Locomotive Engineer's Activity Diary

U.S. Department
of Transportation
Federal Railroad
Administration

Office of Policy and
Program Development
and
Office of Research
and Development
Washington, DC 20590

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DOT/FRA/RRP-96/02
DOT-VNTSC-FRA-96-12

Final Report
September 1996

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
September 1996

3. REPORT TYPE AND DATES COVERED
Final Report
June 1992 - August 1996

4. TITLE AND SUBTITLE
Locomotive Engineer's Activity Diary

5. FUNDING NUMBERS
R6201/RR628

6. AUTHOR(S)
John K. Pollard

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Research and Special Programs Administration
Volpe National Transportation Systems Center
Cambridge, MA 02142

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-FRA-96-12

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Railroad Administration
Office of Policy and Program Development
Washington, DC 20590

U.S. Department of Transportation
Federal Railroad Administration
Office of Research and Development
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOT/FRA/RRP-96/02

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

This document is available to the public through the National Technical Information Service, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

About 200 freight engineers working on several major railroads completed a 14-day diary recording such data as: the demographic characteristics of the participants; how much time they spent working, sleeping at home, sleeping away from home, commuting; and how much time they spent on all other purposes. Data were also gathered regarding the quality of rest, how alert they felt on the job, and how well they could predict the time of the next job start. Their comments were solicited about the factors responsible for fatigue and job-induced stress, and what countermeasures they would prefer.

Analyses of these data are presented showing how hours of sleep and alertness on the job are affected by: job category, age, average daily hours worked, job-start time, and job-end time. Self-rated alertness estimates by time-of-day are given for each railroad along with graphs showing how average alertness varies with hours worked and the effect of having an assistant. There are tables of ratings on ease of falling asleep, ease of staying asleep, and quality of rest for at-home and away-from-home rest. Also included are poll results for some 50 suggested countermeasures and scatter plots of errors in estimates of job-start times.

14. SUBJECT TERMS

Railroad; Engineers; Fatigue; Alertness;
Hours of work; Hours of service

15. NUMBER OF PAGES
68

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT
Unlimited

PREFACE

This study was conducted for the Office of Policy and the Office of Research and Development of the Federal Railroad Administration (FRA) by the Operator Performance and Safety Analysis Division of the Volpe National Transportation Systems Center. It is intended to provide to the FRA and the industry some quantitative measures of various aspects and impacts of crew scheduling as it is currently practiced on a representative sample of major railroads in the United States.

The author is especially grateful to the more than 200 engineers who took the time to complete diaries. Many of them also discussed their insights and recommendations for improvements, both in conversation with the author and in written commentaries included with their diaries. The efforts of numerous officials of the Brotherhood of Locomotive Engineers (BLE) and officials of the various participating railroads in arranging for the site visits are also noted with thanks.

This project was monitored by John Murphy and Gail Payne of the Office of Policy and Garold Thomas and Thomas Raslear of the Office of Research and Development. Their comments and criticisms were much appreciated and essential to the completion of this project.

The data collection forms used were designed by Greg Camus of UNISYS Corp. John Bonin, Frank Shugru, and Ali Sarmiento of W. T. Chen, Inc., developed the data analysis software.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE)	**LENGTH** (APPROXIMATE)
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA** (APPROXIMATE)
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (ha) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT** (APPROXIMATE)
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = .45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)	**VOLUME** (APPROXIMATE)
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 quart (qt) = 0.96 liter (l)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	
TEMPERATURE (EXACT)	**TEMPERATURE** (EXACT)
°C=5/9(°F - 32)	°F=9/5(°C) + 32

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES	0	1	2	3	4	5

CENTIMETERS	0	1	2	3	4	5	6	7	8	9	10	11	12	13

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

Updated 8/1/96

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EXECUTIVE SUMMARY

The goal of this project is to understand both quantitatively and qualitatively how the work scheduling practices of the freight railroads affect the alertness and fitness for duty of train crews. Data were gathered from diaries kept by about 200 engineers employed by six major railroads. These diaries recorded such items as: the quantity and quality of their sleep, estimates of their alertness levels at various times while on duty, time on duty, commuting time, and the accuracy of information provided to crews about job-start times. Survey participants were also asked to describe in their own words what they see as the major contributors to fatigue and what they would like to see done about the problems.

There are several applications for the diary data including: (1) quantitative comparisons of amounts of sleep, accuracy of calling information, etc., among various groups of engineers and against other types of workers; (2) guidance to the FRA in its consideration of alternatives to the current Hours of Service Law and accompanying regulations; and (3) development of improved crew-calling software.

Among the principal findings from this survey are the following:

1. Overall, the surveyed engineers average about seven hours and eight minutes of total sleep per day (about 20 minutes less than the general population, which averages about 7.5 hours). For jobs that start between 2200 and 0400 hours, or end between 0200 and 1100 hours, sleep averages less than six hours. To redress this shortfall, some engineers (10 to 15% of the respondents) suggest longer minimum rest periods (10 or 12 hours), limiting time on duty to 10 hours, and napping in sidings when it is safe to do so.

2. Aside from job-start and job-end times, the other variables reported in the diaries did not have large effects on amount of sleep. The variation among railroads was small, except for one road where the average amount of sleep was about 40 minutes below the industry norm. Among job categories, yard and local engineers got the least sleep, but they fell only about 20 minutes below the average for all types of engineers. Average sleep increased slightly with age, presumably because older engineers enjoyed better jobs as a result of the seniority system.

3. For the most part, engineers reported that the quality of rest at away-from-home facilities was as good as that at home. The major exception to this statement occurred at one terminal where rest was provided at a facility at the edge of the yard, as opposed to a commercial motel located some distance from the yard.

4. Self-rated alertness was influenced by the circadian rhythms of the respondents far more strongly than any other variable. Engineers' circadian rhythms are not very different from those of other workers, because engineers sleep at night whenever they can. They do not adapt even to the extent that workers on permanent night shifts do. Their self-rated, alertness-on-duty curves are roughly similar to the circadian-rhythm curves of the general public, the principal exception being that their periods of lowest alertness frequently extend until 0700 or 0800 hours, whereas most people experience increasing alertness earlier in the

day. This delay in the onset of rising alertness is no doubt attributable to the fact that the respondents were up most of the night.

5. On most railroads, over-the-road engineers average slightly less than 40 hours of on-duty time per week. There was considerable variation among railroads, ranging from less than 35 hours per week to more than 50. Average miles per week varied even more, from a low of about 600 to a high of more than 1300.

6. Average commuting time was less than 30 minutes, one way. Only about 8% of the sample had one-way times exceeding one hour.

7. When questioned about what changes were needed most to reduce stress and improve alertness, engineers responded that more accurate information about the time of the next job start was by far the most important goal. Its achievement requires more precise train line-ups; immediate availability to train crew members of data regarding dead-heads, mark-offs, and other factors that affect their positions in the pool rotations; and elimination of human errors, omissions, and delays in dispatching and crew-calling.

At the time of this survey (1992-94), the average error in an engineer's estimate of the time his next job would start was about 15 minutes for each hour in advance of the actual job-start time. For example, if an engineer made an estimate of the start time for a job that turned out to begin 24 hours later, the average error was about +/- six hours. It is impossible to plan for optimal sleep in the face of this much uncertainty.

1. INTRODUCTION

This study grew out of previous work conducted for the Federal Railroad Administration's Office of Policy. In 1990, the author interviewed officials of seven major railroads and conducted focus-group sessions with three groups of engineers. These discussions were aimed at gaining an understanding of how the crew-calling systems at various railroads work and what problems contribute to fatigue and loss of alertness. This work was published as *Issues in Locomotive Crew Management and Scheduling* (DOT/FRA/RRP-91-01) in February 1991. In the course of that study it became apparent that while the sources of fatigue and stress in the lives of railroad operating personnel were generally known, there were no quantitative descriptors available for most of them.

Planning for this project began with discussions with many of the same officials of various railroads and the Brotherhood of Locomotive Engineers (BLE) who had participated in the previous study. Their ideas were sought as to what specific data should be gathered and by what means. Exact wordings of questions were discussed. Sources of bias and means of avoiding them were considered. Alternative methods of collecting and cross-referencing data were investigated.

A pilot test with the preliminary survey form was conducted using several engineers employed by the Montana Rail Link (MRL) in 1991. This test demonstrated that there was strong interest on the part of engineers in participating in such a survey and also revealed several sources of confusion in the pilot-test form. It also helped to establish what questions could be answered.

2. APPROACH

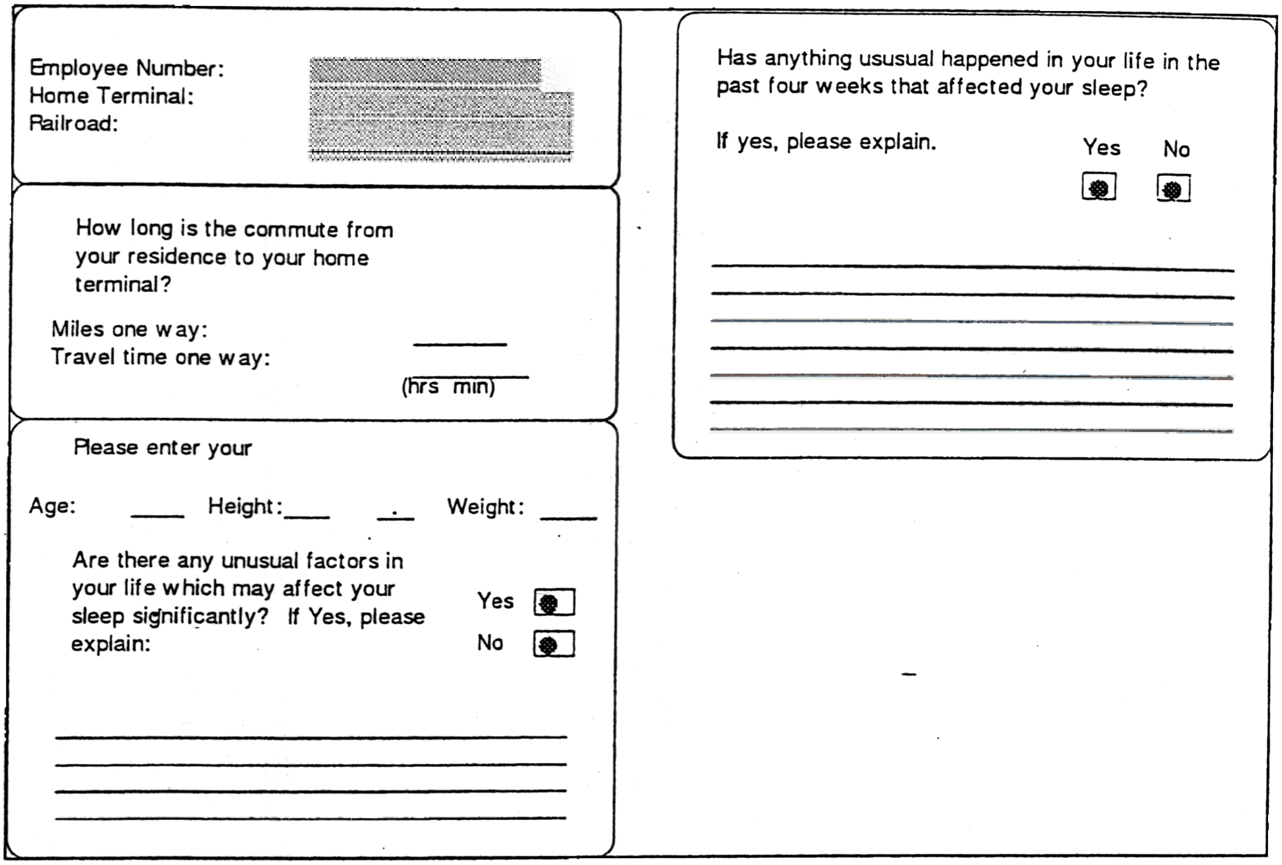
The principal questions this survey is intended to illuminate are:

- How do engineers divide their time among such activities as:
    - working
    - sleeping
    - commuting
    - all other personal time?
- How alert do they feel on the job?
- What is the quality of their sleep:
    - at home
    - away from home?
- How well can they predict when their next jobs will start?
- How do job-start and job-end times affect sleep?
- How many miles do they travel?
- How does having an assistant engineer affect self-rated alertness?

Additional personal data were gathered from each survey participant so that the above-mentioned questions could be related to subject age, job classification, employer, etc. With these data in hand it then became possible to examine interactions, such as:

- How does alertness vary with:
    - time of day
    - employer
    - workload?
- How does average sleep vary with:
    - age
    - place of rest
    - employer
    - workload?

To answer these questions, a diary-type survey was developed as illustrated in Figures 2-1 and 2-2. It received approval by the Office of Management and Budget in June 1992.



Employee Number:
Home Terminal:
Railroad:

How long is the commute from your residence to your home terminal?

Miles one way: ______
Travel time one way: ______ (hrs min)

Please enter your

Age: ____ Height: ____ _._ Weight: ____

Are there any unusual factors in your life which may affect your sleep significantly? If Yes, please explain:

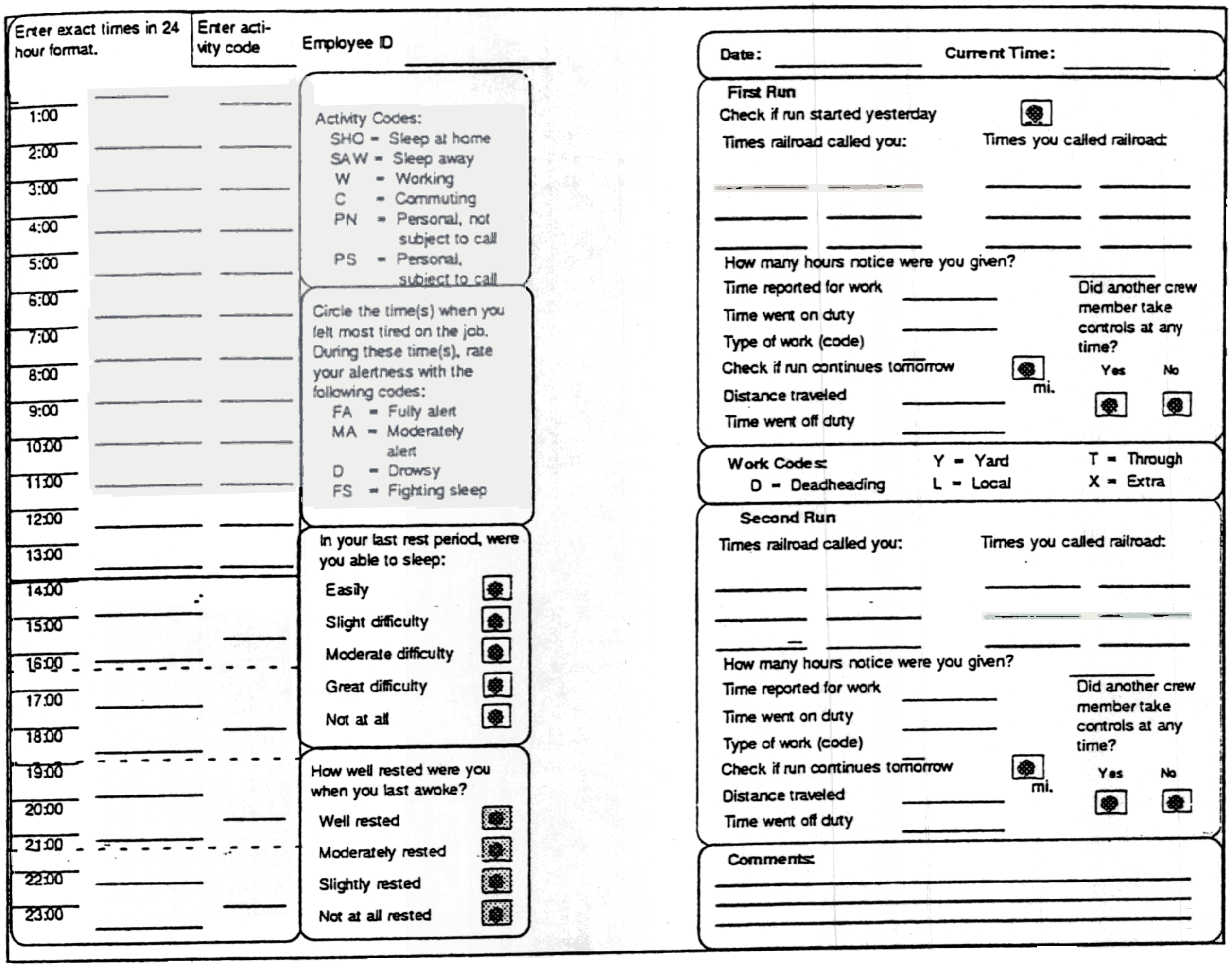
Yes
No

Has anything ususual happened in your life in the past four weeks that affected your sleep?

If yes, please explain.

Yes No

Figure 2-1. Original Header Page Containing ID and Demographic Data



Enter exact times in 24 hour format.
Enter activity code
Employee ID

1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

Activity Codes:
SHO - Sleep at home
SAW - Sleep away
W - Working
C - Commuting
PN - Personal, not subject to call
PS - Personal, subject to call

Circle the time(s) when you felt most tired on the job. During these time(s), rate your alertness with the following codes:
FA - Fully alert
MA - Moderately alert
D - Drowsy
FS - Fighting sleep

In your last rest period, were you able to sleep:
Easily
Slight difficulty
Moderate difficulty
Great difficulty
Not at all

How well rested were you when you last awoke?
Well rested
Moderately rested
Slightly rested
Not at all rested

Date: Current Time:

First Run
Check if run started yesterday
Times railroad called you: Times you called railroad:
How many hours notice were you given?
Time reported for work
Time went on duty
Type of work (code)
Check if run continues tomorrow
Distance traveled mi.
Time went off duty
Did another crew member take controls at any time?
Yes No

Work Codes:
D - Deadheading
Y - Yard
L - Local
T - Through
X - Extra

Second Run
Times railroad called you: Times you called railroad:
How many hours notice were you given?
Time reported for work
Time went on duty
Type of work (code)
Check if run continues tomorrow
Distance traveled mi.
Time went off duty
Did another crew member take controls at any time?
Yes No

Comments:

Figure 2-2. Diary Page from the Original 28-Day Survey Instrument

The 28-day diary shown in Figure 2-2 was administered at four terminals on three different railroads during the fall of 1992 and the summer of 1993. One or two busy terminals were selected on each railroad in consultation with management and the BLE. The BLE local chairmen and local road foremen were also briefed by telephone in advance of each visit. Volpe Center staff, sometimes accompanied by FRA staff, visited each terminal to brief railroad management and BLE officials. Participants were recruited by the author, who spent about three days in the crew room at each terminal. Prospective participants were first given a copy of an introductory letter from William Keppen, Vice President of the BLE. Those who expressed willingness to participate — very nearly everyone — were given a diary, an instruction sheet, a self-sealing business reply envelope, and a copy of the introductory letter. These materials are reproduced in the Appendix.

Unfortunately, the rate of return of completed diaries ranged from as low as about 15% at one terminal to a high of about 40%. Overall, 73 usable diaries were returned, out of about 300 distributed to engineers. These low rates of return were a source of concern, since they could bias findings. The subjective impression of the author was that rates of return were higher at terminals where morale was good and complaints about fatigue were relatively few. Conversely, at the terminals where fatigue seemed greatest, return rates were lower.

In the course of conversations with scores of engineers while these diaries were being handed out, it became apparent that they thought there should be a comparison of the times they thought they would go to work based on what they heard from their line-ups and the times they were actually called to work. Thus, questions were added to the survey form to generate quantitative measures of the accuracy of information about the time of the next job start. Respondents were also encouraged to explain large errors in their estimates whenever possible. Additional questions arose about the frequency of train delays resulting in penalty payments and working out of turn.

In order to address these questions and to encourage a higher return rate, the diaries were modified as shown in Figures 2-3 and 2-4. The diaries were also shortened to 14 days to minimize the burden on respondents. An incentive — a $50 U.S. Savings Bond — was provided to each engineer who returned a completed diary.

Employee Number:
Home Terminal:
Railroad:

How long is the commute from your residence to your home terminal?

Miles one way:
Travel time one way:
(hrs min)

Please enter your

Age: Height: ft. in. Weight:

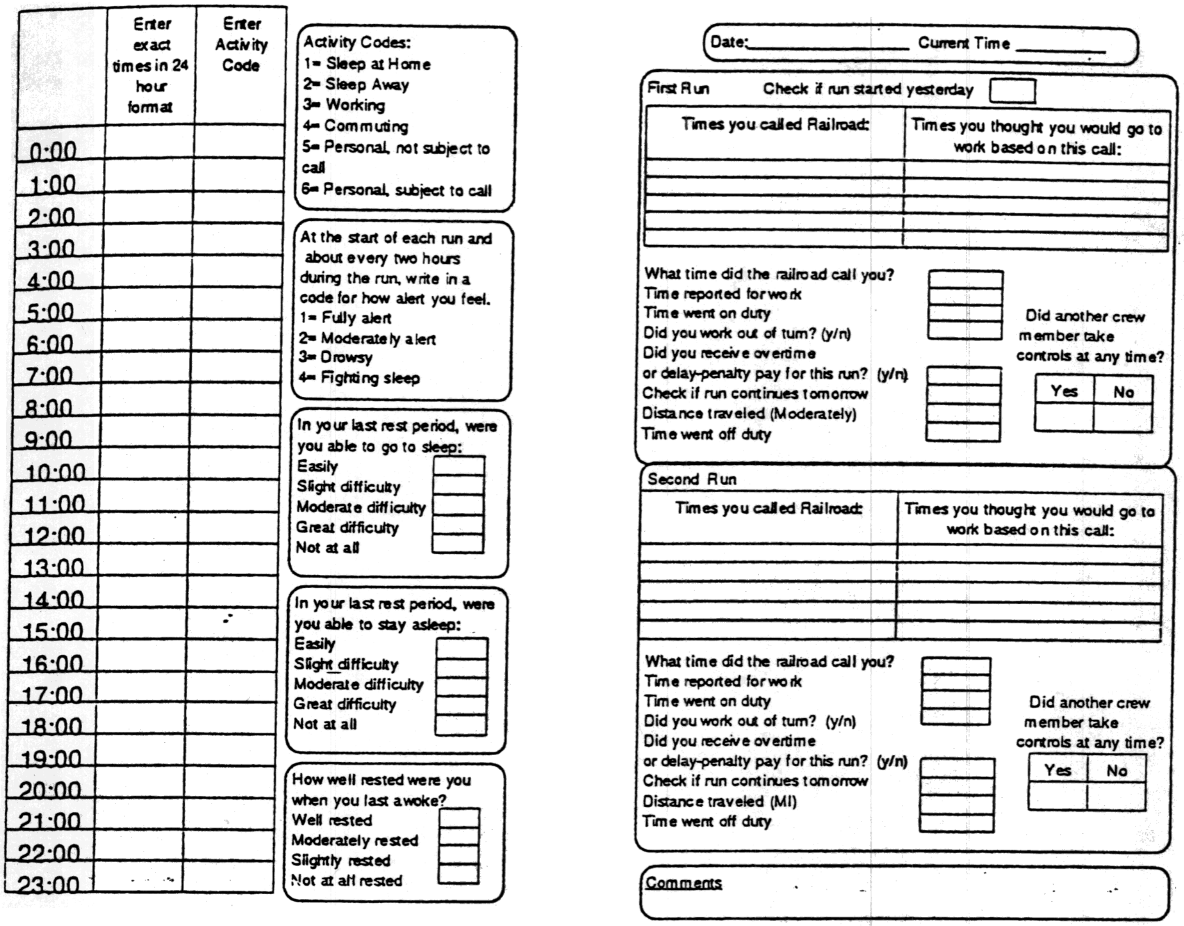
Are there any unusual factors in your life which may affect your sleep significantly?
If Yes, please explain:

What kind of job do you usually work

Regular road assignment ☒
Regular road pool turn ☒
Extra board ☒
Yard, local, work, etc. ☒

Normal wake up time:

Figure 2-3. Revised ID and Demographic Data Page



	Enter exact times in 24 hour format	Enter Activity Code
0:00		
1:00		
2:00		
3:00		
4:00		
5:00		
6:00		
7:00		
8:00		
9:00		
10:00		
11:00		
12:00		
13:00		
14:00		
15:00		
16:00		
17:00		
18:00		
19:00		
20:00		
21:00		
22:00		
23:00		

Activity Codes:
1= Sleep at Home
2= Sleep Away
3= Working
4= Commuting
5= Personal, not subject to call
6= Personal, subject to call

At the start of each run and about every two hours during the run, write in a code for how alert you feel.
1= Fully alert
2= Moderately alert
3= Drowsy
4= Fighting sleep

In your last rest period, were you able to go to sleep:
Easily
Slight difficulty
Moderate difficulty
Great difficulty
Not at all

In your last rest period, were you able to stay asleep:
Easily
Slight difficulty
Moderate difficulty
Great difficulty
Not at all

How well rested were you when you last awoke?
Well rested
Moderately rested
Slightly rested
Not at all rested

Date:__________ Current Time ________

First Run Check if run started yesterday

Times you called Railroad:	Times you thought you would go to work based on this call:

What time did the railroad call you?
Time reported for work
Time went on duty
Did you work out of turn? (y/n)
Did you receive overtime or delay-penalty pay for this run? (y/n)
Check if run continues tomorrow
Distance traveled (Moderately)
Time went off duty

Did another crew member take controls at any time?

Yes	No

Second Run

Times you called Railroad:	Times you thought you would go to work based on this call:

What time did the railroad call you?
Time reported for work
Time went on duty
Did you work out of turn? (y/n)
Did you receive overtime or delay-penalty pay for this run? (y/n)
Check if run continues tomorrow
Distance traveled (MI)
Time went off duty

Did another crew member take controls at any time?

Yes	No

Comments

Figure 2-4. Diary Page for the 14-Day, Revised Version

The Appendix contains the complete instruction sheet for filling out the diary along with example pages.

2.1 Analysis Methods

Two hundred four diaries (73 in the original format, 131 in the revised format) were filled in and returned to the Volpe Center, out of nearly 800 distributed to engineers. There were five diaries in which many days were skipped and no comments were made. These were not entered into the data base. One diary contained good comments and demographic data, but left so much "off-duty" time unaccounted that it could not be entered into the diary portion of the data base, although the demographic and fatigue-mitigation suggestions were recorded. Thus, there were a total of 199 sets of demographic and mitigation-suggestions data, but only 198 diaries. Two of the diaries were missing one page so that a total of 2770 days of engineers' lives were recorded. Fourteen engineers submitted two diaries.

Data from the diaries were entered by Volpe Center staff using the same Delrina Form Flow® software that was used to create the forms. The resulting d-Base® files (one for the header page and mitigation measures poll, and one for the daily pages) were analyzed using three different software packages.

Of the nearly 100,000 data items in the diaries, a few thousand were missing, inconsistent with other items on the same day, or written in a format other than that specified in the instruction sheets. These were interpreted or interpolated by the author in order to generate usable records.

The simplest questions (involving counts, averages, etc., that could be extracted from individual records without conditional statements relating to other records) were answered using Microsoft Excel 5.0®. Somewhat more complicated questions required the use of Microsoft Access 2.0®, sometimes augmented with calls to routines written in Microsoft Visual Basic®.

For the most complex procedures, such as the generation of the job-start-time-estimate-error charts, custom software was written using Clipper®, augmented with calls to certain modules in the DGE Library produced by Pinnacle Publishing.

In the sections that follow, the results of these analyses are described.

3. WORK PERFORMED

Among the most obvious questions that can be answered with the diary data is how many hours per week do engineers work and how does that vary by employer, job category, etc. Overall, the average number of hours worked per week by engineers in the sample was 37.8, not very different from other types of workers. On most roads, yard and local engineers put in the greatest number of hours, primarily because many of them work 12-hour shifts. On some railroads (B, E, and F), extra-board engineers work more than pool engineers, while on others (A and D), they work less.

Assigned runs are often hotshots that take fewer hours than pool runs on Railroads A, C, and D. But on Railroads E and F, assignments are mostly locals, so that the engineers who hold assignments put in more hours than the average pool engineer. Figure 3-1 shows the distribution of average weekly hours worked across railroads and job classifications.

Regular pool engineers on Railroad B averaged only 32.7 hours per week, while those on Railroad D exceeded 54. The 78 hours per week for yard engineers on Railroad C represents a single engineer who worked the 3 PM to 3 AM shift on 13 of the 14 days covered by his diary.

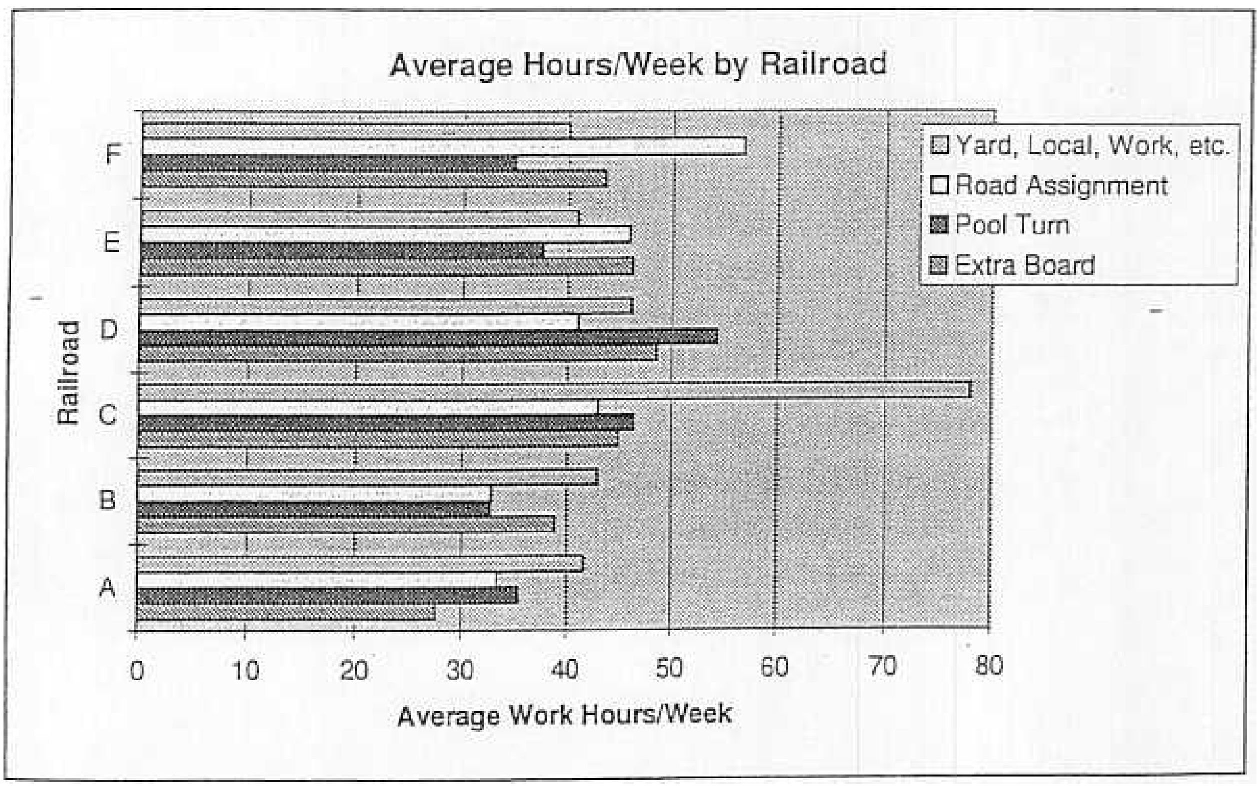


Figure 3-1. Average Hours Worked per Week by Railroad

Most (116) of the engineers in the sample worked in regular pools, with an additional 19 (mostly on Railroad D) in road assignments. Nearly a quarter (47) worked the extra board, often performing both yard and road service. Seventeen respondents were in yard or local service exclusively. Thus, the sample sizes for "yard and local" and "road assignment" are too small to be of much significance in Figures 3-1 and 3-2.

Average miles per week varied much more than average hours. They ranged from a high of about 1300 for pool engineers on Railroad D, to less than half that for assigned runs on Railroad C. Such differences are primarily reflections of differences in terrain, single-track versus dual-track lines, and whether assigned runs are locals or mainline priority trains. Figure 3-2 shows average miles per week for engineers with regular-pool jobs and assigned runs.

Actual miles for yard jobs were seldom reported. Hence, no values are shown for them, nor for extra-board engineers, many of whom spend a portion of their time working yard jobs.

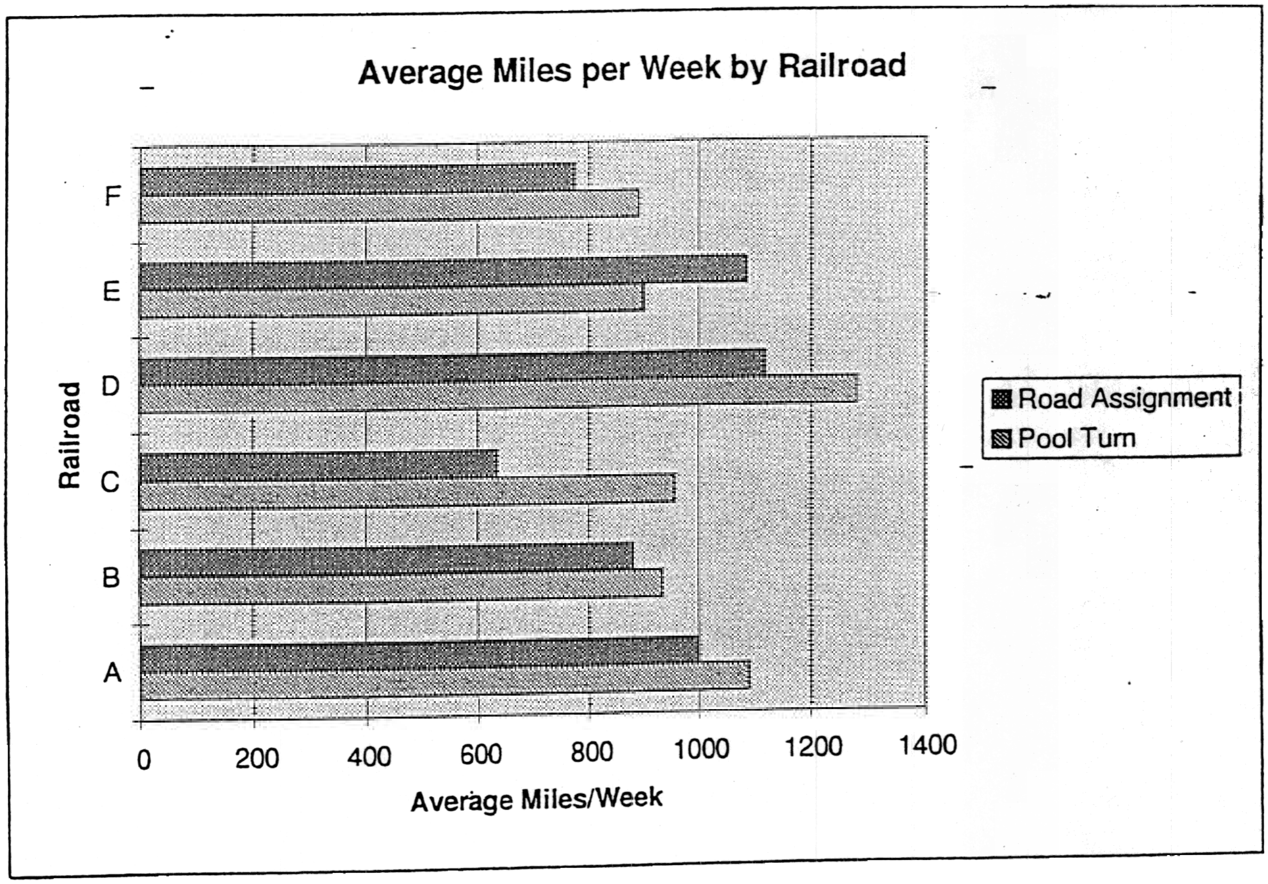
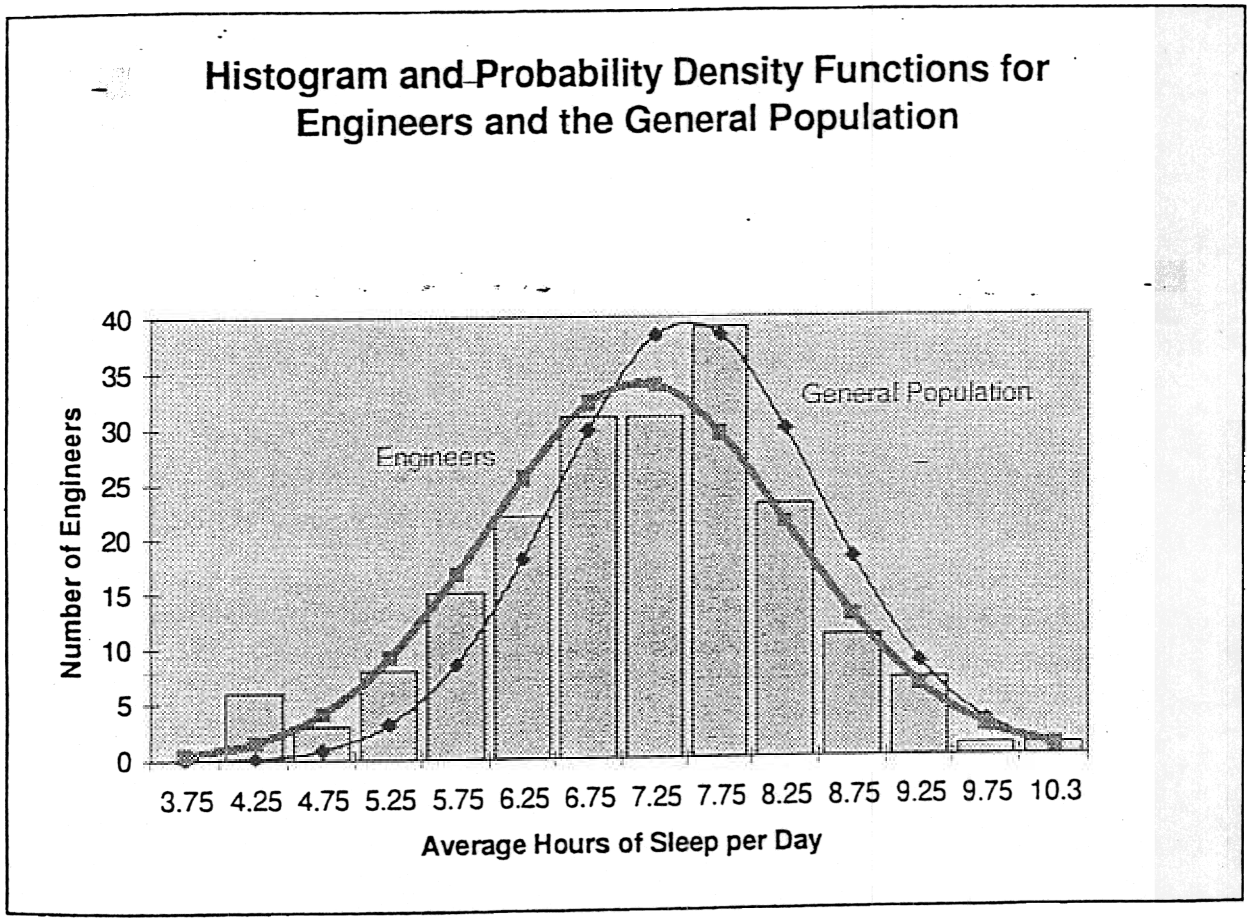


Figure 3-2. Average Miles Traveled per Week by Railroad

4. QUANTITY OF SLEEP

Over the entire sample, engineers reported getting an average of 7.13 hours of sleep per day. This included sleep at home and away. The average length of a sleep episode at home was 6.58 hours, while away it was only 6.08 hours. Napping accounts for the difference between the length of the average episode and the average per day.

The average sleep reported was somewhat less than the eight hours recommended by most experts, but only about 20 minutes less than the average of 7.5 hours per day, which is characteristic of the general population. Figure 4-1 shows the distribution of total daily sleep duration for the sample of engineers and for the general public, while Figure 4-2 summarizes the results for engineers by railroad and place of sleep. Railroad D, from which 16 diaries were received, showed an average of only 6.49 hours per day, substantially below the others.



Source: Reference 1. Note: Height of probability distribution function (pdf) curves scaled to that of histogram.

Figure 4-1. Histogram and PDF for Engineers and the General Population

In Figures 4-2 and 4-3, "Average" refers to average total sleep per day, "Away" refers to the average length of a sleep episode at an away-from-home terminal, and "Home" refers to the length of the average sleep episode at home. Because of naps and split sleep periods, average total sleep per day is greater than the average length of a sleep episode at either location.

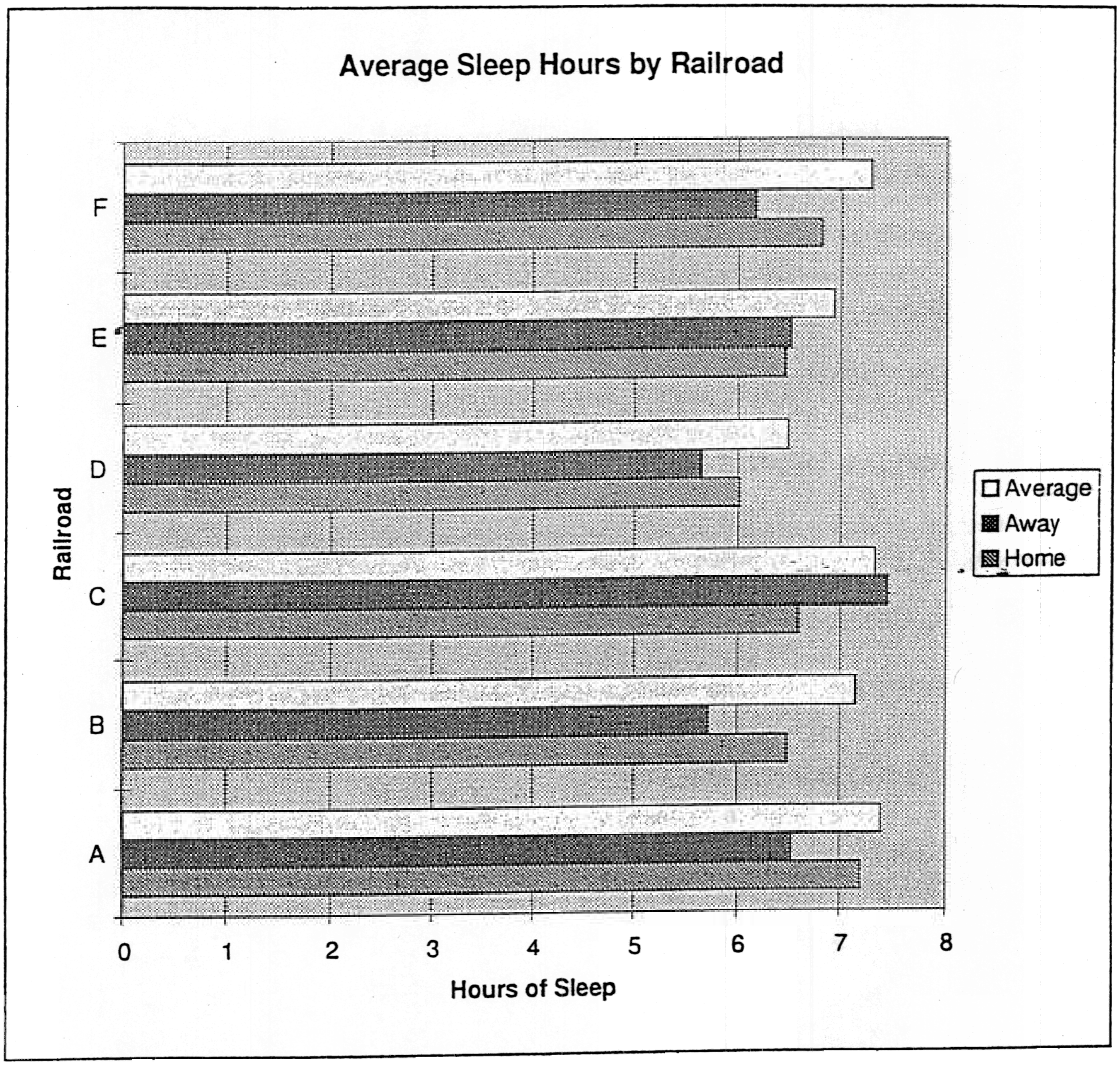


Figure 4-2. Average Sleep Hours by Railroad

Yard engineers reported the least sleep, 6.78 hours per day, followed by those on extra boards at 6.95. Those in regular pools or with assigned runs averaged better than 7.2 hours per day, as shown in Figure 4-3.

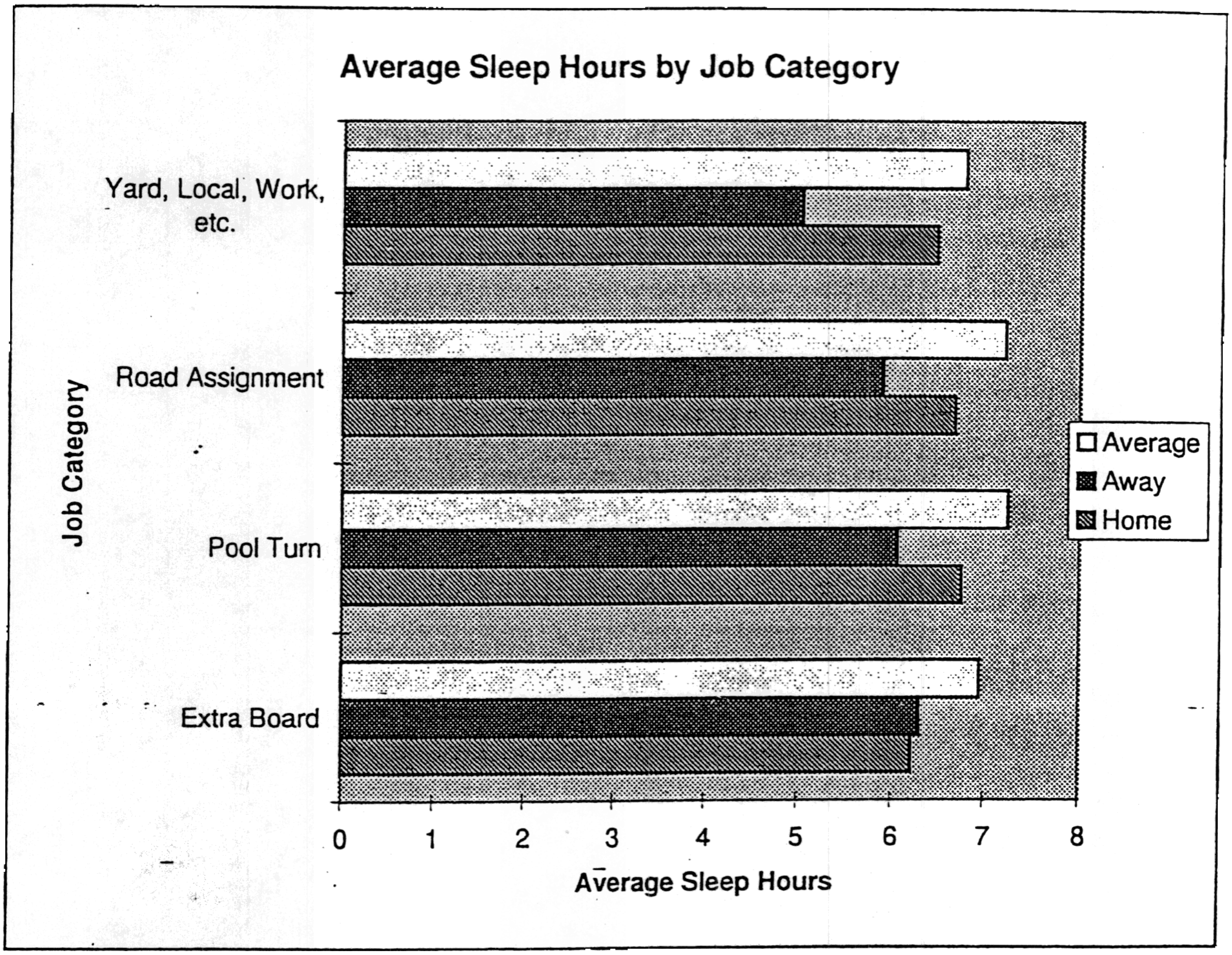


Figure 4-3. Average Sleep Hours by Job Category

Age did not appear to have much effect on sleep. Although average daily sleep tends to decline with age to some degree in the general population, among unionized workers, the seniority system tends to allow older workers the more desirable schedules, and hence more time to sleep. Among engineers, greater seniority affords an opportunity to move from extra-board jobs to pools or assigned runs. Thus, Figure 4-4 shows a slight increase in average sleep with age. Since there were only thirteen engineers in the sample over the age of fifty-five, the significance of this observation is doubtful. The average age of engineers in the sample was forty-four, with 149 of the 199 diaries representing engineers between the ages of thirty-five and fifty-four inclusive.

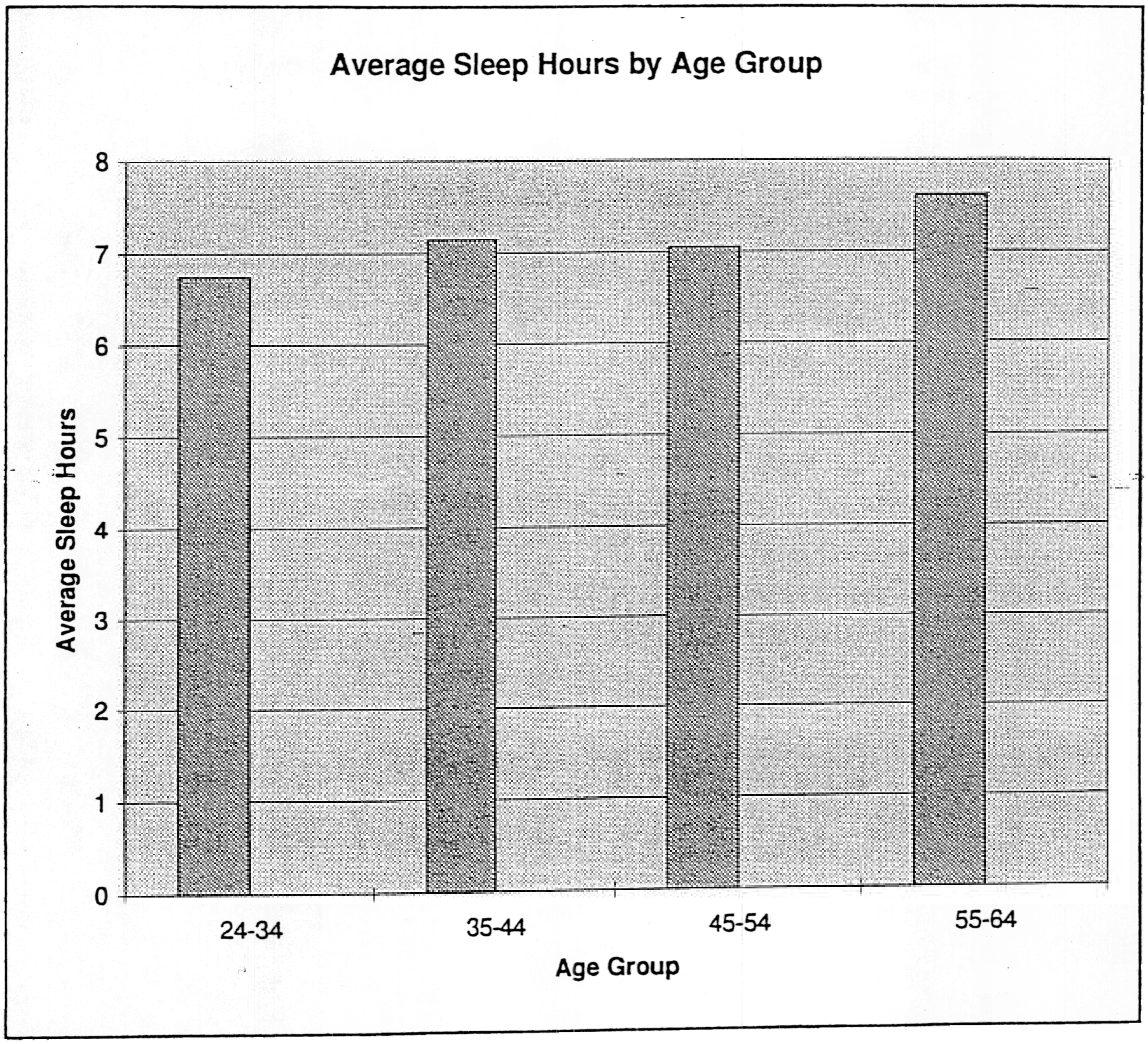


Figure 4-4. Average Sleep Hours by Age Group

To examine the relationship between the number of hours worked per day and the amount of sleep, the scatter plot shown in Figure 4-5 was prepared. There are 198 points on the chart representing the daily averages for each completed diary. (Some points are hidden.) A linear trend line fitted to these points shows that sleep does decline with increasing work, but the effect is modest (correlation coefficient = -0.17316). Average daily sleep declines by about one hour across the range of engineers from those who worked the fewest hours to those who put in the most.

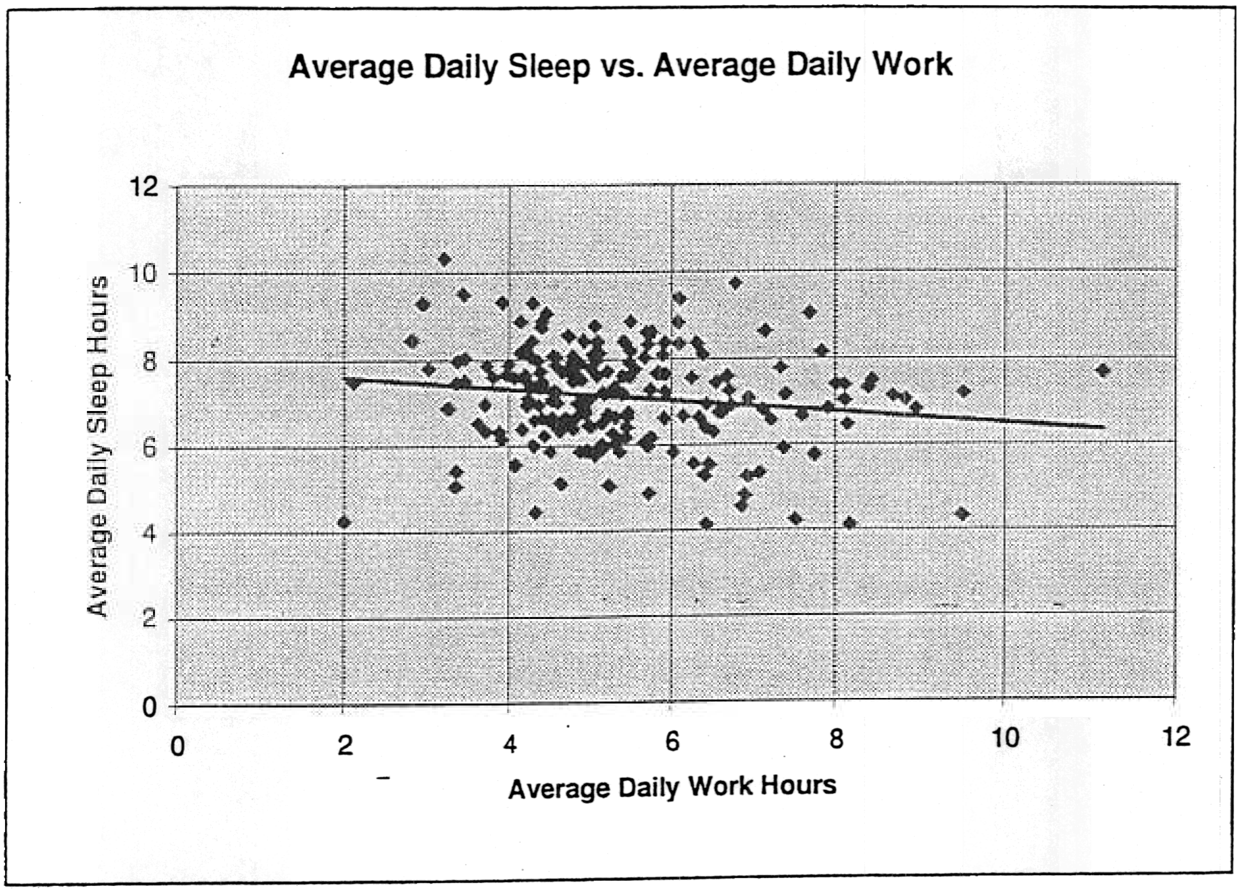


Figure 4-5. Average Daily Sleep vs. Average Daily Hours Worked

Far more important than age, job, or employer as predictors of sleep time were the start and ending times of the job. Engineers who happened to work relatively normal daytime hours on a given day tended to get the most sleep. Those whose jobs started at night or ended in the morning got the least sleep. Figure 4-6 shows the relationship between the average length of total sleep on a given day and the starting time of the job on that day. Job starts between 2200 and 0300 hours are associated with average total sleep of only about five hours.

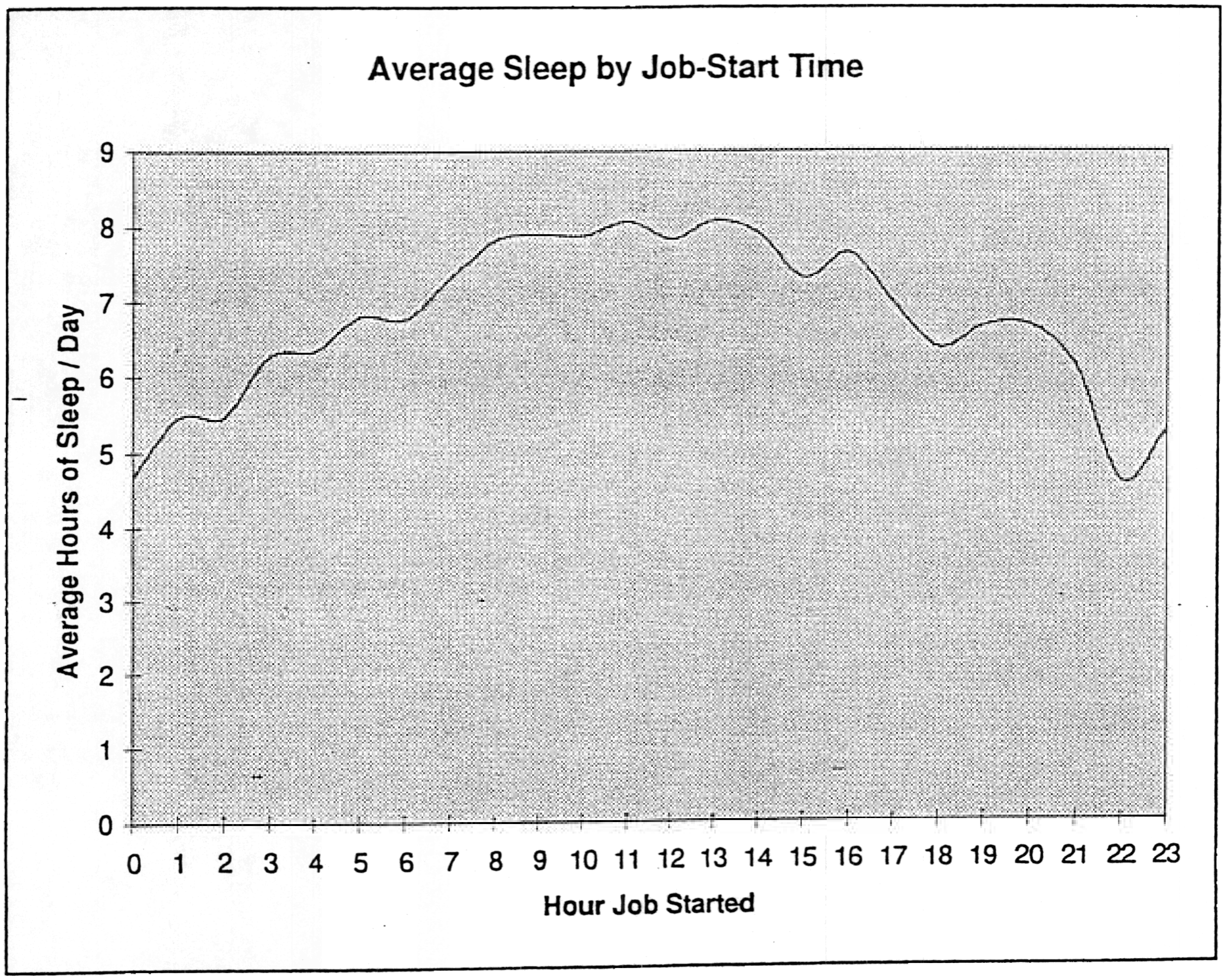


Figure 4-6. Average Sleep per Day by Job-Start Time

Figure 4-7 describes the effect of job-end time on the amount of sleep on the day that the job ended. It is obvious that for jobs that end anywhere from mid-afternoon to midnight, engineers get about two more hours of sleep than they do on days when their jobs end between 0500 hours and noon.

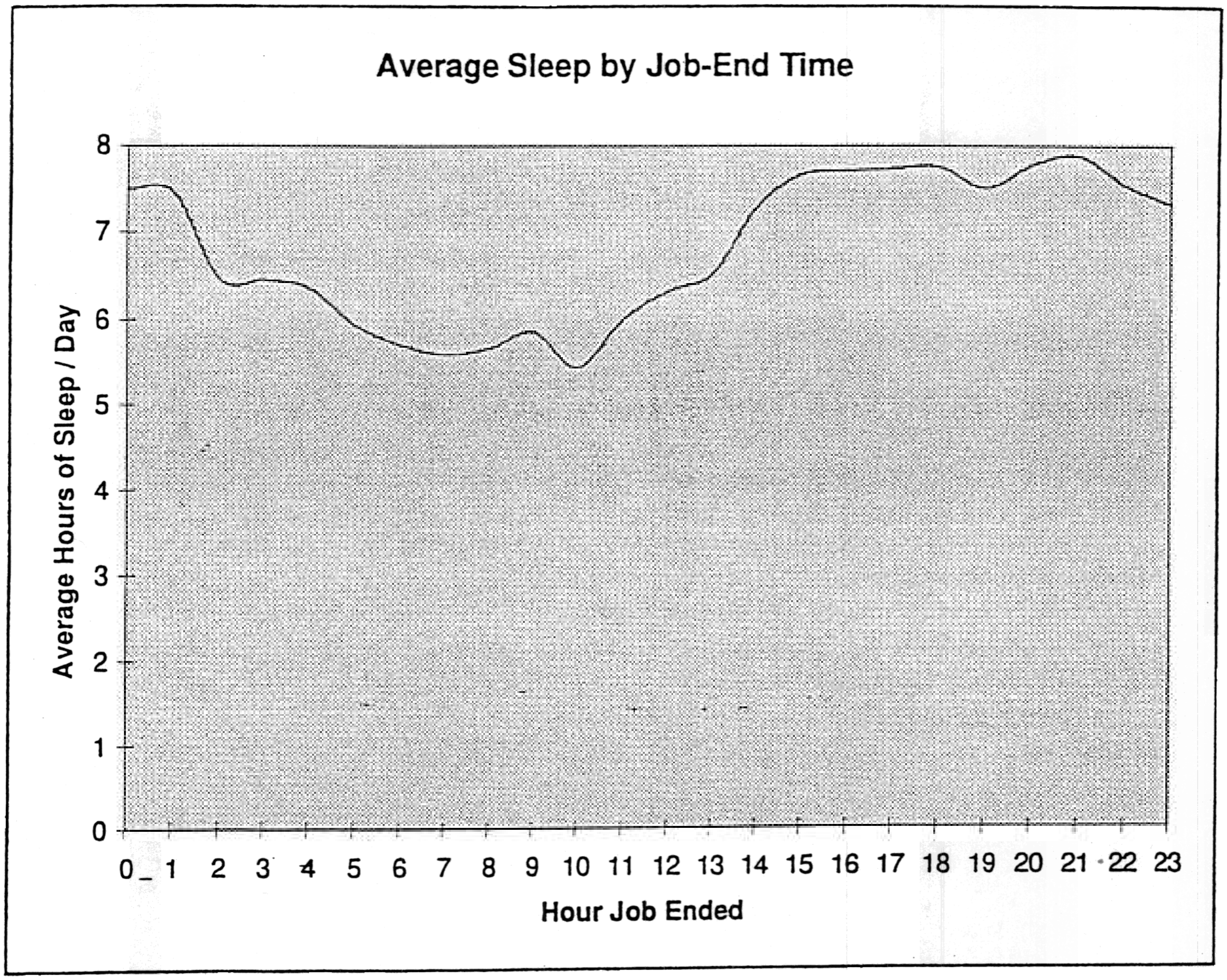


Figure 4-7. Average Sleep per Day by Job-End Time

5. QUALITY OF REST

In the focus-group sessions that preceded this diary study, several engineers said they did not sleep as well away from home as they did in their own beds. Thus, sleep time was marked separately for away versus at-home conditions, and questions were added to the survey regarding how easily the respondents fell asleep each day, how well rested they felt upon arising, and (in the second version only) how easily they remained asleep. See Figures 2-2 and 2-4 for the formats in which these questions were presented.

The responses to these questions were tabulated by railroad, with separate listings for at-home and away-from-home, as well as totals. Tables 5-1, 5-2, and 5-3 show the results of these questions. It is evident that there are not large differences between the at-home and away conditions. For 60% or more of their sleep periods, engineers report being "well-rested" or "moderately rested." Similarly high percentages of respondents reported that they fell asleep "easily" or with "slight difficulty." Ease of remaining asleep (Table 5-3) shows comparable values except that large numbers of the respondents from Railroads B, D, and F did not receive forms containing that question and thus have high "no response" counts.

Table 5-1. Quality of Sleep (Rated by Railroad)

Railroad		Sleep at Home		Away from Home		Total Sleep	
A							
	Well Rested	102	39.69%	48	39.67%	150	39.68%
	Moderately Rested	96	37.35%	44	36.36%	140	37.04%
	Slightly Rested	14	5.45%	14	11.57%	28	7.41%
	Not Rested	3	1.17%	2	1.65%	5	1.32%
	No Response	42	16.34%	13	10.74%	55	14.55%
	Total	257		121		378	
B							
	Well Rested	327	36.09%	109	35.16%	436	35.86%
	Moderately Rested	296	32.67%	124	40.00%	420	34.54%
	Slightly Rested	104	11.48%	51	16.45%	155	12.75%
	Not Rested	32	3.53%	5	1.61%	37	3.04%
	No Response	147	16.23%	21	6.77%	168	13.82%
	Total	906		310		1216	
C							
	Well Rested	27	27.55%	8	19.05%	35	25.00%
	Moderately Rested	32	32.65%	19	45.24%	51	36.43%
	Slightly Rested	10	10.20%	4	9.52%	14	10.00%
	Not Rested	7	7.14%	4	9.52%	11	7.86%
	No Response	22	22.45%	7	16.67%	29	20.71%
	Total	97		42		139	
D							
	Well Rested	55	28.80%	18	30.00%	73	29.08%
	Moderately Rested	62	32.46%	19	31.67%	81	32.27%
	Slightly Rested	31	16.23%	16	26.67%	47	18.73%
	Not Rested	5	2.62%	1	1.67%	6	2.39%
	No Response	38	19.90%	6	10.00%	44	17.53%
	Total	191		60		251	
E							
	Well Rested	88	41.31%	38	46.91%	126	42.86%
	Moderately Rested	60	28.17%	23	28.40%	83	28.23%
	Slightly Rested	32	15.02%	14	17.28%	46	15.65%
	Not Rested	3	1.41%	3	3.70%	6	2.04%
	No Response	30	14.08%	3	3.70%	33	11.22%
	Total	213		81		294	
F							
	Well Rested	164	47.54%	60	41.38%	224	45.71%
	Moderately Rested	100	28.99%	53	36.55%	153	31.22%
	Slightly Rested	27	7.83%	16	11.03%	43	8.78%
	Not Rested	6	1.74%	9	6.21%	15	3.06%
	No Response	48	13.91%	7	4.83%	55	11.22%
	Total	344		145		489	

Table 5-2. Ease of Falling Asleep (Rated by Railroad)

Railroad		Sleep at Home		Away from Home		Total Sleep	
A							
	Easily	148	57.59%	53	43.80%	201	53.17%
	Slight difficulty	40	15.56%	32	26.45%	72	19.05%
	Moderate difficulty	18	7.00%	13	10.74%	31	8.20%
	Great difficulty	10	3.89%	8	6.61%	18	4.76%
	Not at all	1	0.39%	2	1.65%	3	0.79%
	No Response	40	15.56%	13	10.74%	53	14.02%
	Total	257		121		378	
B							
	Easily	454	50.11%	162	52.26%	616	50.66%
	Slight difficulty	166	18.32%	74	23.87%	240	19.74%
	Moderate difficulty	72	7.95%	32	10.32%	104	8.55%
	Great difficulty	53	5.85%	22	7.10%	75	6.17%
	Not at all	13	1.43%	3	0.97%	16	1.32%
	No Response	148	16.34%	17	5.48%	165	13.57%
	Total	906		310		1216	
C							
	Easily	50	51.55%	18	42.86%	68	48.92%
	Slight difficulty	11	11.34%	9	21.43%	20	14.39%
	Moderate difficulty	4	4.12%	7	16.67%	11	7.91%
	Great difficulty	11	11.34%	4	9.52%	15	10.79%
	No Response	21	21.65%	4	9.52%	25	17.99%
	Total	97		42		139	
D							
	Easily	96	50.26%	19	31.67%	115	45.82%
	Slight difficulty	30	15.71%	18	30.00%	48	19.12%
	Moderate difficulty	19	9.95%	9	15.00%	28	11.16%
	Great difficulty	7	3.66%	8	13.33%	15	5.98%
	Not at all	2	1.05%	1	1.67%	3	1.20%
	No Response	37	19.37%	5	8.33%	42	16.73%
	Total	191		60		251	
E							
	Easily	117	54.93%	44	54.32%	161	54.76%
	Slight difficulty	36	16.90%	15	18.52%	51	17.35%
	Moderate difficulty	15	7.04%	10	12.35%	25	8.50%
	Great difficulty	14	6.57%	7	8.64%	21	7.14%
	Not at all	2	0.94%	2	2.47%	4	1.36%
	No Response	29	13.62%	3	3.70%	32	10.88%
	Total	213		81		294	
F							
	Easily	196	56.98%	72	49.66%	268	54.81%
	Slight difficulty	56	16.28%	33	22.76%	89	18.20%
	Moderate difficulty	32	9.30%	25	17.24%	57	11.66%
	Great difficulty	12	3.49%	6	4.14%	18	3.68%
	No Response	48	13.95%	9	6.21%	57	11.66%
	Total	344		145		489	

Table 5-3. Ease of Remaining Asleep (Rated by Railroad)

Railroad		Sleep at Home		Away from Home		Total Sleep	
A							
	Easily	117	45.53%	46	38.02%	163	43.12%
	Slight difficulty	69	26.85%	35	28.93%	104	27.51%
	Moderate difficulty	22	8.56%	19	15.70%	41	10.85%
	Great difficulty	8	3.11%	6	4.96%	14	3.70%
	Not at all	1	0.39%	2	1.65%	3	0.79%
	No Response	40	15.56%	13	10.74%	53	14.02%
	Total	257		121		378	
B							
	Easily	299	33.00%	96	30.97%	395	32.48%
	Slight difficulty	124	13.69%	74	23.87%	198	16.28%
	Moderate difficulty	56	6.18%	29	9.35%	85	6.99%
	Great difficulty	41	4.53%	13	4.19%	54	4.44%
	Not at all	10	1.10%	3	0.97%	13	1.07%
	No Response	376	41.50%	95	30.65%	471	38.73%
	Total	906		310		1216	
C							
	Easily	25	26.04%	11	26.19%	36	26.09%
	Slight difficulty	15	15.63%	10	23.81%	25	18.12%
	Moderate difficulty	8	8.33%	4	9.52%	12	8.70%
	Great difficulty	6	6.25%	5	11.90%	11	7.97%
	No Response	42	43.75%	12	28.57%	54	39.13%
	Total	96		42		138	
D							
	Easily	41	21.93%	9	15.00%	50	20.24%
	Slight difficulty	10	5.35%	3	5.00%	13	5.26%
	Moderate difficulty	2	1.07%	2	3.33%	4	1.62%
	No Response	134	71.66%	46	76.67%	180	72.87%
	Total	187		60		247	
E							
	Easily	99	46.48%	41	50.62%	140	47.62%
	Slight difficulty	42	19.72%	17	20.99%	59	20.07%
	Moderate difficulty	24	11.27%	5	6.17%	29	9.86%
	Great difficulty	15	7.04%	12	14.81%	27	9.18%
	Not at all	3	1.41%	3	3.70%	6	2.04%
	No Response	30	14.08%	3	3.70%	33	11.22%
	Total	213		81		294	
F							
	Easily	5	1.45%	2	1.38%	7	1.43%
	Slight difficulty	3	0.87%	7	4.83%	10	2.04%
	Moderate difficulty	2	0.58%	3	2.07%	5	1.02%
	No Response	334	97.09%	133	91.72%	467	95.50%
	Total	344		145		489	

6. ALERTNESS RATINGS

Engineers' alertness on the job is more strongly influenced by normal biological rhythms than by any other factor. This conclusion is supported by the diaries, in which participants were asked to rate how alert they felt on the job on a four-point scale:

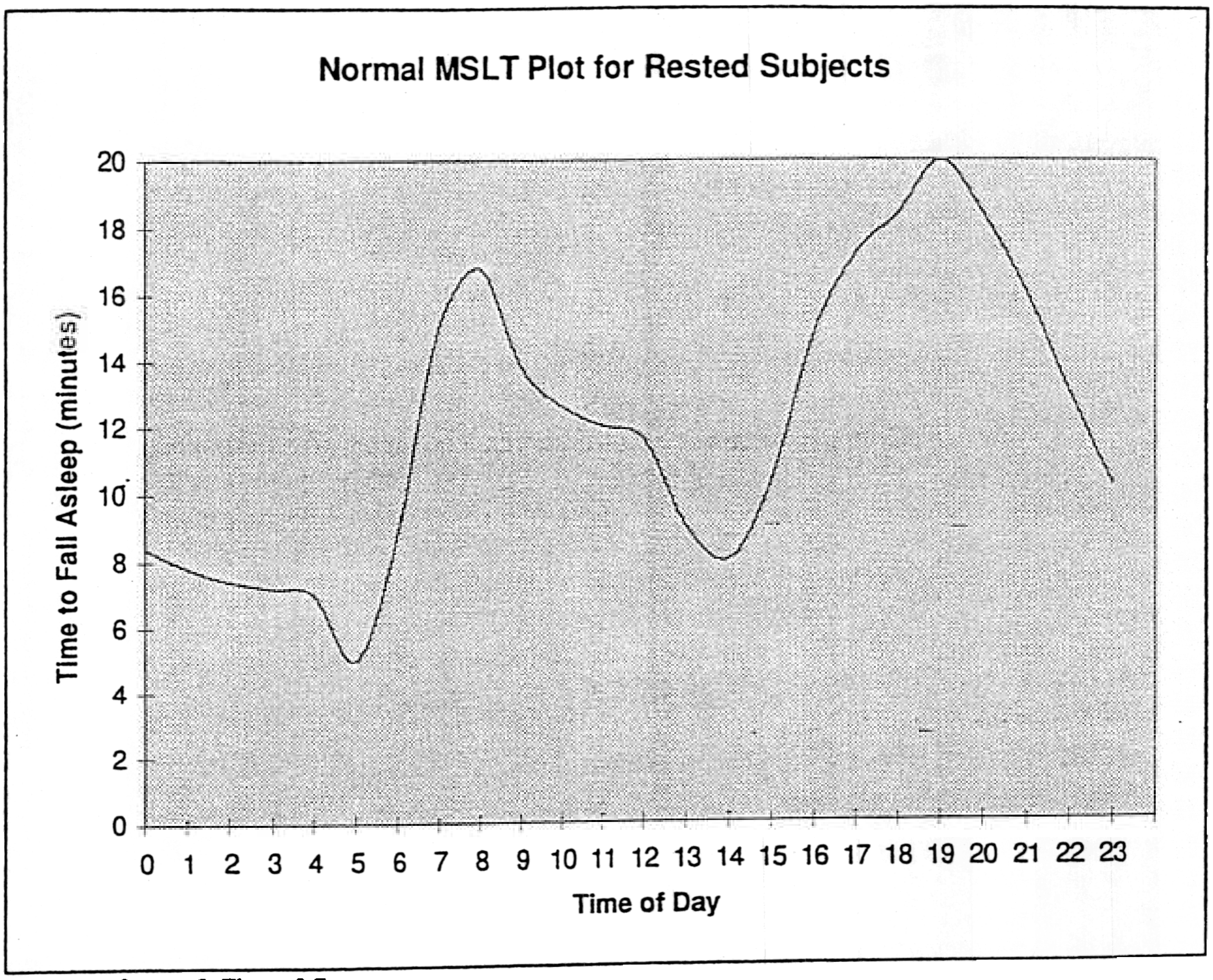
1 - Fully alert
2 - Moderately alert
3 - Drowsy
4 - Fighting sleep.

In the first version of the diary, they were asked to make only one rating per job, but to specify the beginning and end points in time during which they felt most tired. These points were usually a couple of hours apart or more. For the second version, respondents were asked to make the ratings every two hours throughout the job. Diaries of the older type were entered as though they had been in the later format, i.e., whatever rating was shown was assigned to the "starting time," "ending time," and (if 3 hours or more were represented) some intermediate time(s). A total of 4508 alertness ratings were recorded in the completed diaries.

In the figures that follow in this section, these alertness ratings are plotted by time of day for various groupings of the sample population. From these figures, it is immediately apparent that circadian rhythms are the dominant influence. For perspective, Figure 6-1 shows the normal circadian rhythm of rested subjects drawn from the general population. That figure expresses alertness in terms of sleep latency, which is the most widely accepted objective measure of alertness. It can be made only in a laboratory setting in which subjects are wired to an EEG apparatus and allowed to fall asleep as quickly as they can in bed in a quiet, dark, comfortable room. A given test terminates either when the subject falls asleep, as indicated by the EEG record, or after 20 minutes have elapsed. The test is typically administered every two hours around the clock to a given subject, and is thus known as the Multiple Sleep Latency Test (MSLT). Normal, rested subjects usually fall asleep in only a few minutes during the wee hours (the circadian nadir), but take nearly 20 minutes (and often are unable to fall asleep at all) during the hours of maximum alertness (mid-morning and evening). In Figures 6-2 through 6-7, which show the self-rated alertness on duty of engineers on the six railroads, the self-rated alertness scale (1 to 4) appears on the left, while the 0 to 20 minute scale for the superimposed standard MSLT curve appears on the right. Figure 6-8 displays average alertness by time of day over all railroads in the sample.

The decline in alertness associated with the circadian nadir is much stronger than differences between railroads, between job classifications, between age groups, etc. The alertness ratings reported by engineers look much like those reported by other workers, except that the nadir lasts somewhat longer, with large numbers of engineers reporting drowsiness as late as 8:00. Since the engineers were on duty, their alertness ratings never dropped as low as those of the laboratory subjects, who were in bed and encouraged to fall asleep. These differences are especially apparent in the afternoon hours.

Engineers on Railroad D consistently report feeling less alert than engineers on other railroads, which is consistent with their getting less sleep than engineers on other railroads.



Source: Reference 2, Figure 3.7.

Figure 6-1. Normal MSLT Plot for Rested Subjects

The author who supplied this figure, Dr. Martin Moore-Ede, describes "peak alertness" as characterized by MSLT scores of 15 minutes or greater; "slightly impaired alertness" as scores of 10 to 15 minutes; "reduced alertness" as 5 to 10 minutes, and "dangerously drowsy" as scores below 5 minutes.

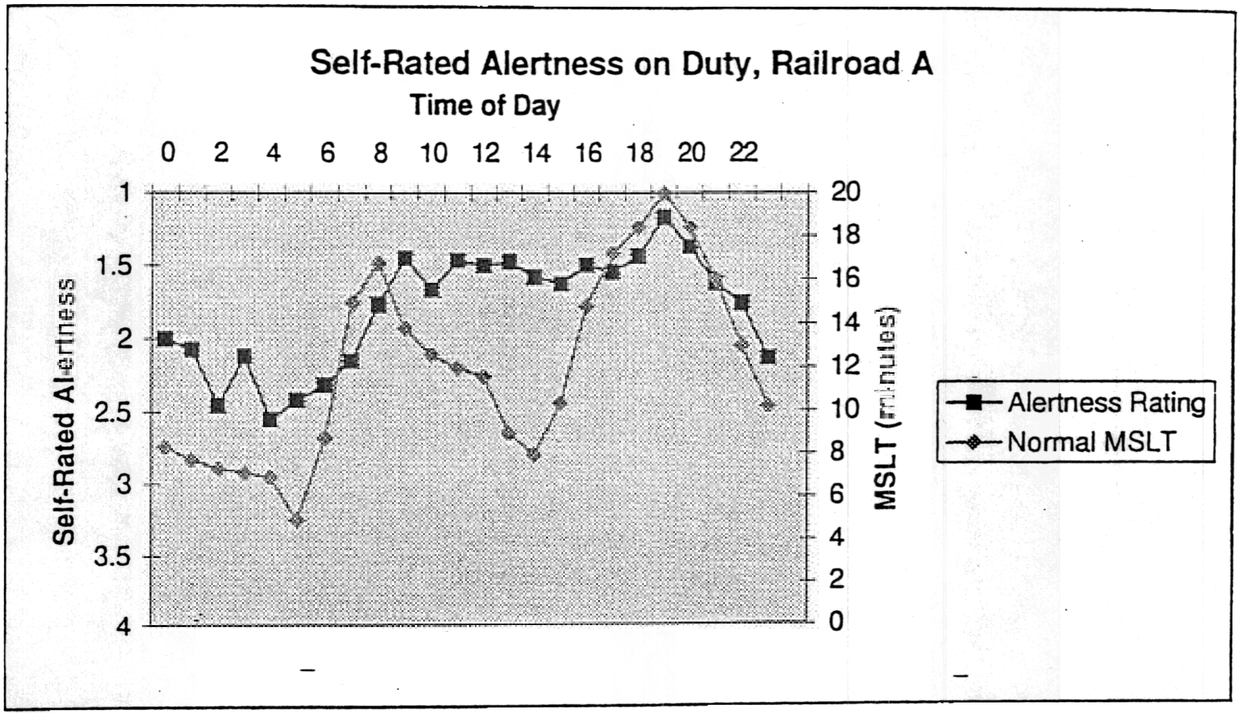


Figure 6-2. Self-Rated Alertness on Duty, Railroad A

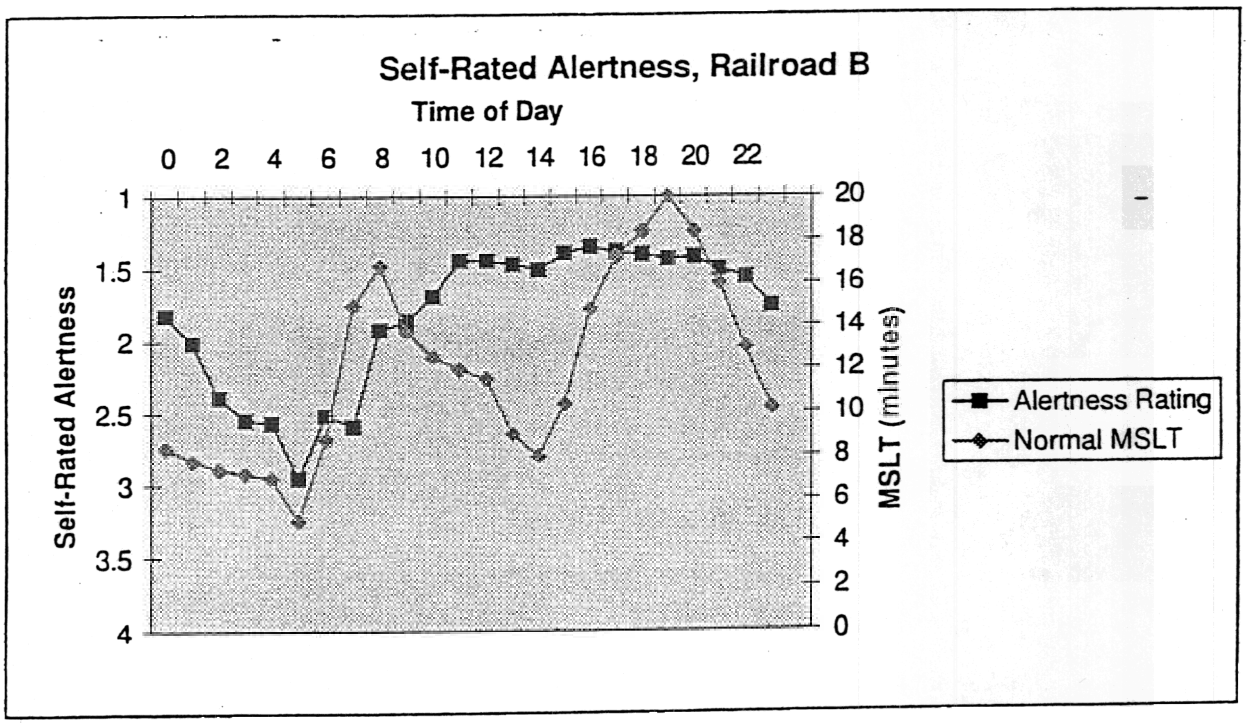


Figure 6-3. Self-Rated Alertness on Duty, Railroad B

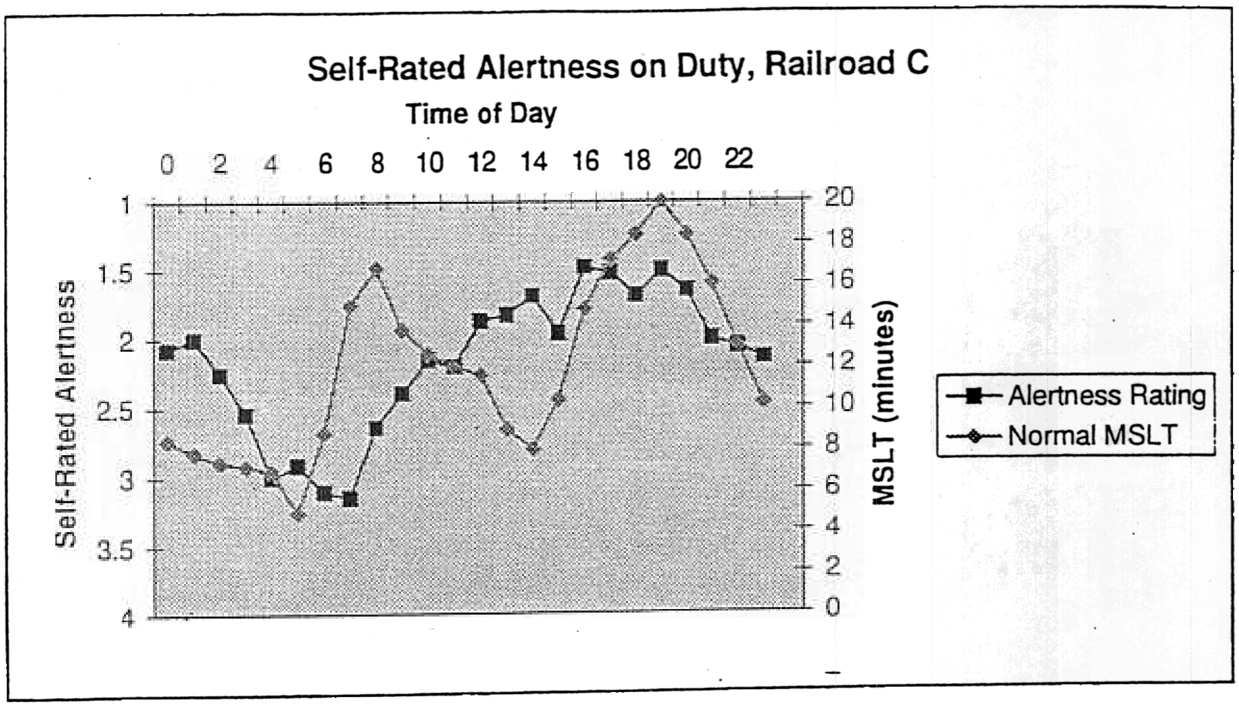


Figure 6-4. Self-Rated Alertness on Duty, Railroad C

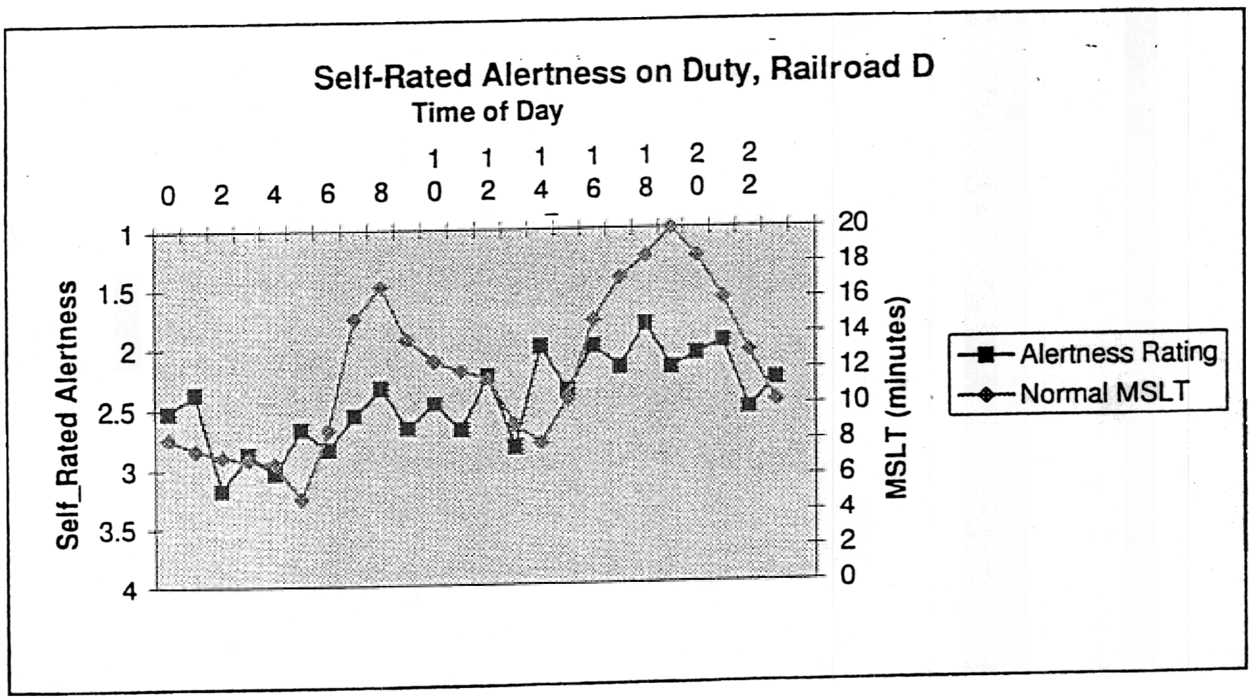


Figure 6-5. Self-Rated Alertness on Duty, Railroad D

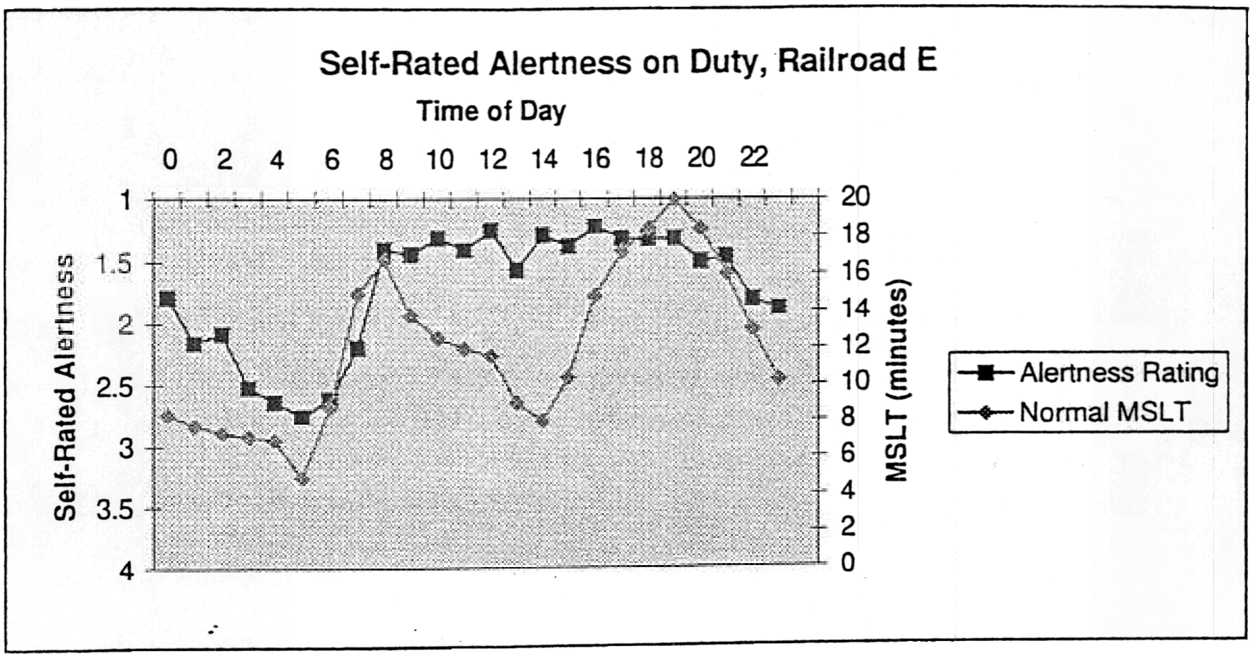


Figure 6-6. Self-Rated Alertness on Duty, Railroad E

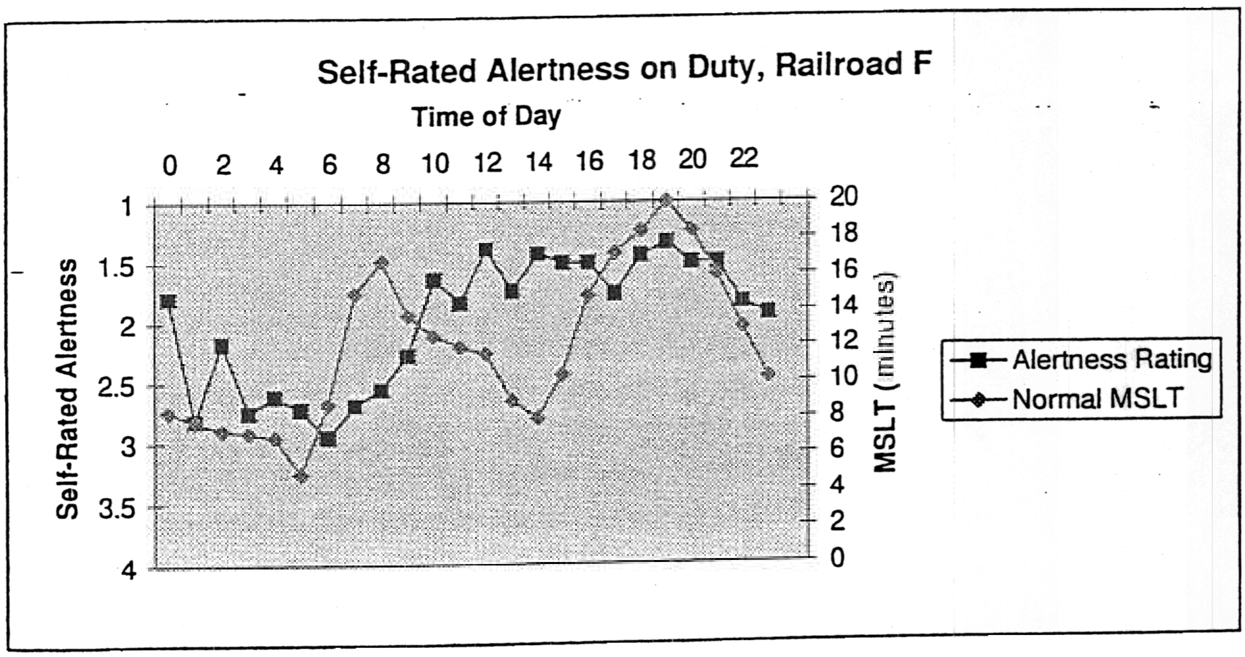


Figure 6-7. Self-Rated Alertness on Duty, Railroad F

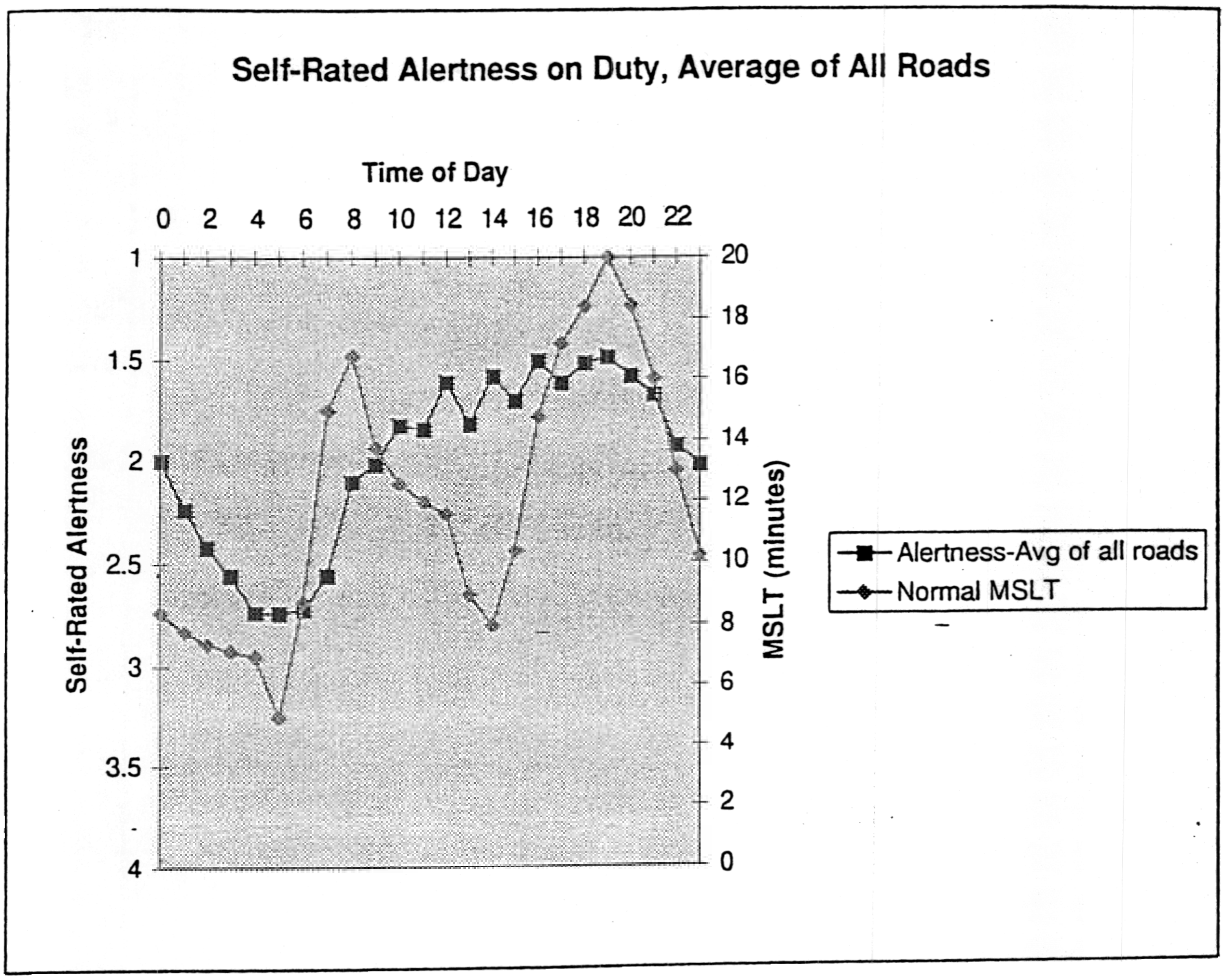


Figure 6-8. Self-Rated Alertness on Duty, Average of All Roads

6.1 Hours Worked vs. Alertness

Engineers who work more hours tend to have a lower level of average alertness. The linear trend line in Figure 6-9 shows that as average daily hours increase, alertness declines from an average of about 1.75 (on a scale where 1 = fully alert, 2 = moderately alert, 3 = drowsy, and 4 = fighting sleep) to about 2.25. Such a change probably translates to falling asleep a few minutes sooner in a situation conducive to nodding off.

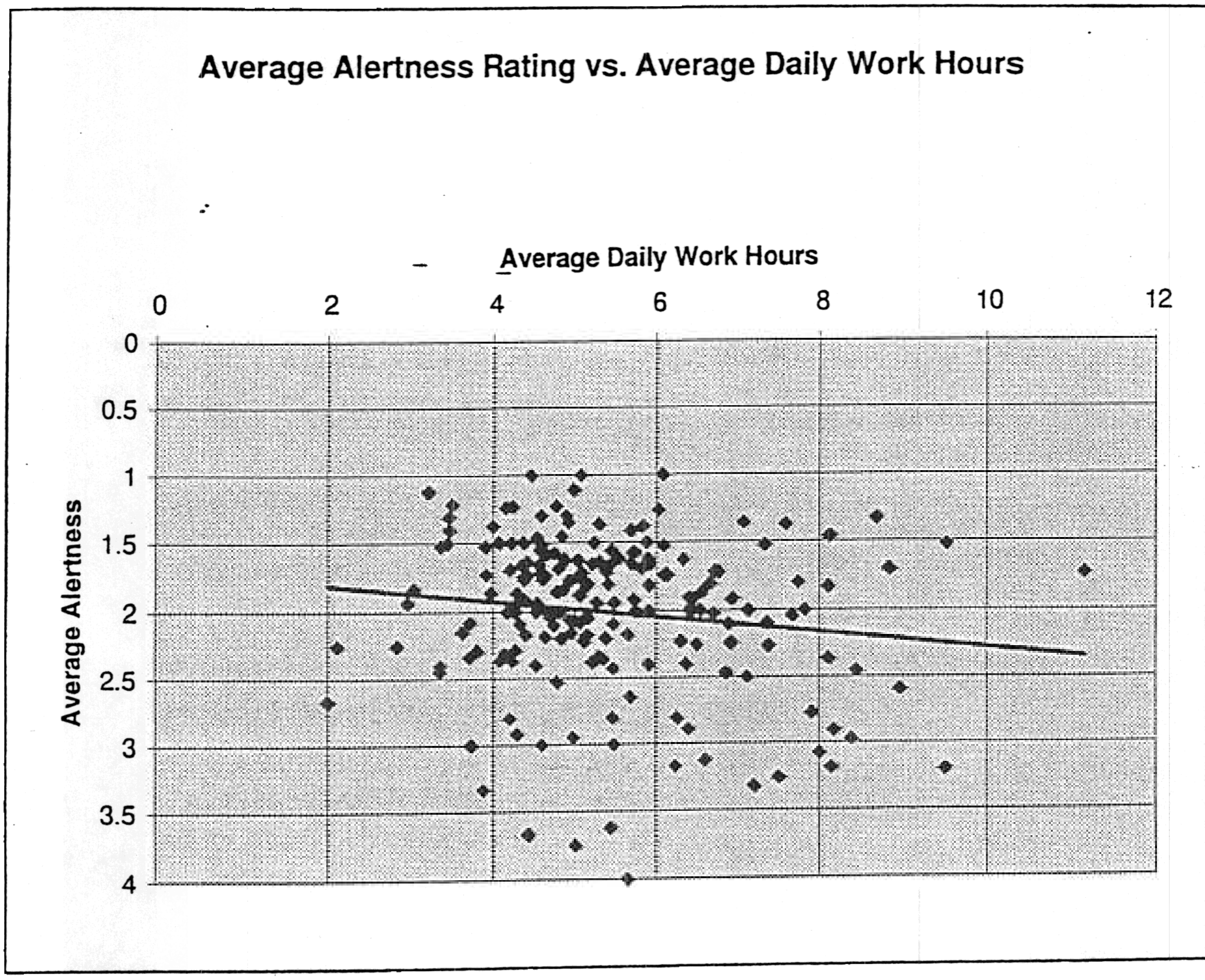


Figure 6-9. Average Alertness Rating on Duty vs. Average Daily Work Hours

The correlation coefficient for the data series in the figure above is 0.1519.

6.2 Effect of Assistant Engineers on Alertness

Out of 1927 jobs performed by the engineers in the sample, 199 (10.3%) were done with some assistance at the controls. Usually, the assistants were student engineers. When engineers commented on the effect of an assistant, it was usually to report that they felt less fatigued as a result. However, a few said that having a student increased their stress levels. More than 12% recommended "two engineers" as a preferred fatigue-mitigation measure.

While a second engineer may reduce fatigue, that is not the same as increasing alertness. Figure 6-10 shows that self-rated alertness is unaffected by the presence of a second engineer throughout most of the day and the earlier part of the night. During the critical circadian nadir, the assisted engineers reported a slightly worse level of alertness than those working without help. Such ratings simply reflect the fact that it is easier to stay awake when actively involved in a task than when merely observing and monitoring.

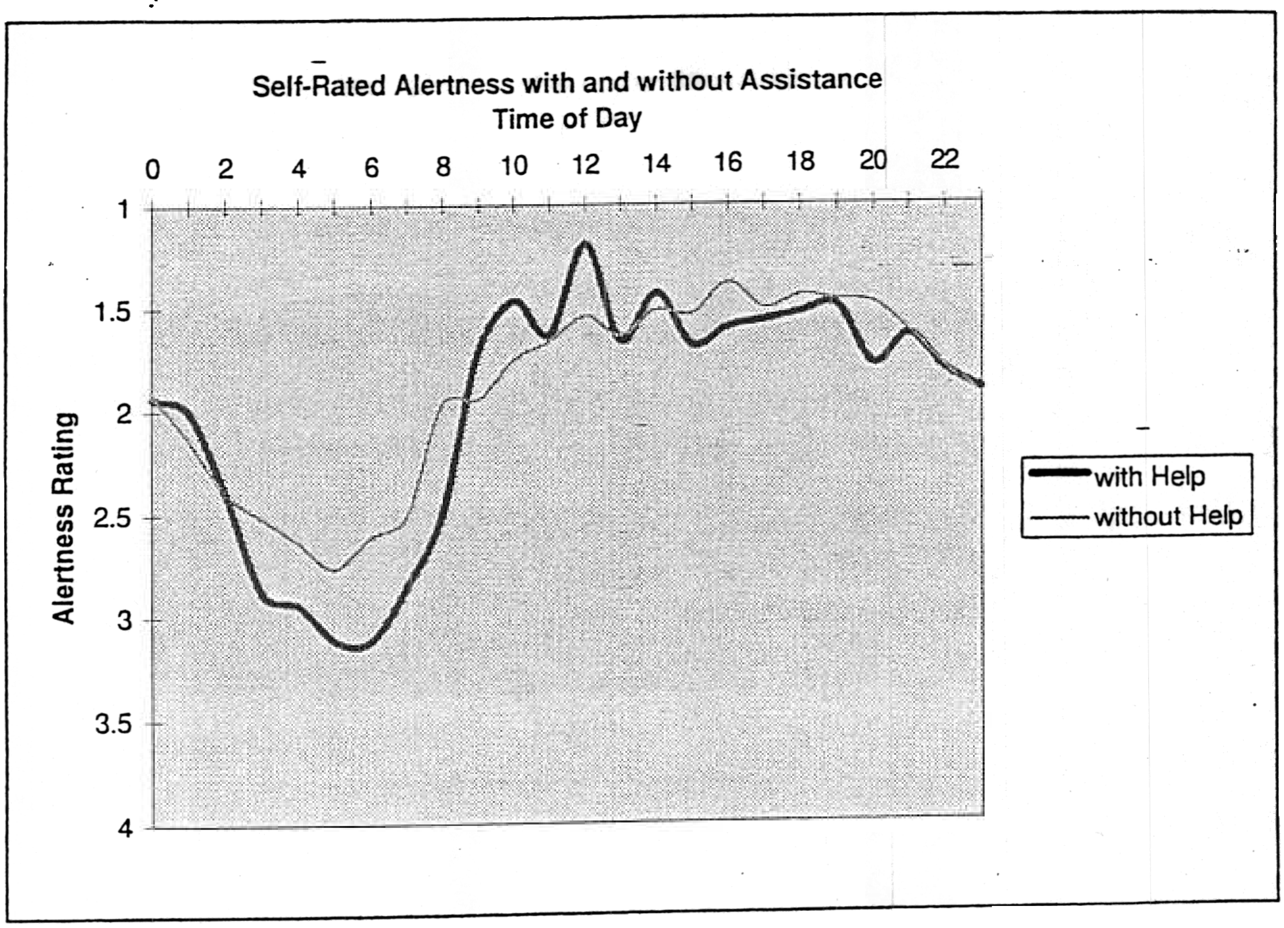


Figure 6-10. Self-Rated Alertness on Duty with and without Assistance

7. COMMUTING TIME

Anecdotal evidence about the long commutes being made by some operating employees have led to questions about how much "rest" time is being consumed by travel from residence to home terminal. Reorganizations, especially conversions to interdivisional runs, have left a substantial number of engineers living a hundred miles or more from the place they usually report for work. Hence, diary respondents were asked for their commuting distances and times. They were also asked to show the actual amount of time spent commuting each day.

As it turned out, the vast majority of engineers have commuting times of less than 30 minutes. Only about 17% have commutes longer than 30 minutes; fewer than 7% exceed one hour. Figure 7-1 shows the distribution of one-way commuting times.

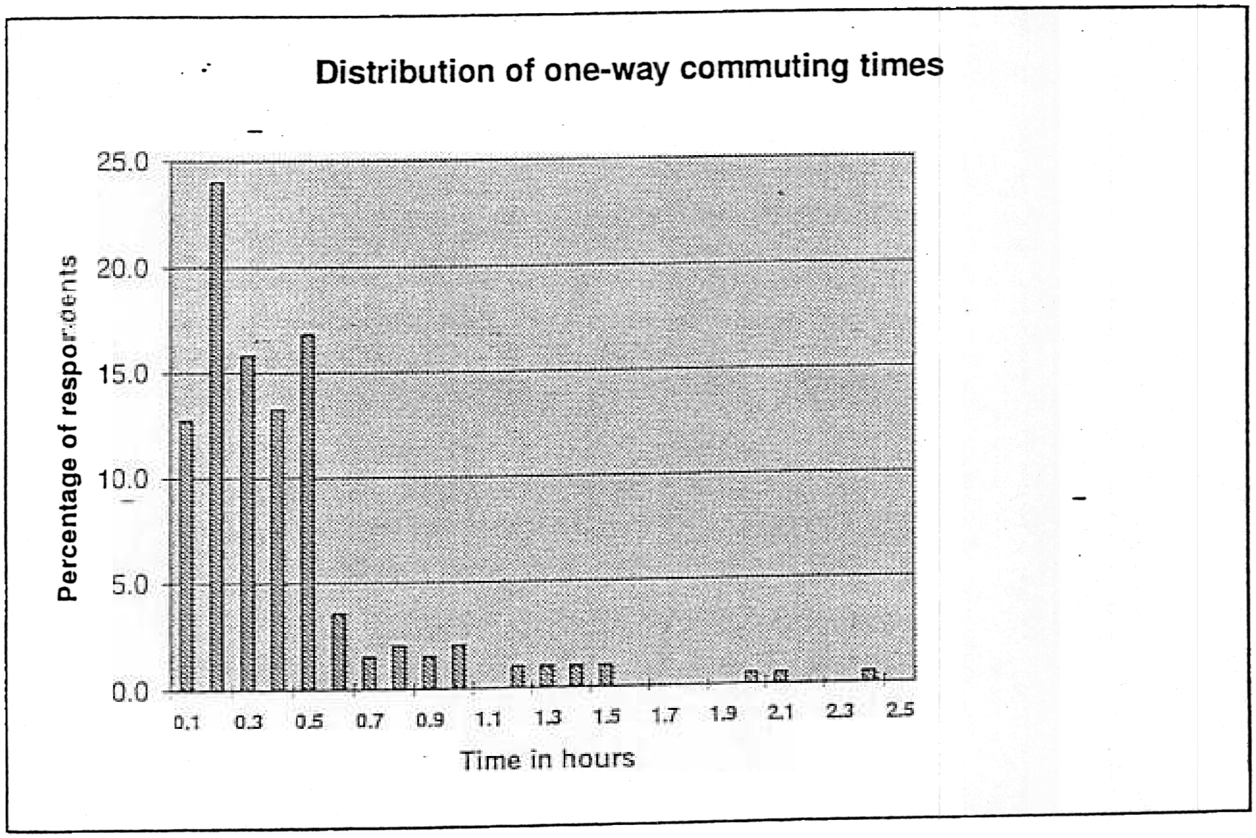


Figure 7-1. Distribution of One-Way Commuting Times

Because most of the respondents had short commutes, they chose not to report them in the timelines on their diary pages. Rather, this time was subsumed under personal time ("subject to call" on the way to work, "not subject to call," usually, on the way home). Hence, no meaningful averages can be calculated from the timeline data.

8. SUGGESTED MITIGATION MEASURES FOR STRESS AND FATIGUE

At the back of each diary were nine blank pages. As the diaries were distributed, each recipient was strongly encouraged by the author to write down his/her suggestions for the best ways to mitigate fatigue and enhance alertness. This space could also be used to describe problems or incidents that caused or aggravated fatigue and any other matters related to the issue. Most of the survey respondents made at least one or two suggestions. About 10% wrote more extensive comments, filling all or nearly all of the nine pages. The author developed a list of some 50 types of suggestions, which were grouped into three broad categories:

Regulatory/Labor Agreement

R1	Two qualified engineers in cab
R2	Longer minimum rest (10 or 12 hours)
R3	Limit hours on duty to 10
R4	Guaranteed right to mark off for fatigue
R5	Allow napping when safe to do so
R6	Guaranteed days off
R7	Standards for hotels, especially for noise
R8	Overtime pay for hours after 12 on duty
R9	"Alimony" after 12 hours at away terminal
R10	Limit maximum hours worked per month
R11	Minimum 8-hour call time
R12	No calls 1-8 AM
R13	More sick days
R14	More FRA safety inspections
R15	Less complex work rules

Management Initiatives

M1	Improve train line-up information system
M2	Improve calling system and caller training
M3	Improve dispatching
M4	Training/wellness/fitness programs
M5	Improve crew limo service
M6	More regular assignments
M7	Avoid running low-priority trains at night
M8	Move crew rest facilities away from yards
M9	Improve ROW maintenance
M10	Improve track signage
M11	Improve pre-trip preparation of equipment
M12	Fill vacant position/Increase personnel
M13	Better dead-head information
M14	Fewer dead-head moves
M15	Shorter districts
M16	Reduce bad-order cars in trains

M17 Better trained conductors
M18 Shorter/lighter trains
M19 Fewer terminal assignment changes

Locomotive Design

L1 Improve seat (comfortable for napping)
L2 Improve HVAC
L3 Reduce cab noise level
L4 Relocate horn to rear of locomotive
L5 Improve alerter
L6 Improve/clean toilet
L7 Improve instrument layout
L8 Aircraft headsets for radios
L9 Improve dynamic brakes
L10 Improve locomotive suspensions
L11 Improve windows (tinted)
L12 Improve wipers
L13 Improve visibility with more ditch-lights
L14 Improve defrosters
L15 Improve field of vision
L16 More cab signals

The suggestions contained in each of the diaries were then encoded along with other information from the header page. All of the suggestions that a given engineer mentioned were registered. Thus, some engineers "voted" for as many as ten items, while some voted for none.

Figure 8-1 shows the results of this poll. It is immediately apparent that measures to improve the accuracy with which an engineer can predict the time of the next job start are by far the most frequently mentioned. These include, first and foremost, more accurate train line-ups, followed by better crew-calling practices, better dead-heading information, and improved dispatching. These improvements depend largely on the efforts of management and are thus classified as "Management Initiatives."

In the group labeled "Regulatory/Labor Agreement," the three that stand out are: (1) the establishment of higher standards for away-from-home accommodations, especially with regard to noise; (2) the removal of prohibitions against napping in sidings; and (3) the qualification of other train-crew members as co-engineers so that the engineer can have some relief, especially on longer runs.

Among possible "Locomotive Design" improvements, heating and air-conditioning systems were the most frequently mentioned, followed by reductions in noise levels, and seat-design enhancements.

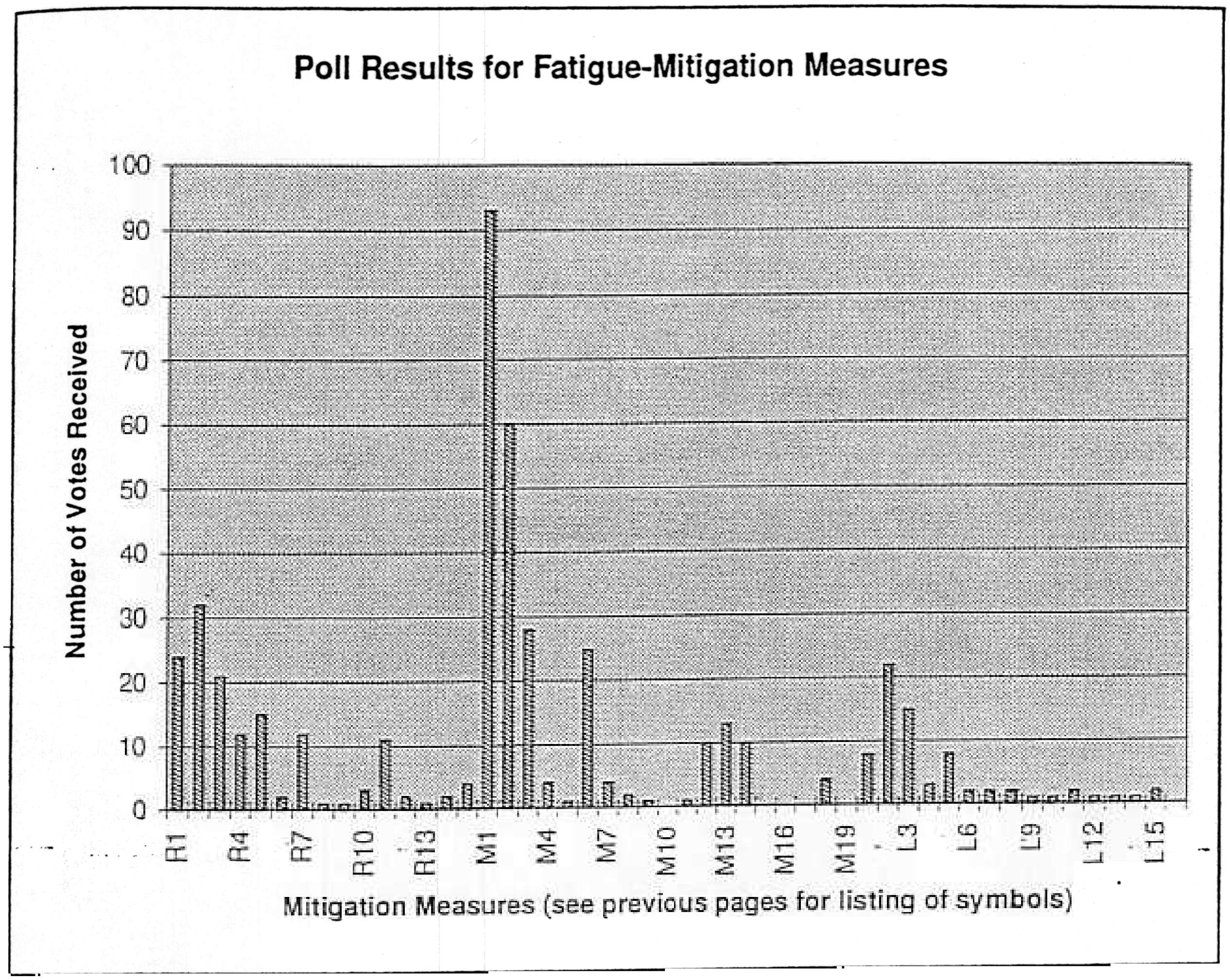


Figure 8-1. Poll Results for Fatigue-Mitigation Measures

9. ESTIMATING JOB-START TIMES

Since it became apparent early in the course of this study that uncertainty about job-start times was of paramount concern to engineers, much discussion with them focused on how their uncertainty could be quantified. The most workable method was that adopted for the second wave of diaries, collected in 1994. That method required engineers to make their best guesses about what time their next jobs would start each time they telephoned or otherwise interrogated their railroad's calling system. In their diaries, they wrote the time and date of the call, the time they estimated they would go on duty and the actual on-duty time (along with other information about the job), as illustrated in Figure 9-1.

Date: 2/2/94 Current Time 23:30

First Run Check if run started yesterday ☐

Times you called Railroad	Times you thought you would go to work based on this call
0700 2/2	12:00
1100 2/2	16:00

What time did the railroad call you? 12:00
Time reported for work 14:00
Time went on duty 14:00
Did you work out of turn? (y/n) N
Did you receive overtime or delay-penalty pay for this run? (y/n) N
Check if run continues tomorrow
Distance traveled (mi) 226
Time went off duty 23:00

Did another crew member take controls at any time?

Yes	No
	✓

Figure 9-1. Entry Form for Job-Start-Time Estimate

With the data described above, one can easily calculate an error value for each estimate, which is simply the absolute value of the difference in time between the estimated job-start time and the actual job-start time. To characterize the accuracy with which a group of engineers can estimate job-start times, scatter plots can be generated in which the horizontal axis represents the number of hours before an actual job start that a call about that job was made. The vertical axis represents the error values for those calls. The slope of a line fitted to the scattered points is an indicator of the accuracy of the information available to the group of engineers. The smaller the slope, the better the quality of the information.

Figures 9-2 through 9-7 show these accuracy indicators for the six railroads. For Railroads D and F, the number of data points is very small because the question did not appear in the diaries that their engineers received. However, some engineers receiving the original diary form took it upon themselves to record the times they thought they would go to work. These estimates were used in generating the figures for those railroads, although the numbers of points are too small to be of statistical significance.

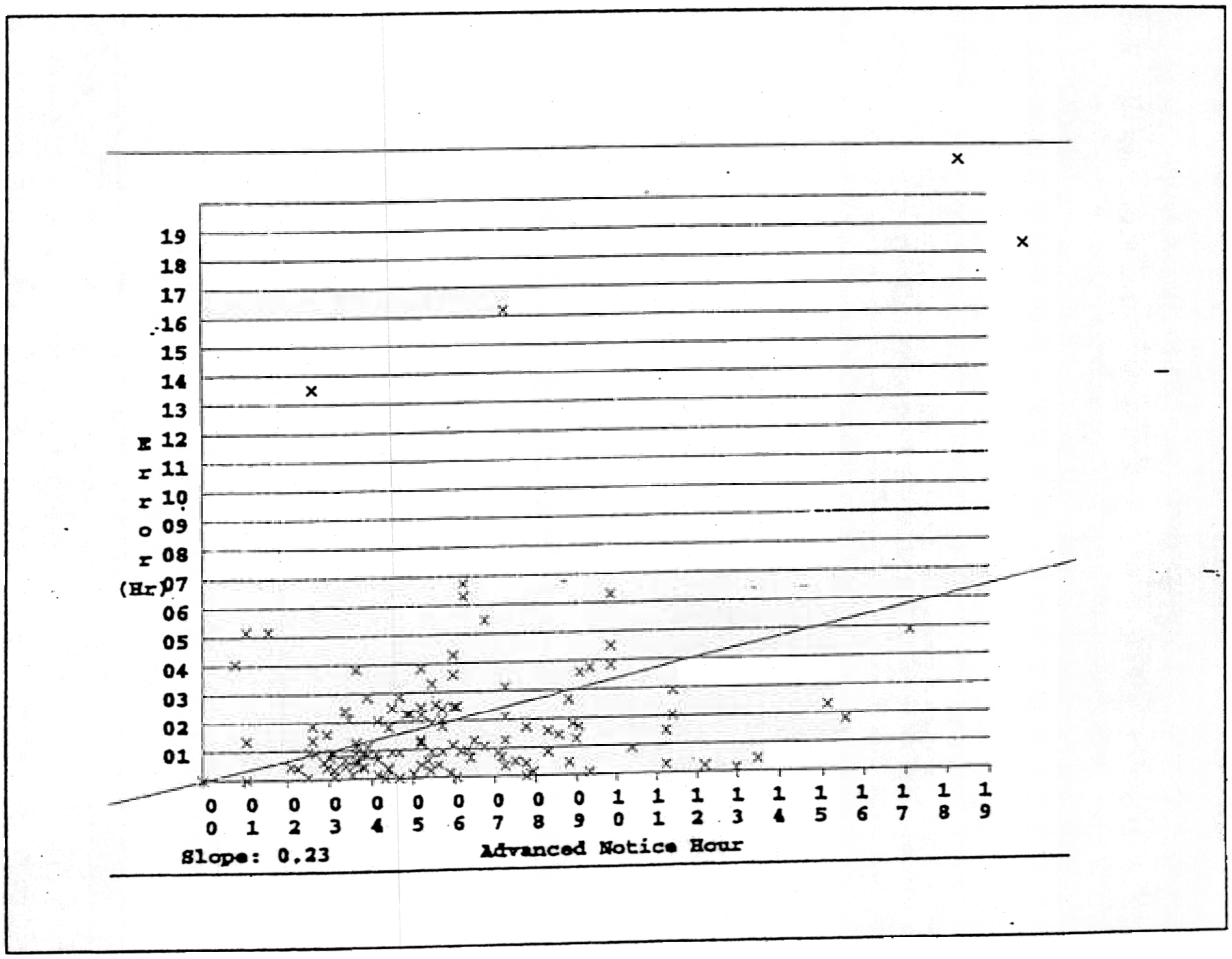


Figure 9-2. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad A

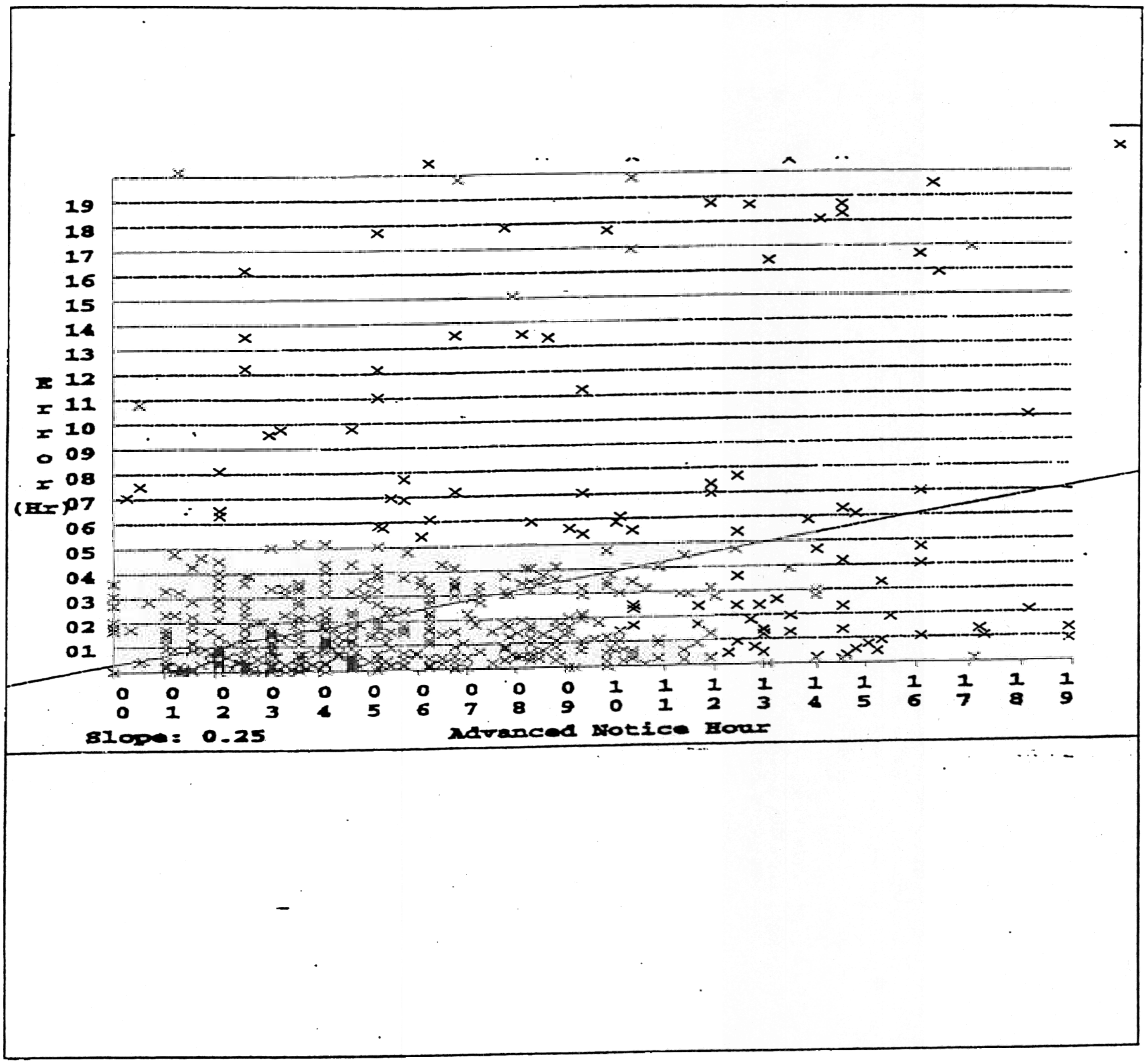


Figure 9-3. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad B

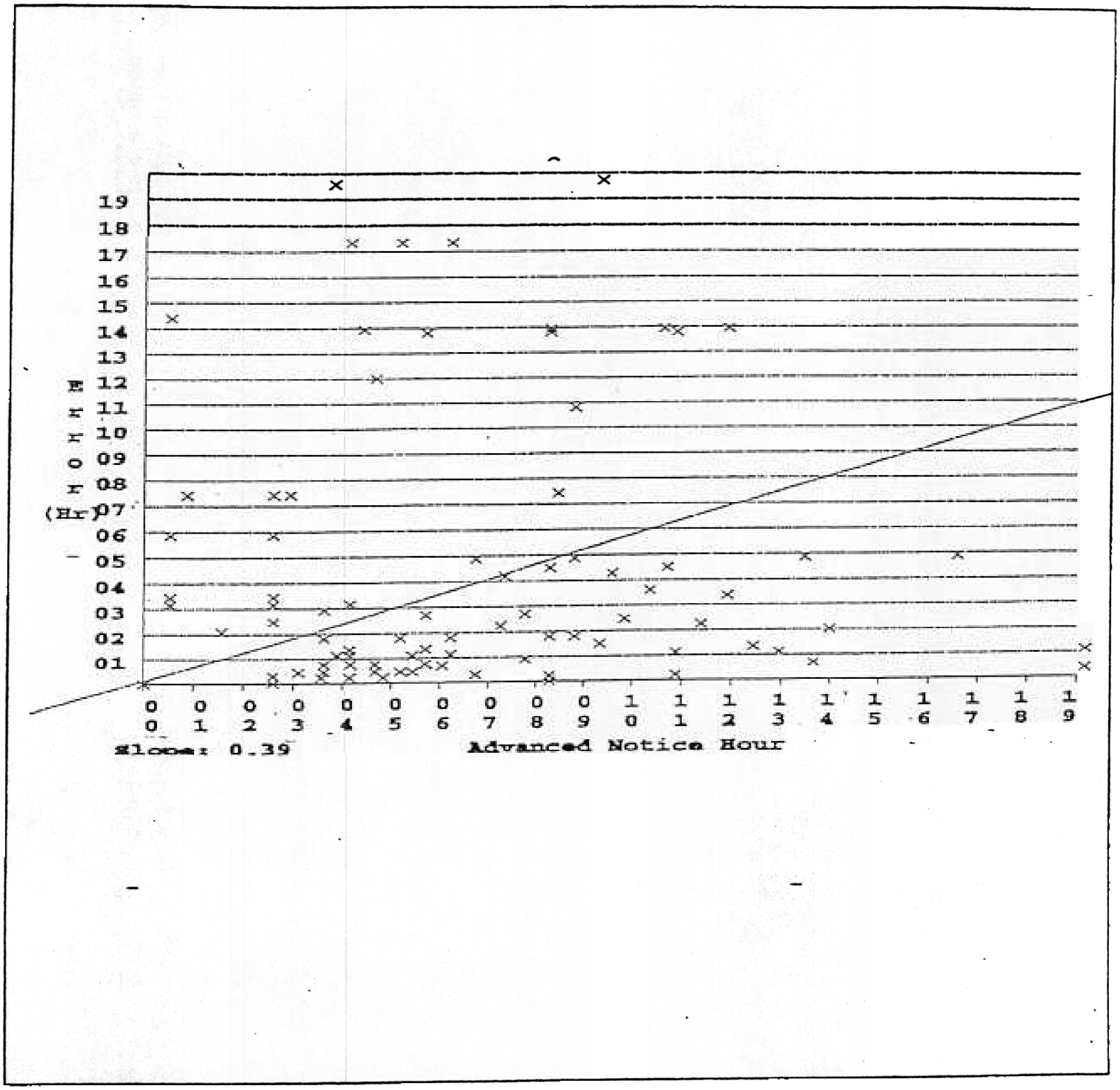


Figure 9-4. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad C

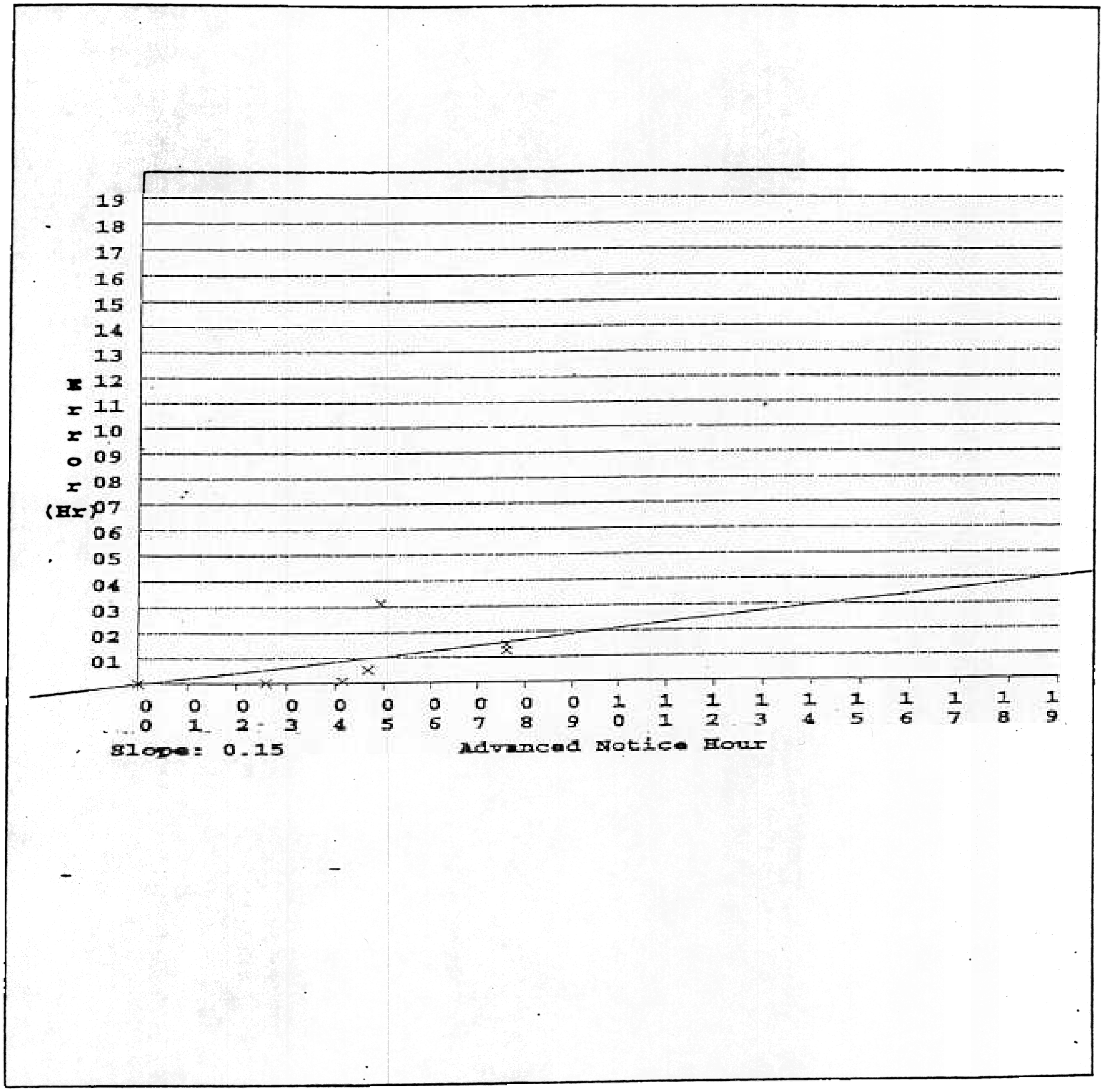


Figure 9-5. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad D

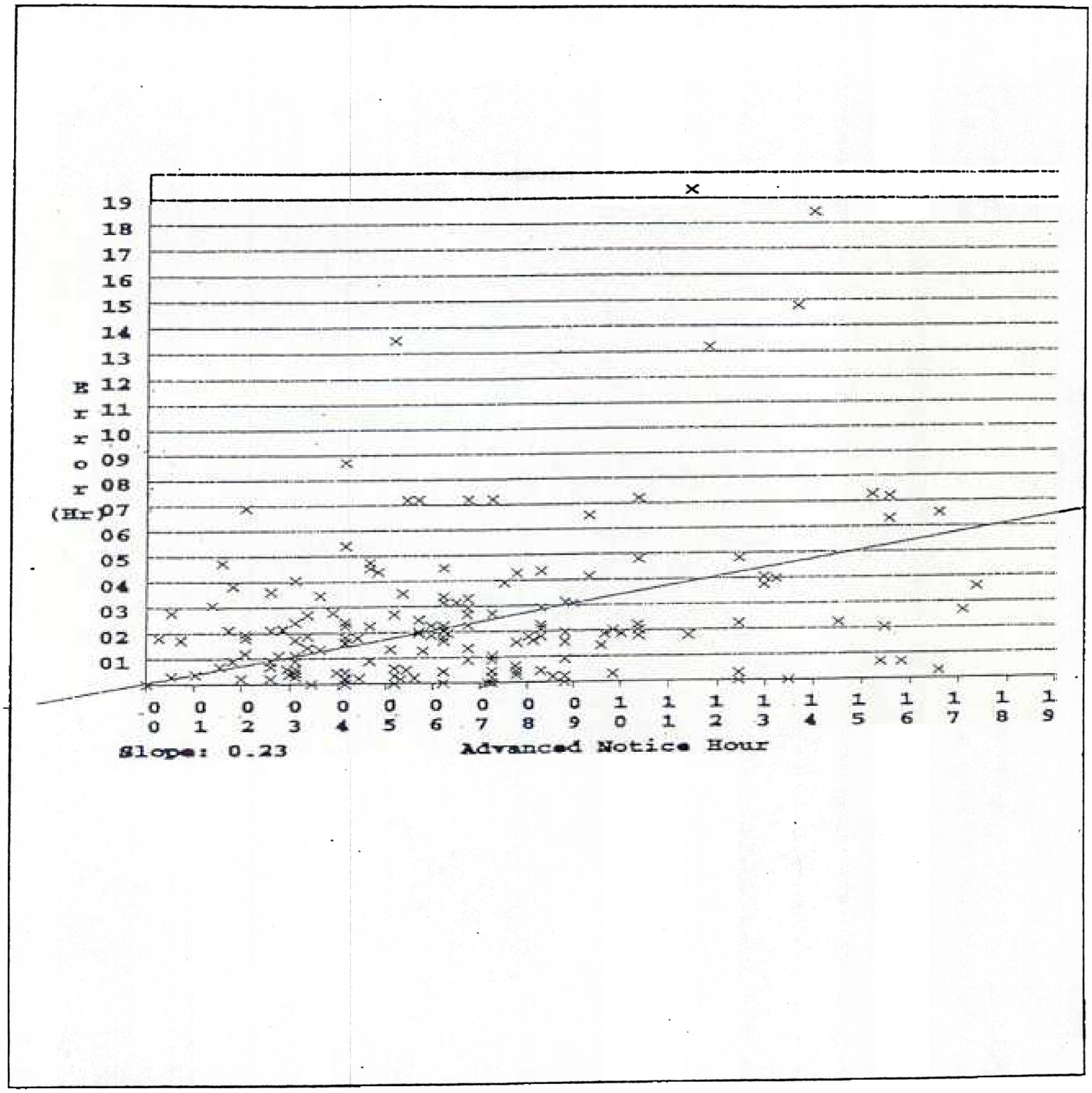


Figure 9-6. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad E

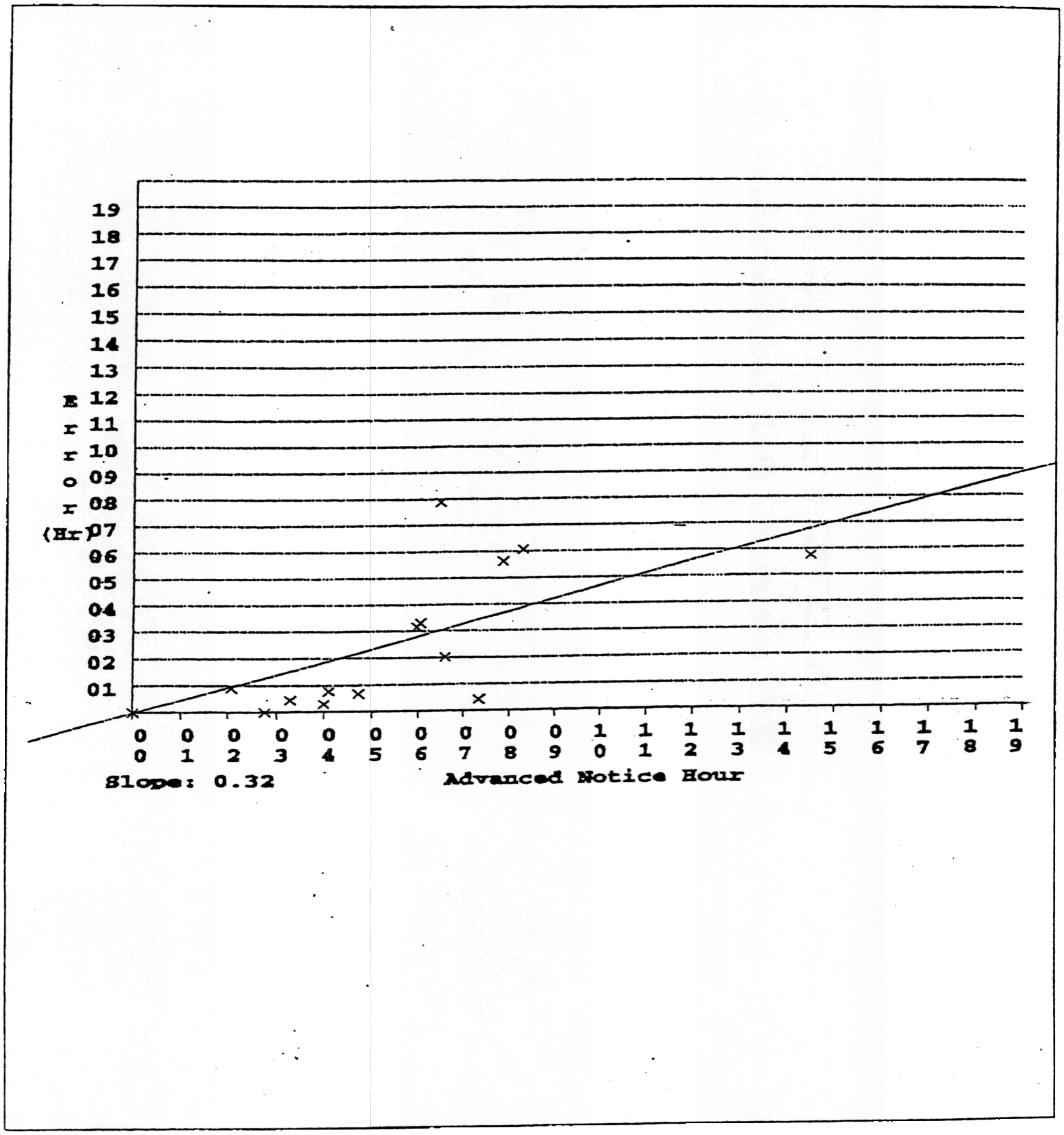


Figure 9-7. Errors in Estimated Job-Start Time vs. Hours before Actual Job Start, Railroad F

From the figures above, one can infer that the uncertainty in an engineer's estimate of next-job-start time increases about a quarter of an hour for each hour by which the time at which the estimate is made leads the time of the actual job start. For example, if an engineer is attempting to estimate the start-time of a job that will turn out to begin 24 hours after the time that the estimate is made, the uncertainty will be about plus or minus six hours.

Engineers on Railroad A faced the least uncertainty; the slope of their error line was only 0.23. On Railroad C they had almost twice as much uncertainty—a slope value of 0.39. The slope for Railroad D is only 0.15, but the number of samples is too small for this to be of any significance.

Although the figures above are labeled by railroad, the sample sizes are much too small to represent an entire railroad. Rather, they represent one terminal, or a small group of terminals. There is every reason to expect that there will be substantial differences between different terminals in the same system.

Furthermore, there are two possible sources of bias in these numbers. Although the diaries recorded about 1900 job starts, only about 800 of these starts had associated start-time estimates. It is clear that in many situations in which an engineer had a good idea as to when his next job would start, he had no reason to call the railroad or record an estimate. Thus, a large portion of calls that would have had small errors were never made. On the other hand, there were a large number of instances in which a call was recorded, but no estimate was made. Many of these were noted with remarks that the information provided by the railroad was insufficient to make a useful estimate of job-start time. Thus, there were also large numbers of calls that would probably have had large errors, had estimates been made.

9.1 Causes of Errors

Participants in this survey were encouraged to comment on the causes of train delays and other factors that upset their schedules. About one-tenth of the respondents made such comments, thus providing a sample of a few dozen such incidents. However, when it came to identifying the cause of the unexpected changes in train-departure times, the most frequent response was a question mark. Far too often, engineers simply did not know why the line-up or the pool-rotation had changed. The lack of feedback to them about such matters was the source of considerable resentment towards management. They often expressed suspicions of carelessness or sheer perversity on the part of the dispatching or crew-calling staff.

Changes that resulted in surprise early calls were much more likely to provoke a comment than late calls. Engineers are well aware of the numerous conditions that can delay trains, and are not surprised when they occur. They seldom bothered to comment on them. Furthermore, they seem to be able to cope with delayed calls by taking one or more naps in order to be at least somewhat rested when they finally depart.

A call that came several hours earlier than expected was the one most likely to result in a critical lack of sleep and an angry comment in a diary. When the cause was identified, it was most frequently unexpected dead-heading. Sometimes the reason for the unexpected dead-heading was given as "out-of-town crews not rested" (presumably because the trains on which they arrived were late), but most commonly the reason was unknown. It often seemed capricious to the engineers.

The third most commonly cited explanations for surprise calls were extra trains that appeared on the line-up, seemingly out of nowhere. Illness or other unplanned mark-offs were the fourth leading cause. Beyond that there were one or two mentions of such problems as marking up to a temporary vacancy and getting bounced out of it, derailments, and severe weather.

To provide the reader with further insight into engineers' perceptions of surprise calls, the following collection of anecdotes from the diaries is offered:

> I called work at 5:07 PM and was told I was two times out (due to take the second departure, if the pool is single-ended or the fourth train in a double-ended pool) and would work at 4:30 AM. At 5:08, an engineer laid off, which moved me up to work at 10:45 PM. No effort was made to call me so that I could get my rest for the 10:45 call. I was up 24 hours with no sleep.
>
> Upon tie-up on 9/17/92, we were told that there would be no deadheads to our home terminal, and that we could expect to go on duty at 15:30 on 9/18. At 06:00, the Chief Dispatcher decided to deadhead one crew by auto, so– we went on duty at 10:00. Fortunately, we'd had a good night's sleep.
>
> No line-up. Derailment (about a thousand miles to the east) this morning about 02:30. Still no line-up at 22:00.
>
> If the company fails to have enough crews at the away-from-home terminal, they can call an emergency and use home-terminal crews back-to-back until the away-from-home crews get rested. Then they call away-from-home crews back-to-back until the pool is back even again. This happens whenever business is lopsided. This can throw your estimate off by 12 hours.
>
> Noon & 16:00 taped line-ups listed me for about 05:00 on 10/3/92. 20:00 line-up, which I listened to at 20:50 listed me for a train at 23:00. That train had to be out of (a terminal 250 miles to the west) before 16:00, so it should have been on the line-up. Needless to say, I was short of sleep.
>
> Last night AVR said we would work at 06:00, but we weren't called until 15:00 for a 16:50 departure. Trip took four hours longer than normal, account CTC trouble and a bad unit we had to set out.
>
> This train was cleared for and would run 50 MPH, but caught a slower train 125 miles from home. Speeds ranged from 10 to 25 MPH for nearly six hours. There wasn't a relief crew available until 14:30 (twelve hours after time we had gone on-duty), so it was "stored en route."
>
> When I tied up on 5/1/93, my turn was 17 times out, so I should get the 34th train (one-for-one with away-from-home crews). I ended up with the 27th train, because there were not enough rested out-of-town crews.
>
> 4 times out on home board and 7th overall at 21:30. Don't know what happened!! (engineer was called at 22:50 for 00:20). Think RR used pool engineers to fill yard jobs, resulting in call much earlier than expected.
>
> Set up off turn to dog catch. Should not have been called until 22:00. (engineer went on duty at 18:20)
>
> 7/7/94 - When I was called at 13:30, I was told I was needed immediately for a piloting job. I accepted the short call and went on duty at 15:00. I then talked to the dispatcher of (the other railroad) who told me the rail grinder I was supposed to pilot was still 70 miles away. It didn't arrive until 19:00.

6/8/94 - Talked to crew management at 13:15 to see if anything varied from tapes such as deadheads or possible dog catches. Was informed nothing showing until 03:00, 6/9/94. Told them I would be out of pager range for 3 to 4 hours as long as nothing showing. Checked again at 14:30 and tape was the same. Pager went off 75 miles from home at 16:20 for 18:00 dog-catch call. Records show that the location of this train at 13:00 was such that a dogcatch was a sure thing. It was poor communication between dispatcher and crew management that caused me to almost miss a call and go to work without a nap.

5/17/94 - At 20:30 last night I was notified of being bumped off my regular job, which would have started at 07:00 this morning. Instead I am now starting at 23:59 tonight. 5/18/94 - 07:59 held over to double (work a double shift) for an engineer who got a flat tire.

Train #43825 has not existed for weeks, but still shows on the line-up; switch job 201G shows a daily vacancy, but has been filled. Crew callers have been told of these problems, but fail to take action. (Such errors can cause engineers to mis-estimate their positions on a board, if they are not careful.)

Called caller at 13:00. Was told I would get out about 21:00. Drove 2.5 hours to (my home terminal) arriving at 18:00 and went to bed thinking I would get out soon. Woke up at 22:00, still not ordered. Finally called at 01:45 for 02:45. Not rested because of too much anxiety over bad line-ups. At 02:45, train was still 60 miles west of town. Another bad call due to poor coordination between dispatchers. Train was called even though they had known work 56 miles west of town that would take at least an hour. We finally left town at 05:50 on a different train, with 3:05 against us on the H.S. Law. Fought sleep the whole trip.

"Computers were down" resulting in incorrect information on number of times out & line-ups.

6/20/94 - Deadhead by plane to (away-from-home terminal). Engineer had missed call; used me to protect ID service. Handled wrong; should have used someone out of inactive pool. Extra board should not be used for ID service when there are rested pool men in town. Notified at 13:30 that mistake was made and released to DH home at 18:40.

6/15/94 - at 08:30, I was called to DH at 09:30 to meet a weed sprayer at 13:00. Upon arrival at the meet point, I learned the sprayer would not arrive until 19:00. We did not start work until the next day.

Asked crew planner yesterday at 13:15 if I could DH home on train leaving at that time, since I knew a derailment had blocked the flow of other trains that could take me home. "No," was the answer. Some 20 hours later I was DH'd home.

On Sunday, the 13th, they DH'd four crews to (away-from-home terminal) by Amtrak. On Monday they DH'd three crews back to (home terminal) at 06:00. On Tuesday, they were going to DH three crews back to (away-from-home terminal), one of which would have been DH'd both ways. On Tuesday afternoon, they decided not to DH at that time, but at mid-night -- three crews, all of which would be the same three crews that DH'd home. Later they decided to DH just one crew, which was just ahead of the three that were supposed to DH earlier in the day.

3/13/94 - used off regular assignment to fill in for yard engineer, because extra board was exhausted. No clue on line-ups that this was going to happen.

Was called at 07:35 and told to report for yard job at 13:00. Call busted at 11:05, no work today.

At 07:00 showed for about 15:00. Kept waiting and not sleeping. Had about decided to mark off at 22:30, but found out from crew dispatcher that a very good mileage run was first out. Decided to go for the money at 00:30.

They said I was lost in the computer and assigned to a regular job. (respondent was on the extra board)

Called out of turn because no rested extra-board engineers available.

(an extra-board engineer:) I was first out from 07:00 on 3/20/94 until 09:30 on 3/21/94. At 07:00 on 3/20, they told me I would work at 11:45, then they told me 15:30. I waited all day and all night for the phone to ring.

Checked computer at 11:00; it was not working, as happens most weekends. Called line-up number at 13:00; it was not working. Called crew dispatcher at 13:45; rang for three minutes, no answer. Called line-up number at 14:45; found I was first out.

Yardmasters in .... never give out any information about when they will offer a train.

One engineer attached a seven-page, type-written letter to his diary, which dealt with several sources of stress and fatigue. The portion of that letter that describes the principal causes of uncertainty in his pool is reproduced below:

"I believe most employees check their turns on the board in the morning when they wake, and again in the early evening, until they get close to being called to work. At which time they monitor their status more frequently and plan their remaining time accordingly.

"The problem I see, that affects this situation the most, is related to the way the carrier regulates the running of the crews.

"The (department within the crew management system) that is in charge of deciding which crews to run on which trains does a very poor job of keeping the ratios even. They allow one district to fall so far behind on the ratio board, that the only way to catch them up is to 'fleet' crews, i.e., to run several crews from the same district in a row, instead of alternating districts as they should. The result of this type of regulation is that it only makes things more out of balance, because it creates a shortage of one district's crews at the other end of the road. And therefore even more 'fleeting' is done at that end, because of the shortage of rested crews.

"Secondly, (there is) total uncertainty as to how many times out your turn actually is. For example, lets say an employee gets up in the morning and he is second out. He listens to the line-up of trains to run and understands that the fourth train to run, the one he figures he stands for, is to run around noon. That employee will plan his day accordingly. He will do whatever chores or errands that need to be done, pack his bag and prepare to go to work early in the afternoon. What he could not know is that (crew balancing) has decided to 'fleet' crews from the other pool on those first four trains. So when noon or one o'clock rolls around and our employee is not yet called, he calls (crew management) again and finds out he is still second out and still stands for the forth train, but now the fourth train is on the line-up for early evening. Couple this with our notoriously poor line-ups and this employee, who planned to go to work around noon, ends up going to work around midnight. If he had known this was going to happen, he would have planned his rest accordingly.

"Now lets look at it from the other side of the situation. Our employee checks his turn around six o'clock PM, and finds he is six times out. Listening to the line-up, he hears that the twelfth train is figured to run around six o'clock AM. So he spends his evening playing ball with his sons, mowing the lawn, or whatever. Our employee goes to bed around ten o'clock, expecting to get eight hours of sleep. What our employee did not know was that (crew balancing) has decided to 'fleet' our employee's pool on the next half-dozen trains. As a result, he is called around midnight to go to work, totally unrested. If he had known this was going to happen, he could have gone to bed right after dinner.

"(Crew management and crew balancing) have staunchly refused to cooperate in the area of better regulation of calls. As a matter of fact, they won't even make an attempt to keep the affected employees informed of how they are going to run crews.

"At one point in the past, (engineers) offered to help regulate the ratio board and showed (crew balancing) how it could work. (Crew balancing) refused the help, and things have continued to run poorly ever since."

That engineer's comments were echoed by several others at his terminal who also complained of the unwillingness of crew management to accept offers of help from engineers in dealing with the problems in balancing ratio boards. Some reported that the system had been made to work well for a period of a few weeks, but deteriorated as soon as there were no longer any engineers on site working with the balancers.

Brotherhood of Locomotive Engineers

STANDARD BUILDING
CLEVELAND, OHIO 44113-1702
TELEPHONE: 216/241-2630
FAX: 216/241-6516

W. C. KEPPEN
International Vice-President

September 25, 1992

TO ALL LOCOMOTIVE ENGINEERS GIVEN THE OPPORTUNITY TO PARTICIPATE IN THE FRA-LOCOMOTIVE ENGINEERS ACTIVITY DIARY STUDY.

Dear Sisters and Brothers:

By now many of you are aware that representatives of the Federal Railroad Administration (FRA) are circulating report forms referred to as a LOCOMOTIVE ENGINEERS ACTIVITY DIARY. This record keeping device is a continuation of an earlier effort by the FRA to collect data on work/rest cycles. Such information is important in determining the effects of your work and off-duty environment on your ability to report for work in a well rested state.

As many of you know, this is an area of deep concern for the Brotherhood of Locomotive Engineers (BLE) and, as such, we would like to encourage your dedicated participation in this and any other effort in the area of fatigue related studies. I have reviewed the activity diary and I am confident that the data obtained through this effort will be used for its stated purpose. Your General Committees and the International Division will continue with their efforts and activities related to these subjects, but there are certain things we cannot do for you, this is one of them.

Please give serious consideration to participating in this effort and to faithfully completing all information requested in the booklets. As noted on the inside cover of the diary; your reports will only be seen by the research team and the results will be reported only in summary formats, ..."your identity will not be revealed.".

Thank you for your participation in this effort, I remain,

Fraternally yours,

W. C. Keppen

William C. Keppen
Vice President

LOCOMOTIVE ENGINEER'S ACTIVITY DIARY INSTRUCTIONS

1. Please fill in the information about yourself at the beginning of the diary right now. If you have any questions, ask your local chairman or call me toll-free: (800) 845-0194. Or write me at:

John Pollard, DTS-45
U. S. Dept. of Transportation
55 Broadway
Cambridge, MA 02142

Or FAX me at (617) 494-3622. I am generally in the office 9:30 to 6:00 eastern time, but the toll-free line is in an unoccupied lab, so you'll probably get my answering machine. If you do, I promise I'll call you back as soon as I can.

2. The diary should be kept for a straight 14-day period. Please bring your diary up to date at least once a day **INCLUDING DAYS WHEN YOU DID NOT WORK.** The diary should run continuously for 14 calendar days. Be sure to record your sleep time on days when you are marked off for any reason (sick, vacation, training, scheduled day off, etc.).

3. For each day, we would like to know how you spend your time according to the six categories listed:

-Sleep at home (1)
-Sleeping away from home (2)
-Working, including deadheading (3)
-Commuting to and from your railroad job (4)
-Personal, not subject to call, that is, everything else you do while you are marked off or during your mandatory rest period (5)
-Personal, subject to call, everything else you do while you are subject to call or already called but not yet on duty (6)

Each time you change from one kind of activity to another, mark a line at that time and write the code number for the new activity at the end of the line. Pages 2 and 3 of the instructions show a couple of examples filled out. During your working hours only, write down a code number for how alert you feel at the start of the run and about every two hours thereafter.

EXAMPLE OF A DAY STARTING AT HOME

	Enter exact times in 24 hour format	Enter Activity Code
0:00		1
1:00		
2:00		
3:00		
4:00		
5:00		-
6:00	0630	6
7:00		
8:00		
9:00		
10:00		
11:00		
12:00	1330	4
13:00	1400	3
14:00	1	
15:00		
16:00	2	
17:00		
18:00	3	
19:00		
20:00	4	
21:00		
22:00	2300 3	4
23:00		

Activity Codes:
1= Sleep at Home
2= Sleep Away
3= Working
4= Commuting
5= Personal, not subject to call
6= Personal, subject to call

At the start of each run and about every two hours during the run, write in a code for how alert you feel.
1= Fully Alert
2= Moderatly alert
3= Drowsy
4= Fighting sleep

In your last rest period, were you able to go to sleep:
- Easily ✓
- Slight difficulty
- Moderate difficulty
- Great difficulty
- Not at all

In your last rest period, were you able to stay asleep:
- Easily ✓
- Slight difficulty
- Moderate difficulty
- Great difficulty
- Not at all

How well rested were you when you last awoke?
- Well rested
- Moderately rested ✓
- Slightly rested
- Not at all rested

EXAMPLE OF A DAY STARTING ON DUTY

	Enter exact times (24 hour format)	Enter Activity Code
0:00	3	3
1:00		
2:00	4 03:15	4
3:00	0330	2
4:00		
5:00	– –	
6:00		
7:00		
8:00	7:55	5
9:00		
10:00		
11:00		
12:00	12:00	2
13:00	13:00	
14:00	2	
15:00		
16:00	3	
17:00		
18:00	2	
19:00		
20:00	2	
21:00		
22:00	3	
23:00		

Activity Codes:
1= Sleep at Home
2= Sleep Away
3= Working
4= Commuting
5= Personal, not subject to call
6= Personal, subject to call

At the start of each run and about every two hours during the run, write in a code for how alert you feel.
1= Fully Alert
2= Moderatly alert
3= Drowsy
4= Fighting sleep

In your last rest period, were you able to go to sleep:
- [ ] Easily
- [ ] Slight difficulty
- [x] Moderate difficulty
- [ ] Great difficulty
- [ ] Not at all

In your last rest period, were you able to stay asleep:
- [ ] Easily
- [x] Slight difficulty
- [ ] Moderate difficulty
- [ ] Great difficulty
- [ ] Not at all

How well rested were you when you last awoke?
- [ ] Well rested
- [x] Moderately rested
- [ ] Slightly rested
- [ ] Not at all rested

4. In case you had more than one sleep period that ended on a given day, please answer the sleep questions about the last completed sleep for that day. Please use 24-hour time format in your entries.

5. At the top of the second page for each day, please enter the date and time (24-hour format) you are filling in the information. If you are writing more than once a day in your diary, this should be the time of the last entry for the day.

6. For each run, including deadheads, please fill in the information requested. If you are working at midnight on the first run, then answer only the questions about the time you went off duty, distance traveled and whether any other crew member handled the controls. See examples on pages 5 and 6.

7. For the questions about times you called the railroad, please include as calls other means you have of getting information such as talking to other employees, computer terminals, etc. Likewise, for times the railroad called you, please include other means such as face-to-face notice.

8. Use the space at the bottom of the page for short comments. Whenever you are deadheaded, make sure to mention it in this space and describe any problems about that particular deadhead. Also use it to refer to longer comments in the pages at the back of the diary as shown in the examples.

EXAMPLE OF A RUN THAT STARTED THE DAY BEFORE

Date: 2/10/94 Current Time 23:30

First Run Check if run started yesterday ✓

Times you called Railroad	Times you thought you would go to work based on this call

What time did the railroad call you?	
Time reported for work	
Time went on duty	
Did you work out of turn? (y/n)	
Did you receive overtime or delay-penalty pay for this run? (y/n)	
Check if run continues tomorrow	
Distance traveled (mi)	226
Time went off duty	315

Did another crew member take controls at any time?

Yes	No
✓	

Second Run

Times you called Railroad	Times you thought you would go to work based on this call
0800	1100
1100	1430

What time did the railroad call you?	1130
Time reported for work	1300
Time went on duty	1300
Did you work out of turn? (y/n)	N
Did you receive overtime or delay-penalty pay for this run? (y/n)	Y
Check if run continues tomorrow	✓
Distance traveled (mi)	
Time went off duty	

Did another crew member take controls at any time?

Yes	No

Comments departure delayed due to traffic

EXAMPLE OF A RUN THAT STARTED ON THE CURRENT DAY

Date: 2/2/94 Current Time 23:52

First Run Check if run started yesterday [ ]

Times you called Railroad	Times you thought you would go to work based on this call
0700	12:00
1100	16:00

What time did the railroad call you?	12:00
Time reported for work	14:00
Time went on duty	14:00
Did you work out of turn? (y/n)	N
Did you receive overtime or delay-penalty pay for this run? (y/n)	N
Check if run continues tomorrow	
Distance traveled (mi)	226
Time went off duty	23:00

Did another crew member take controls at any time?

Yes	No
	✓

Second Run

Times you called Railroad	Times you thought you would go to work based on this call

What time did the railroad call you?	
Time reported for work	
Time went on duty	
Did you work out of turn? (y/n)	
Did you receive overtime or delay-penalty pay for this run? (y/n)	
Check if run continues tomorrow	
Distance traveled (mi)	
Time went off duty	

Did another crew member take controls at any time?

Yes	No

Comments

9. After you have finished the 14 days, please comment on any problems that may have adversely affected your sleep during the period such as illness, unusual weather, etc.

10. We would appreciate hearing any ideas you have about ways to reduce fatigue and stress among engineers.

11. If your diary is lost or damaged, please call me at (800) 845-0194, and I will mail another one to your home address. You can start a new 14-day cycle if necessary.

12. When you have finished, please return the diary to me in the postage-paid envelope provided. Also tear off this sheet of the instructions and fill out the back with U.S. Savings Bond ordering information using the full name (not initials) of the person who will own the bond (this could be your child, grandchild, etc.), social security number of the owner and address. If you order the bond as a present for someone else, fill in your name on the second line and your mailing address. If you wish to list a co-owner or beneficiary, fill in that line too. Return the bond order with the completed diary and you will receive a $50 U.S. Savings Bond. These bond orders will be processed in a batch, so it may take two or three months until you receive yours in the mail.

NAME OF OWNER : ____________________

(please spell out first name)

SSN OF OWNER:________________________________

DELIVERED IN CARE OF:________________________

(fill in only if different from owner)

COOWNER:____________________________________

ADDRESS:____________________________________

TOWN:_______________________________________

STATE & ZIP:________________________________

APPROVED FOR PAYMENT:__________________________

John K. Pollard

REFERENCES

1. Webb, Wilse B. 1992. *Sleep, the Gentle Tyrant,* Anker Publishing.

2. Moore-Ede, M. 1992. *The Twenty-Four-Hour Society.* Addison-Wesley Publishing, Reading, Massachusetts.