtime available to union members in excess of the overtime worked by contract personnel performing similar duties.

The team also identified the following factors that contributed to improper control of overtime: (1) inadequate work planning resulting in inefficient use of man-hours; and (2) insufficient ability to track overtime and identify deviations. The enclosure provides the detailed results of the staff's review.

NOV 07 1990

Edward G. Greenman

- 3 -

The licensee's management has verbally committed to strict compliance with Generic Letter 82-12 guidelines, as defined in Zion administrative procedure ZAP-09, and plans to increase resources and improve work planning to alleviate the need for excessive amounts of overtime. However, it should be noted that the team had a concern regarding the adequacy of the licensee's staffing plan with respect to meeting the objective of the guidelines transmitted in Generic Letter 82-12, which is to have operating personnel work a nominal 40-hour workweek when either unit is operating. Some members of management also stated that the practice of exceeding the NRC guidelines will be discontinued, regardless of plant conditions. The DLPQ staff supports continued close monitoring of overtime at Zion by the resident staff to ensure that the licensee fulfills its commitments.

We propose that the region monitor the licensee's progress in the following areas:

- (1) control of overtime in accordance with the NRC policy statement, specifically implementation of Zion administrative procedure ZAP-09;
- (2) improvements in work planning; and
- (3) increases in appropriate plant staff.

If you have any questions, please do not hesitate to contact me at FTS 92-1004, or Jared S. Wermiel, Chief, Human Factors Assessment Branch, at FTS 492-0160.

*JS*

Jack W. Roe, Director  
Division of Licensee Performance  
and Quality Evaluation, NRC

Enclosure: As stated  
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\*See previous concurrences

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## ENCLOSURE

### ASSESSMENT OF OVERTIME USE AT ZION NUCLEAR POWER STATION, UNITS 1 AND 2, FOR THE PERIOD JANUARY 1989 TO SEPTEMBER 1990

#### 1. BACKGROUND

In mid-1990, the Office for Analysis and Evaluation of Operational Data (AEOD) conducted a diagnostic evaluation of the Zion Nuclear Power Station, Units 1 and 2 (Zion). The report from this investigation (August 1990) stated that both licensed and non-licensed operators had worked "excessive" overtime. These findings confirmed prior observations made by the Zion resident inspection staff, who had been tracking the use of overtime at Zion since February 1990.

Because of the close succession of the Unit 1 and 2 refueling outages and a series of unplanned outages for equipment repair, personnel at Zion have been working on an outage schedule for most of the September 1989 to September 1990 time period. The high amount of overtime worked by individuals at Zion on a weekly basis, coupled with the extended nature of the Zion outage schedule, was identified as creating the potential for personnel errors due to cumulative fatigue effects. In response to these concerns, the staff conducted an assessment of overtime worked by personnel at Zion. In this assessment, the team (1) reviewed the amount of overtime worked by plant personnel with respect to the potential for increased frequency of personnel errors, and (2) identified the factors contributing to the excessive amounts of overtime.

#### 2. OVERVIEW OF ASSESSMENT ACTIVITIES

During the week of September 10 to 14, 1990, two NRR staff members, David R. Desaulniers and Isabel M. Herb, of the Human Factors Assessment Branch (LHFB) were assisted by Ann Marie Bongiovanni of the Zion resident inspection staff in conducting the onsite portion of the assessment of overtime. Inspection activities focused on overtime worked between January 1989 and September 1990. Because the licensee had frequently used outage schedules since September 1989, the team focused particularly on the last 12 months of this period. The team performed the following three primary activities to examine overtime use in the operations, maintenance (instrument, electrical, and mechanical), health physics, and chemistry departments:

- o A significant number of plant staff and management was interviewed. The interviews focused on their experiences and observations concerning overtime, fatigue-related errors, and the reasons that plant personnel had worked excessive amounts of overtime (see Appendix A for a complete list of persons interviewed);
- o Documentation of the licensee's policies and practices concerning the control of overtime was reviewed. These documents included: administrative procedures and union agreements, overtime records and tracking systems, and licensee self-assessments concerning work planning and overtime control (see Appendix B for a complete listing of documents reviewed); and

- o Events and general operating experience at Zion were examined with respect to the overtime worked by the personnel involved in the event. The team identified events involving human performance through a review of licensee event reports (LERS), the licensee's human performance evaluation system (HPES) reports, and personnel error evaluation program (PEEP) reports. The team reviewed the schedules worked by the individuals involved in these events for the 28 days before the event.

The results of the assessment are provided in the following sections:

### 3. ASSESSMENT OF ZION OVERTIME POLICY

The team reviewed the licensee's administrative procedures for controlling overtime and its agreement with the union for work scheduling. These documents were reviewed with respect to NRC "Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Plants" (NRC Policy) as transmitted in NRC Generic Letter No. 82-12, "Nuclear Power Plant Staff Working Hours." During 1989 and 1990, the licensee changed its administrative procedures for controlling overtime and temporarily revised its agreement with the union for work scheduling. The specific changes in Zion's overtime procedure are discussed herein highlighting the differences from the NRC Policy. The team's findings concerning the licensee's implementation of the procedures to control overtime are also presented.

#### 3.1 Zion Administrative Procedure - 0 "Conduct Of Operations"

Zion Administrative Procedure, "Conduct of Operations" (ZAP-0), was in effect during 1989 through April 26, 1990. This procedure is consistent with the NRC Policy with respect to the numerical limitations on working hours. However, the team noted that ZAP-0 was not consistent with the NRC Policy in that it did not include all positions held by individuals performing safety-related duties. Moreover, ZAP-0 was internally inconsistent and did not meet the intent of the NRC Policy. The procedure allowed personnel to exceed the guidelines to compensate for personnel shortages resulting from promotions, resignations, or extended illnesses, which conflicts with its stated objective "to maintain an adequate number of personnel. . . such that the use of overtime is not routinely required to compensate for inadequate staffing" (emphasis added).

#### 3.2 Agreement Between Management and the Union for the Unit 2 1990 Outage Scheduling

On March 12, 1990, the licensee issued "Outage Schedule of Unit 2 1990" (Attachment A). This agreement between the union and management (local agreement) established new guidelines for the scheduling and the assignment of overtime in the operations department, for the duration of the Unit 2 1990 outage.

Before the local agreement was implemented, the "Collective Bargaining Agreement between Commonwealth Edison Company and Local Unions" (1988-1991) resulted in some individuals rarely volunteering for overtime while others



worked overtime whenever it was available. If properly implemented, the local agreement should have reduced the individual excesses of overtime which resulted. However, Zion management did not fully enforce the maximum working hour limits available to them in the agreement to reduce individual overtime. For example, in the operations department, four instances were identified in which individuals exceeded 100 hours per week and 16 instances were identified in which individuals exceeded 90 hours per week during the time this agreement was in effect. In addition to exceeding the guidelines in the NRC Policy, the individuals in these instances exceeded the objectives stated in the agreement, "a maximum of 72 hours, with an anticipated absolute maximum of 84 hours per week."

### 3.3 Zion Administrative Procedure - 09 "Overtime Guidelines"

In an August 4, 1989 inspection report, the NRC staff expressed a concern that the Commonwealth Edison Company (CECO) did not appear to have sufficient measures in place to ensure that safety-related work was not being jeopardized by personnel working too many hours. In response to this concern, CECO issued Nuclear Operations Directive (NOD) QA.13 (December 31, 1989) which established guidelines for working overtime at the utility's nuclear stations. Accordingly, the licensee developed Zion Administrative Procedure (ZAP) - 09, "Overtime Guidelines."

#### 3.3.1 Implementation of ZAP-09

ZAP-09 expanded the scope of the overtime guidelines, as previously defined in ZAP-0, to include specific positions within the health physics, chemistry, and maintenance departments, contracted personnel performing safety-related work, and additional positions within the operations department (Appendix C provides a complete listing of positions to which the guidelines apply). To the extent that ZAP-09 has identified personnel performing safety-related duties, the scope of applicability of the procedure is consistent with the NRC Policy.

The team found the ZAP-09 limits on working hours were consistent with the NRC Policy guidelines. However, the licensee failed to control overtime to the limits stated in the procedure. Although ZAP-09 became effective on April 26, 1990, working hours were not maintained within ZAP-09 guidelines during the Unit 2 1990 outage (March 21 to August 30, 1990). Instead, the licensee continued to use the local union/management agreement, which permitted an absolute maximum of 84 hours per week, as the basis for work scheduling and the control of overtime.

During interviews with Zion management, the team discovered that the licensee had decided to adhere to the local agreement, as opposed to ZAP-09, partly because it believed that the local agreement provided an absolute maximum limit on overtime, which could be legally enforced in the context of labor law. In contrast, ZAP-09 was perceived as a guideline that was not legally defensible as a maximum limit on overtime. However, review of the overtime records showed that the licensee failed to use this "legal" agreement to maintain working hours below the 84-hour per week limit it established.

### 3.3.2 Approval of Deviations from ZAP-09

Section 2 of ZAP-09, "Approval of Guideline Deviations," is consistent with the NRC Policy with respect to approval of overtime. However, the licensee failed to fully implement the approval procedures. Furthermore, the licensee approved overtime despite written communication from the scheduler suggesting concern about decreasing personnel effectiveness as a result of the overtime requirements.

Review of overtime authorizations from April 29, 1990, to August 12, 1990, revealed that the licensee management did not normally complete the pre-authorization forms. This failure to obtain pre-authorization occurred during a period when deviations regularly occurred and, consequently, could have been anticipated. Furthermore, the licensee management did not complete post-authorization forms for overtime deviations for several dates and did not consistently complete these forms in a timely fashion.

The team identified a specific concern regarding three weeks of overtime that were pre-approved, despite the following statement shown on the pre-authorization form: "I can no longer (in good faith) state that personnel effectiveness or attitude will not be affected by overtime requirements." This statement was signed by the scheduler, the assistant superintendent of operations, and the production superintendent. Zion management, cognizant of the overtime authorizations, indicated that they had extended and modified the outage in response to these concerns. Nevertheless, the failure to adhere to the procedure and approve overtime, despite the scheduler's concern regarding personnel effectiveness, cannot be considered prudent with respect to ensuring public health and safety.

### 3.3.3 Tracking of Deviations

The tracking of deviations from ZAP-09 is not consistent across departments. For example, operations department deviations from ZAP-09 guidelines were compiled on a weekly basis. This system, however, did not use a seven-day rolling schedule. ZAP-09 states that individuals should not be permitted to work more than 16 hours in any 24-hour period, 24 hours in any 48-hour period, or 72 hours in any 7-day period. The practice of tracking deviations on a calendar week basis fails to identify instances in which the guidelines are exceeded when the 24-hour, 48-hour, or 7-day periods are divided across 2 calendar weeks.

The radiation protection and chemistry departments recently implemented a computer-based tracking system that included a rolling seven-day schedule for identifying deviations. Conversely, the maintenance departments had not yet instituted any formal tracking systems at the time of the inspection, although Zion's quality assurance department had noted in April and June 1990 that the maintenance departments were deficient in their ability to track overtime according to the ZAP-09 procedure.

### 3.3.4 Reporting of Deviations

ZAP-09 requires that a semiannual report be submitted to the Vice-President, Pressurized Water Reactor (PWR) Operations. The team examined an August 2,

1990, memorandum to the Vice President, PWR Operations, communicating deviations in the operations department during the period from January 1, 1990, to July 1, 1990. Although the memorandum referenced ZAP-09, the reporting requirements of ZAP-09 were not applied. The memorandum did not report deviations according to approval status (e.g., before the fact, after the fact, or not approved). ZAP-09 does not require a semi-annual report for radiation protection or chemistry technicians unless the duty technician positions exceeded the guidelines. This practice is a concern to the extent that management believes deviations have not occurred only because a report was not filed.

### 3.3.5 Potential Violation

The team believes that the numerous deviations from Zion administrative procedures with respect to approval, tracking and reporting of overtime as noted above, may constitute violations of 10 CFR 26.20 which requires the licensee to establish and implement policy and procedures that address, among other factors, fatigue, so that there is reasonable assurance that nuclear power plant personnel are not impaired in their ability to safely and competently perform their duties.

## 4. ANALYSIS OF ZION PERSONNEL OVERTIME

### 4.1 Description of Overtime by Department

The team examined the average number of hours worked per pay period for each position in the departments covered by ZAP-09. This review of overtime data revealed that several departments had exceeded the NRC Policy guidelines. The excessive overtime occurred primarily in the unit outages throughout the September 1989 to August 1990 time period. Consequently, the team examined levels of overtime according to plant conditions. Figures 1 through 7 provide the results of these analyses, as discussed in the following sections:

#### 4.1.1 Operations

Figures 1, 2, and 3 show the average hours worked per pay period (14 days) by various positions in the operations department. The graphs in these figures reveal that shift supervisors, nuclear station operators, equipment operators, and equipment attendants began working significantly more hours when the units were in outage. However, the shift control room engineers and the shift engineers maintained a nominal 40-hour workweek, regardless of plant conditions.

For the pay periods from March through June of 1990, nuclear station operators averaged over 125 hours worked every two weeks (Figure 2), and non-licensed operations personnel averaged at least 130 hours every two weeks (Figure 3). The continuous nature of these long workdays raises a concern that the risk of human error may have increased because of the cumulative effects of fatigue.

The peak averages for the bargaining unit employees were also of particular concern, because the averages were high enough to suggest that individuals approached or exceeded the guidelines of the NRC Policy. Further investigation revealed that several employees had exceeded the guideline of 72 hours worked

in a 7-day period. The team expressed concern about the following data for the period from September 1989 to August 1990: in 44 instances, personnel worked over 90 hours in one week, and in 17 additional instances, personnel worked 100 or more hours in one week. The team also identified 5 instances in which individuals worked 200 or more hours in two weeks, and 5 additional instances in which individuals worked between 284 hours and 297 hours in a 3-week period.

#### 4.1.2 Radiation Protection and Chemistry

Personnel in the radiation protection and chemistry technician positions experienced an increase in workload during the outage periods, but the overtime worked by radiation protection technicians was particularly high (Figure 4). During the 10th pay period of 1990, for example, 23 technicians worked an average of 150 hours in 14 days. With respect to the long term effects of continuous overtime, the radiation protection technicians continued to work excessive hours during both major outage periods. Individuals often worked 10 to 12 hours a day, 7 days a week for extended periods of time. From September through November of 1989, and from March through May of 1990, these technicians maintained work schedules of 130 or more hours worked every 2 weeks for 8 weeks and 12 weeks, respectively. However, not all personnel in these departments performed safety-related work. Following implementation of ZAP-09 on April 26, 1990, a "duty technician" was assigned to each shift to be responsible for safety-related duties. Each day, work schedules were reviewed to identify individuals that would qualify to work as the duty technician.

#### 4.1.3 Mechanical Maintenance

Mechanical maintenance supervisors, A-men, and B-men all increased their overtime hours during the outages (Figure 5). The plot for the senior mechanic represents one employee, and thus exhibits more extreme fluctuations. The two major peaks in Figure 5 show averages of 130 to 140 hours per pay period.

#### 4.1.4 Instrument Maintenance

Although overtime for personnel in instrument maintenance (Figure 6) increased significantly during the outages, the average number of hours, even during peak workload periods, remained at or less than 130 per pay period.

#### 4.1.5 Electrical Maintenance

Electrical maintenance personnel (Figure 7) experienced an increase in workload during outages. During the first major outage (September through December of 1989), electrical maintenance supervisors worked an average of 120 to 140 hours every two weeks, and these same employees worked an average of 120 to 130 hours every two weeks during most of the second major outage (February through August, 1990). Other electrical maintenance personnel also worked more overtime during these two time periods, although the difference was not as significant.

#### 4.1.6 Summary of Overtime by Department

The significant quantities of overtime worked by the personnel in these departments indicate that Zion may be particularly vulnerable to human

performance decrements. The team was particularly concerned about the unusually high amounts of overtime in the operations department. Information concerning individual excesses in overtime was not readily available from other departments. Consequently, the team did not evaluate the frequency of these occurrences.

Studies indicate that individuals who vary from a normal 8-hour workday/40-hour workweek suffer from degraded cognitive and motor skills (see "Applicable Research," Section 4.4). Personnel working excessive overtime may successfully perform routine tasks even when less alert, thus not revealing reduced abilities. However, such personnel may find that their ability to respond quickly to an emergency situation is significantly affected.

#### 4.2 Relationship between Personnel Errors and Overtime

The team reviewed work schedules of personnel involved in plant events to identify instances in which fatigue may have contributed to degraded performance. The team reviewed plant events involving human performance included in licensee event reports (LERs), human performance evaluation system (HPES) reports, and personnel error evaluation program (PEEP) reports and examined the applicable personnel overtime records.

##### 4.2.1 Findings

Thirty LERs, 12 HPES reports, and 6 PEEP reports were reviewed, but there was insufficient data to determine a direct link between hours worked and the errors made by the personnel involved.

#### 4.3 Conclusions Regarding Overtime Use and Personnel Errors

Individuals in the operations department frequently exceeded the working hour guidelines of the NRC Policy. According to the policy, personnel performing safety-related work should not work more than 72 hours in any 7-day period. Overtime data were not readily available for individuals from other departments to determine similar circumstances.

In general, the team found that there was insufficient data to determine if overtime practices at Zion resulted in safety-related errors at the plant. The data available did not support a sufficient analysis to determine causal relationships between work scheduling and human errors. Reporting procedures, particularly for LERs, are not sensitive to concerns of performance decrement due to fatigue. However, research on extended working hours (see Section 4.4) indicates that that amount of overtime worked by personnel at Zion is a concern because it may degrade their ability to perform routine safety-related duties. More importantly, fatigue may degrade an operator's ability to rapidly process the complex pattern of information that is presented in an offnormal plant condition. Consequently, the ability to respond in a timely fashion may be jeopardized, and errors in responding are more likely to occur as a result of lapses in short-term memory.

In the review of Zion's internal assessments, the team discovered inadequacies in the licensee's evaluation and reporting of these events with respect to the potential for fatigue to have been a contributing factor. HPES reports in

which the individuals involved had been working overtime did not reflect the work schedules. Several of the HPES reports involved personnel whose overtime in the days or weeks leading to the event had exceeded the guidelines of the NRC Policy. However, as a rule, the report either designated the work scheduling section "Not Applicable" or omitted the section entirely.

The staff's review also revealed weaknesses in the licensee's current capabilities to track overtime. The licensee had difficulty in providing cumulative summaries of overtime in departments other than operations. The unavailability of these records at the site indicates that management continues to lack the tools necessary to adequately control overtime.

#### 4.4 Applicable Research

The amount of overtime worked by personnel at Zion exceeds amounts at which research indicates human performance begins to degrade. Studies on the effects of overtime have found that human performance degrades as the number of hours worked in a day increases. Significant decrements in both cognitive and motor skills occur with a departure from the 8-hour workday/40-hour workweek. Alertness declines after increasing shift length by 50 percent. The ability to sustain one's attention declines with increasing fatigue, as does short-term memory. Performance on tasks which require sets of rules to be applied, such as diagnostic tasks, can be expected to degrade.

Because the majority of the research literature focuses on studying the effects of merely compressing the work schedule (i.e., working longer hours and having a shorter workweek), the results of these studies are a conservative estimate of the effects of the Zion work schedules on human performance. At Zion the workdays were frequently increased in length without the benefit of shortening the workweek.

An analysis of work schedules by seven experts in chronobiology, fatigue, and shift scheduling, indicated that schedules similar to those observed at Zion were "unsatisfactory" with respect to maintaining performance over a period of more than four weeks. Furthermore, the literature suggests that 20 hours of overtime every two weeks may actually double human error rates. Figures 1 through 7 reveal that Zion personnel frequently worked 20 to 50 hours of overtime in a two-week period.

In a study investigating Swedish nuclear power plant operators, it was found that many of those involved in an incident had worked a considerable amount of prior overtime. Studies have shown that fatigue due to long work hours or highly concentrated work results in less attention to certain types of signals: people develop their own subjective standards of what is important, and as they become more fatigued, they ignore more signals. Frequently, workers may not even be aware that their performance is impaired. In a study specific to the nuclear industry, control-room operator alertness was examined on an "alertness continuum", with one end representing focused wakefulness, and the other end representing the point of sleep onset. A well-rested individual can usually move rapidly (within seconds) to more alert and vigilant stages from lower stages. In contrast, a tired (sleep-deprived) individual would have the tendency to drift back to the lower end of the continuum in a few minutes. According to expert opinion, the transition to full alertness and peak ability

to cognitively process information, such as the determination of the precise meaning of an alarm signal and necessary corrective actions, may require minutes rather than seconds.

Although the team did not identify specific events at Zion that clearly resulted from personnel fatigue, numerous studies have indicated that the types of tasks performed at nuclear power plants are susceptible to fatigue-related degradation. Not realizing that their own performance has been degraded, fatigued workers may become less effective in their tasks. The evidence found in the literature suggests that, at the very least, the potential for human error at Zion has increased with the increase in the overtime worked by the individuals.

## 5. PERSONNEL PERCEPTIONS OF OVERTIME AND PERFORMANCE

The team interviewed several individuals from each department in which overtime was being assessed. The team selected individuals representing a range of responsibilities and positions (e.g., technicians, operators, supervisors, and schedulers) within each department. In the interviews, the team collected the experiences and observations of Zion personnel concerning the effect of outage work schedules on personnel performance.

### 5.1 Zion Staff's Perceptions Regarding Fatigue and Errors

None of the individuals interviewed indicated that they knew of an error that was directly attributable to fatigue. Members of Zion's quality control and quality assurance departments indicated that they had not observed errors that appeared to be fatigue-related. There were only a few cases reported of difficulty staying awake on the job or when driving home.

The majority of those interviewed did not believe that fatigue has had a significant effect on performance. However, many of the staff indicated that while the schedules had resulted in fatigued workers, the workers "do not allow" fatigue to affect their performance, or "the procedures and verifications do not allow us to make a mistake." In contrast, several individuals expressed concern about the amount of overtime that was being worked in the operations department and indicated that "some people do not know their own limits."

### 5.2 Zion Staff's Observations Regarding Overtime and Fatigue

Plant personnel observed that fatigue had affected personalities or attitudes rather than performance. The interviewees believed that the overtime had strained interactions between the operations and instrument maintenance departments. Workers were described as becoming more irritable, and instances of strained relationships at home were reported. Several interviewees noted a decline in worker morale as the outage progressed.

In general, there was a consensus that "forced" overtime was the most difficult to work, particularly when the overtime was required on the 11 pm to 7 am shift. This view was consistent with the opinion that people coped with the long working hours by preparing themselves (e.g., resting) for it. When "forced" to work overtime without much advance notice, individuals did not have time to prepare.

The desire to work overtime varied considerably between individuals. One individual indicated that working over 100 hours in a week was "no problem" and wished for more available overtime hours. However, the majority of the people interviewed expressed that they were tired of working the overtime. This disparity in the workers' attitudes toward working overtime enabled individuals to accumulate excessive overtime as a result of consistently volunteering to work hours that others had refused.

## 6. ASSESSMENT OF FACTORS CONTRIBUTING TO EXCESSIVE OVERTIME

In addition to expressing the concerns presented in Section 3.3.4 pertaining to the inadequacies in the overtime tracking capabilities at Zion, the team made the following observations and conclusions regarding the factors contributing to the excessive use of overtime. These findings are based upon interviews with members of Zion's management and staff, and reviews of the licensee's procedures, practices, and self assessments concerning work scheduling.

### 6.1 Staffing

The team and members of Zion management identified a lack of adequate staffing as one of the primary contributors to the use of overtime. Members of the chemistry and radiation protection departments indicated that they were understaffed, but the lack of qualified personnel was most evident in the operations department. Recent shortages in licensed positions were in part attributed to cancellation of a license class several years ago and the subsequent postponement of a class in progress, which resulted in high attrition in the class.

Many of the individuals interviewed, including members of Zion's management, perceived that the minimal staffing levels in first line management positions had resulted from failure of the corporate management to approve requested increases in staffing. Interviewees believed the corporate management had "set" staffing levels according to a corporate assessment of staffing needs. Some interviewees believed that the corporate assessment had relied too heavily on historical data and had underestimated inadequate future workloads and staffing needs. Other interviewees stated that low staffing levels resulted from austerity measures imposed by the corporate management.

Interviewees were also critical of hiring and training practices, indicating that there was a failure to adequately consider attrition in classes and reductions in department staffs because of reassignments, promotions, and resignations. The team has similar concerns for the licensee's current plans to address personnel shortages in the operations department and meet the intent of the NRC Policy which is to have operating personnel work a 40-hour workweek when either unit is operating. The licensee has based staffing projections for January 1992 on a plan that does not adequately address attrition in training programs and the loss of personnel to other departments. Interviewees stated that Zion management wants to encourage nuclear station operators (NSOs) to enter supervisory positions. However, the staffing plan does not address this source of attrition in the NSO position.



## 6.2 Plant Availability Goals

Several interviewees stated that Zion has a goal of limiting each scheduled outage to a period of 70 days. The NRC Policy recognizes that outages result in an increased need for overtime. However, the overtime worked during the refueling outages for Unit 1 in 1989 and Unit 2 in 1990 is indicative that the schedules were unrealistic with respect to meeting the intent of the NRC Policy and Zion administrative procedures. The licensee has allowed numerous deviations from its procedures for overtime control.

## 6.3 Collective Bargaining Agreement

The staff reviewed the collective bargaining agreement (1988-1991) between CECO and local unions of the International Brotherhood of Electrical Workers and conducted interviews with plant staff. As a result, the staff concluded that Zion's adherence to the union agreement resulted in some of the observed excesses in overtime.

The agreement to make overtime available on the basis of the cumulative overtime list enabled individuals to work excessive amounts of overtime. Interviewees also stated that the union agreement required the licensee to make overtime available to union members in excess of the overtime worked by contract personnel performing similar duties. Finally, some of the overtime worked by radiation protection personnel resulted from a union agreement requiring that only union technicians act as timekeepers for union employees. This requirement eliminated the possibility of reducing the overtime burden by distributing some of the workload among non-union contract personnel.

## 6.4 Work Planning

Many interviewees made complaints concerning work planning. There was a consensus among the employees interviewed that much of the overtime was unnecessary or unproductive because of inadequate work planning. Interviewees commonly cited a lack of coordination among work groups which resulted in individuals waiting for parts, equipment, or personnel support. Interviewees reported that operations personnel commonly worked overtime to support tests that were delayed excessively or not performed. Some individuals indicated that scheduling was not receiving adequate support (e.g., personnel did not receive advance notice of jobs to be scheduled and work groups did not commit to meet scheduled objectives).

The licensee has identified the need to improve daily work planning and has instituted programs to address this issue. In addition, members of the licensee management stated that they are attempting to improve outage scheduling. The licensee expanded the department responsible for outage planning from 1 to over 12 individuals in the past 2 years. The team did not attempt to assess the adequacy of the licensee's efforts to enhance its work planning activities.

## 7. CONCLUSIONS

The event and overtime information reviewed did not provide sufficient data to determine if personnel errors occurred or increased in frequency because of

the effects of cumulative fatigue. However, the team did confirm observations by the regional staff and the DET that plant personnel had worked excessive overtime. Within the departments examined, individuals in the following positions worked the most overtime: nuclear station operators; equipment operators and attendants; and radiation protection technicians.

In over 60 instances, individuals in the operations department worked more than 90 hours in a week and regularly exceeded the working hour guidelines transmitted in the NRC Policy and contained in Zion's administrative procedures. Studies of extended working hours indicate that the performance of individuals working such hours can be expected to degrade. Because individuals in these positions perform safety-related duties, and may be required to respond to a plant emergency, the practice of allowing excess overtime cannot be considered prudent with respect to protecting public health and safety. Excessive working hours result in operator fatigue and consequently, the ability to respond appropriately and in a timely fashion is likely to be degraded.

The team identified the following underlying causes for the excesses of overtime:

- (1) Outage scheduling was unrealistic with respect to maintaining reasonable compliance with the NRC Policy and administrative procedures for the control of overtime;
- (2) Staffing at minimum levels resulted from inadequate forecasting and support of personnel needs; and
- (3) Collective bargaining agreements that:
  - (a) allow individuals to volunteer for excessive amounts of overtime; and
  - (b) require the licensee to make overtime available to union members in excess of the overtime worked by contract personnel performing similar duties.

In addition, the team identified the following factors that contribute to the inadequate control of overtime: (1) inadequate work planning resulting in inefficient use of man-hours, and (2) inadequate ability to track overtime and identify deviations.

The licensee management has verbally committed to strict enforcement of the NRC Policy in the future and plans to increase staff resources and improve work planning to alleviate the need for excessive amounts of overtime. Some members of plant management also stated that they intend to maintain levels of overtime below those stated in the guidelines, regardless of plant conditions. It is recommended that the resident staff continue to monitor the extent to which the licensee management's commitments are met, specifically, (1) the control and tracking of overtime in accordance with the NRC Policy and ZAP-09, (2) efforts to improve work and outage planning, and (3) progress in attaining adequate staffing levels in the operations department.

## APPENDIX A

### Management:

Thomas Joyce	Plant Manager
William Kurth	Production Superintendent
Peter LeBlond	Assistant Superintendent, Operations
Robert Johnson	Assistant Superintendent, Maintenance
James LaFontaine	Assistant Superintendent, Work Planning
Thomas Flowers	Unit Outage Planner
Eugene Broccolo	Performance Improvement Director

### Operations:

Ralph Dietz	Operating Scheduler
Dan Giernoth	Unit Supervisor
Jerry Marsh	Shift Foreman
John McSorley	Nuclear Station Operator
Fred Cook	Nuclear Station Operator
Patrick Comerford	Equipment Operator
Lee Danson	Equipment Operator
Wayne Gerdes	Equipment Attendant

### Chemistry:

Brent Schramer	Chemistry Supervisor
Rich Winiarski	Chemistry Technician A
James Cope	Chemistry Technician B

### Radiation Protection:

Randall Mika	HP Services Supervisor
Michael Finney	Rad-Chem Scheduler (previously)
Robert Pratt	Radiation Protection Scheduler
Kevin McEvoy	Contamination Control Coordinator
Craig Wepprecht	Health Physicist
Oscar Fick	Radiation Protection Technician
Robert Lindquist	Radiation Protection Technician

### Maintenance, Electrical:

Ben Higginbottom	Electrical Maintenance Supervisor
John Parker	Electrical Maintenance Supervisor
Mark Rottman	Electrical Maintenance A-Man

Maintenance, Instrument:

David Stachon	Instrument Maintenance Supervisor
Steven Zander	Instrument Maintenance Supervisor
Michael Braim	Instrument Maintenance A-Man
Robert Cole	Instrument Maintenance A-Man

Maintenance, Mechanical:

Bernard Radman	Mechanical Maintenance Supervisor
Charles Nelson	Mechanical Maintenance A-Man

Human Performance Evaluation System:

Richard Flessner	Corporate HPES Coordinator
Dennis Sheehan	HPES Coordinator

Quality Programs:

Carl Schultz	Quality Control Supervisor
Thomas Van De Voort	Quality Programs Superintendent
Annette Dennenberg	Quality Programs Operations Group Leader
Donald Felz	Quality Programs Maintenance Group Leader

APPENDIX B

- A. Zion Administrative Procedure - 0 "Conduct of Operations"
- B. Zion Administrative Procedure - 09 "Overtime Guidelines"
- C. Zion Licensee Event Reports
- D. Zion Deviation Reports
- E. Human Performance Evaluation System Reports
- F. Personnel Error Evaluation Program Reports
- G. Quality Programs Monthly Reports
- H. Quality Assurance Surveillance Reports
- I. Outage Schedule of Unit 2 1990
- J. Projected Staffing Levels
- K. Collective Bargaining Agreement between Commonwealth Edison Company and Local Unions of the International Brotherhood of Electrical Workers (1988-1991)
- L. Diagnostic Evaluation Report for the Zion Nuclear Power Station, Units 1 and 2 (NRC/AEOD) August, 1990
- M. NRC Resident Staff Inspection Reports

APPENDIX C

(Applicability of ZAP-09)

Within the Operating Department:

- Shift Engineer (SRO)
- Shift Supervisor (SRO)
- Station Control Room Engineer (SRO)
- Nuclear Station Operator (RO)
- Equipment Operator A
- Equipment Attendant (only when performing safety-related work or scheduled as part of the plant's safety shutdown response team)
- Auxiliary Operator (only when performing safety-related work or scheduled as part of the plant's safety shutdown response team)

When moving fuel or performing core operations:

- Fuel Handling Supervisor (SROL)
- Shift Supervisor (SROL)
- Nuclear Fuel Handler A
- Nuclear Fuel Handler B

Within the Health Physics Services Department (on each shift):

- Duty Radiation Protection Technician

Within the Chemistry Department (on each shift):

- Duty Chemistry Technician

Within the Maintenance Department, when performing safety-related work:

- Maintenance Supervisor (EM, IM, MM)
- Control System Technician (IM)
- Senior Mechanic (EM, MM)
- A Mechanic (EM, IM, MM)
- B Mechanic (EM, IM, MM)

Any contracted personnel performing safety-related work

## OUTAGE SCHEDULE OF UNIT 2 1990

A Union/Management agreement has been reached regarding scheduling for the Unit 2 outage. Key elements of this agreement include:

- Mandatory 12 hour shifts (Optional 4 hrs early or 4 hrs over)
- Possible force to a maximum of 12 hours on first RDO with 48 hours notice
- RDOs will have first choice of O.T. to a MAX of 12 hours per calendar day and chosen to cover MINIMUM SHIFT COVERAGE according to O.T. list.

Managements desire is to eliminate, if possible, 16 hour shifts and approach compliance with NRC guidelines. Towards this end, we have established a target maximum of 72 hours, with an anticipated absolute maximum of 84 hours per week.

There will be three shifts per day:

- 1) Night Shift (1st) hours will be 7 pm to 7 am.  
2 NSOs, 1 A man, and 2 B men will be allowed 11 pm to 11 am.
- 2) Day Shift (2nd) hours will be 7 am to 7 pm.  
2 NSOs, 1 A man, and 2 B men will be allowed 3 am to 3 pm.
- 3) Middle Shift (3rd) will be 3 pm to 3 am.  
2 NSOs, 1 A man, and 2 B men will be allowed 11 am to 11 pm.
- 4) Hours for personnel during their training week (i.e., not mandatory 12s) will be 7 am to 3 pm. 3 am to 3 pm optional to meet MAXIMUM SHIFT COVERAGE.

There will be 48 hours notice of forcing of the first RDO, following the Thursday deadline described below.

If forced for 16 hours, there will be an 11 hour off period until next scheduled start time, providing it does not result in another force.

RDOs will be requested by Thursday, of the week before schedule's start.

Request for O.T. starting time change will be for the entire week, i.e., early or over, as per the shift rules, described above.

Only Shift Supervisors may release employees from O.T. hours once the schedule has been posted.

MINIMUM/MAXIMUM Shift Coverage for terms of the agreement as a follows:

<u>NSO</u>	<u>A Men</u>	<u>B Men</u>
5/8	3/5	8/11

In the event maximum coverage would be exceeded the highest person on early or over O.T., according to the O.T. list, would be refused the opportunity to work.

TED HOLDEN  
Chief Steward

*Ted Holden*  
3-12-90

22370

RALPH DIETZ  
Scheduler

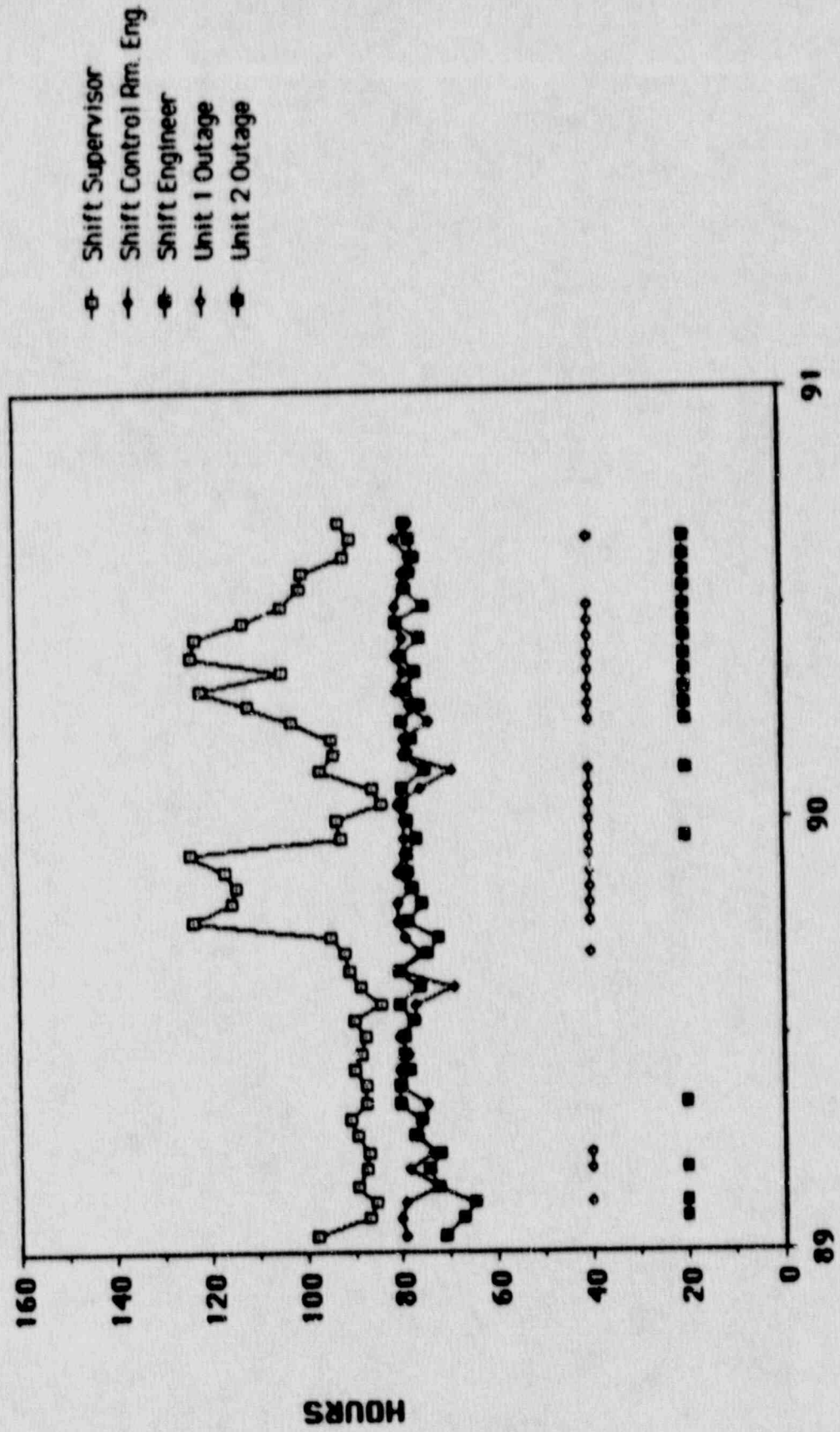
*Ralph Dietz*  
3/12/90

PETE LEBLOND  
Asst. Supt. Operating

*Peter LeBlond*  
3/12/90

**FIGURE 1. OPERATIONS**

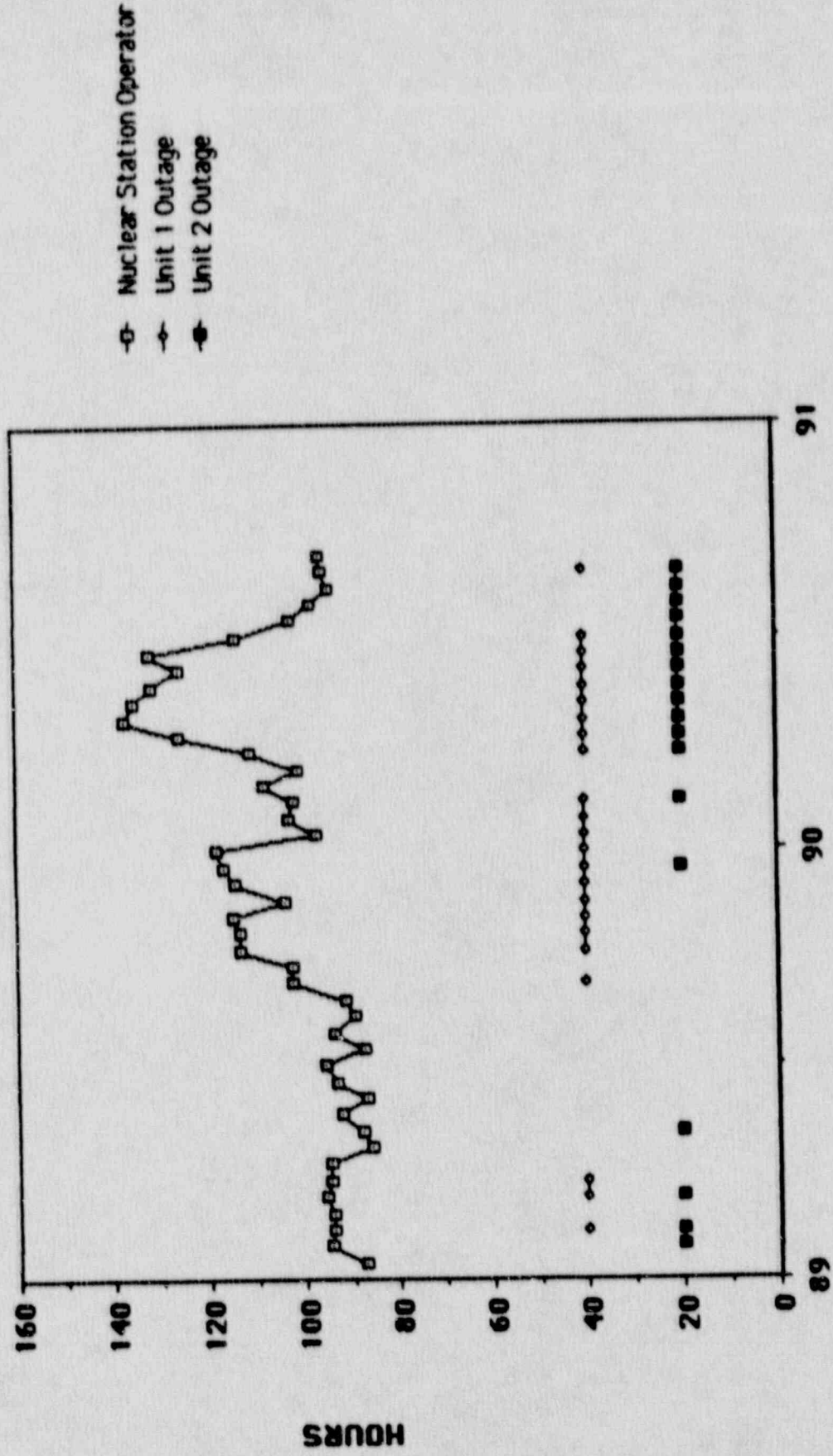
(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)





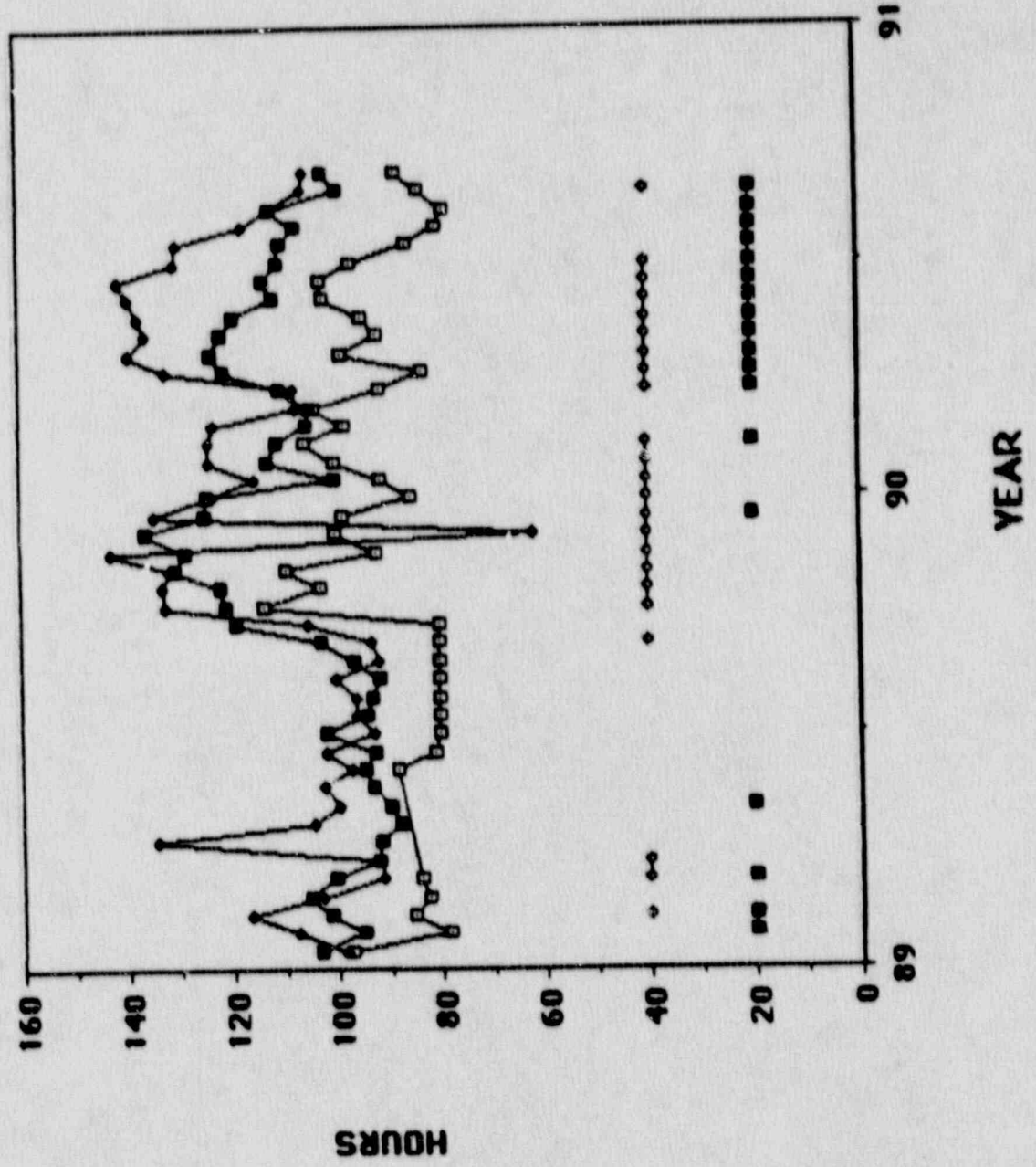
**FIGURE 2. OPERATIONS**

(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)

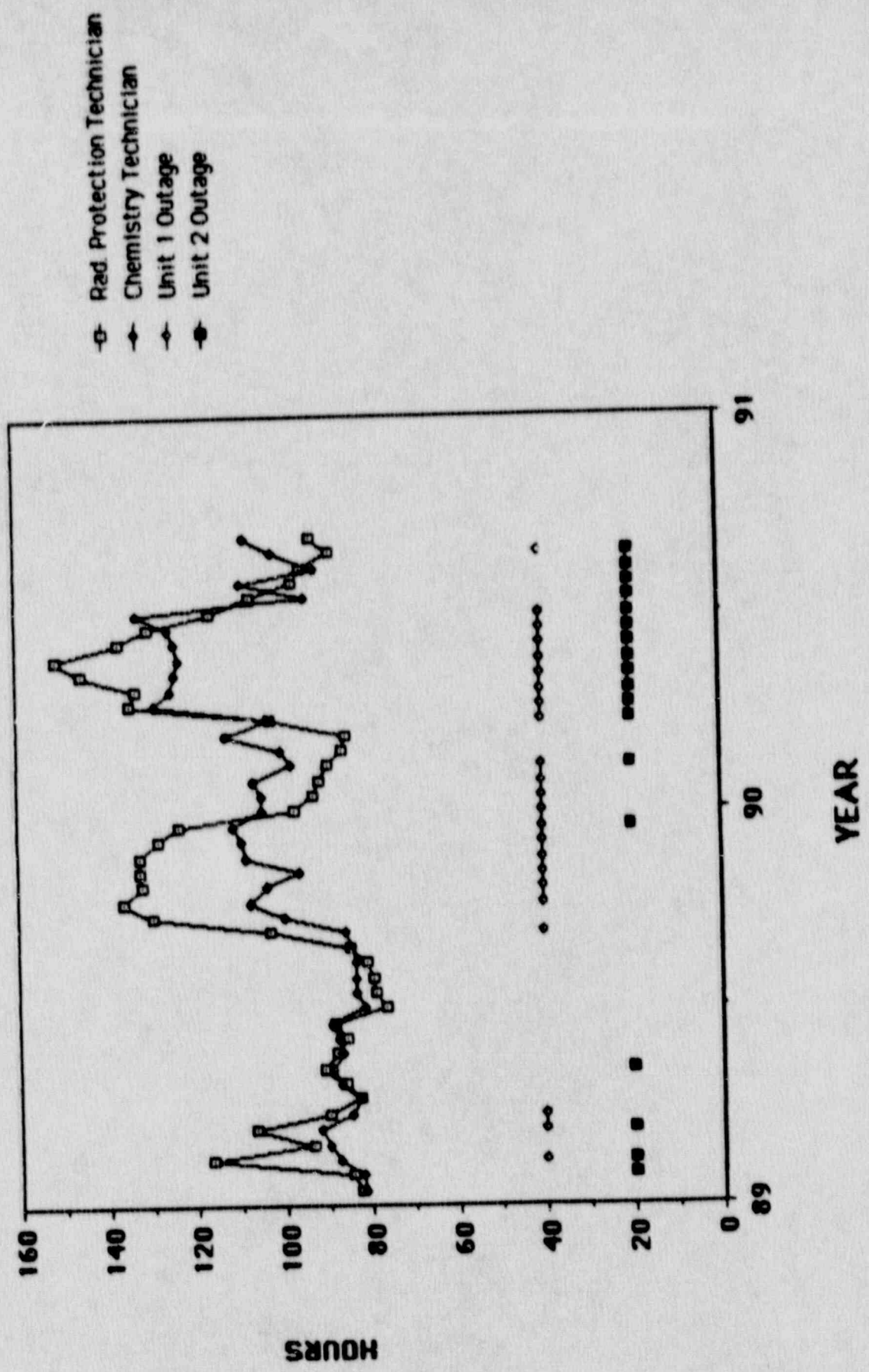


**FIGURE 3. OPERATIONS**

(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)

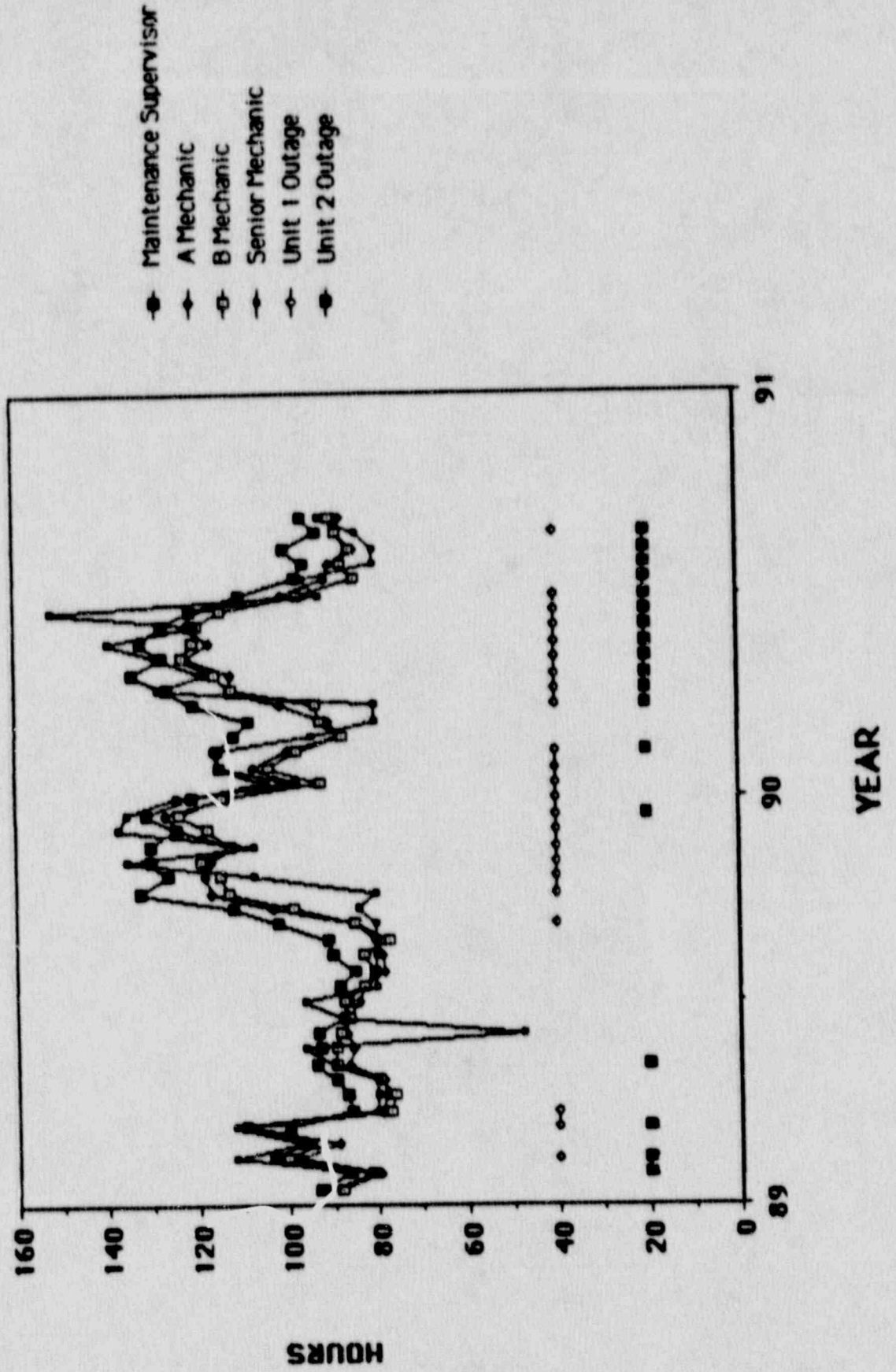


**FIGURE 4. RADIATION PROTECTION AND CHEMISTRY**  
 (AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)



**FIGURE 5. MECHANICAL MAINTENANCE**

(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)



**FIGURE 6. INSTRUMENT MAINTENANCE**

(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)

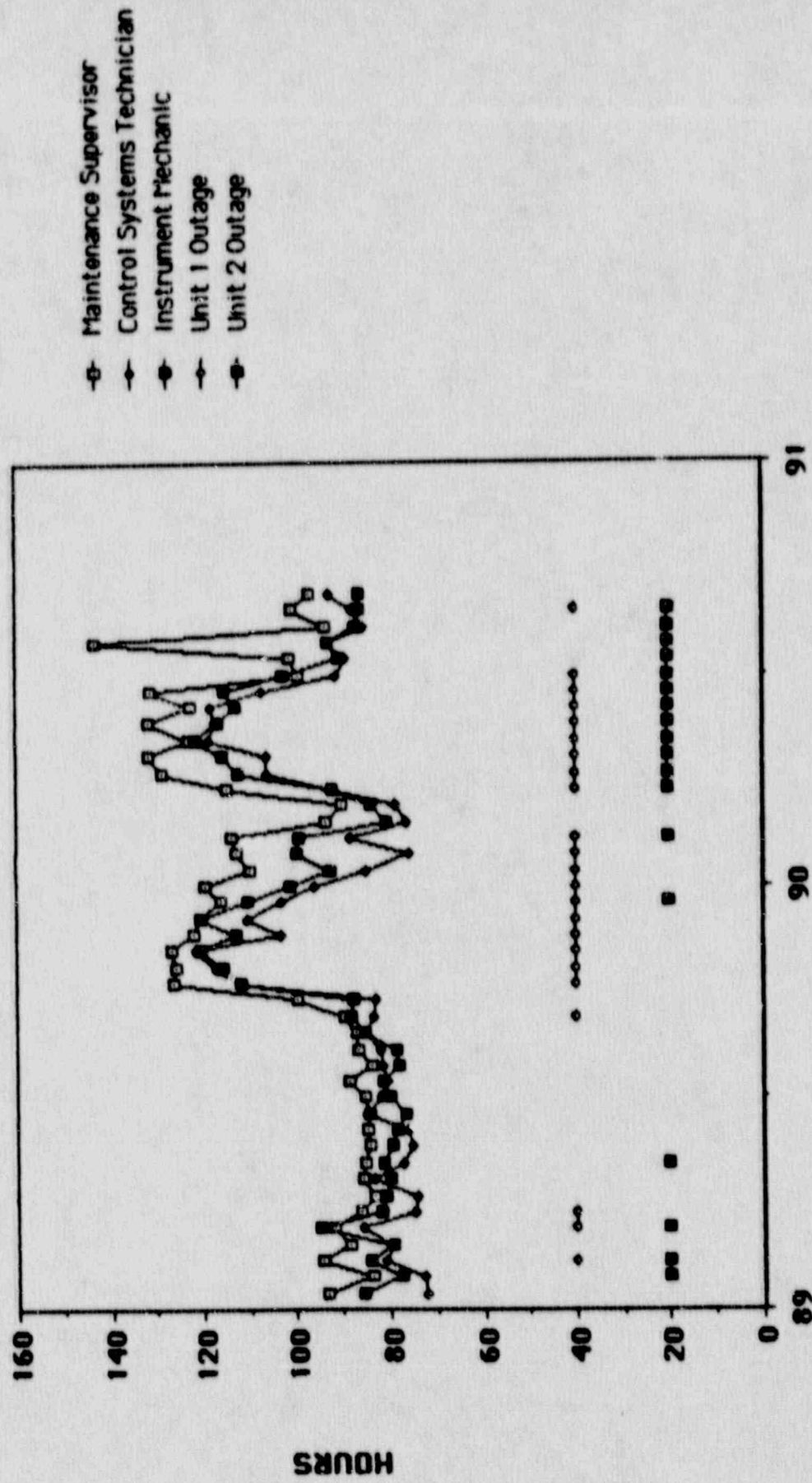


FIGURE 7. ELECTRICAL MAINTENANCE

(AVERAGE HOURS WORKED PER TWO WEEK PAY PERIOD)

