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RAILROAD SAFETY

Engineer Work Shift Length and Schedule Variability

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GAO/T-RCED-92-68

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to discuss our recent analyses of railroad accidents and engineer work schedules that are contained in our report, Railroad Safety: Engineer Work Shift Length and Schedule Variability.[1] We understand that the report will be released to the public today.

Before I discuss the results of our work, I would like to express my appreciation for the excellent cooperation provided by the railroad industry. The Association of American Railroads, the Federal Railroad Administration (FRA), and several railroads provided us with data that were instrumental to the successful completion of our work.

The length of engineer work periods is governed by the Hours of Service Act, which requires that railroad operating personnel may work no more than 12 continuous hours. After 12 hours, they must be given a minimum of 10 consecutive hours off duty. Furthermore, they must be given at least 8 consecutive hours off duty in every 24-hour period.

Our work focused on whether (1) railroads were complying with the Hours of Service Act, (2) shortening the maximum number of hours per shift allowed under the act would improve safety, and (3)

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[1]GAO/RCED-92-133, Apr. 20, 1992.

work schedule factors other than the maximum number of hours affect safety. Although we reviewed only engineer work schedules, both industry and FRA officials agreed that these schedules reflect the same conditions found in the schedules of other train crew members.

In summary, we found the following:

-- The four railroads we sampled were substantially complying with the provisions of the Hours of Service Act.[2] These four represent about 36 percent of the freight ton-miles carried by all U.S. railroads in 1990. We estimated that, 99.4 percent of the time, engineers were given at least 10 hours off duty following a work period of 12 or more hours. We found no instances in which an engineer received less than 8 hours off duty in any 24-hour period.

-- Our analysis of 1989 and 1990 accident data and sampled engineer work schedules showed that reducing the maximum number of hours allowed per shift from 12 to 10 may have little effect on the number of rail accidents that occur because only 4.5 percent of all human-factor-caused accidents in 1989 and 1990 occurred after 10 hours in an engineer's shift. We estimated that about 83 percent of

[2]We analyzed work schedule data from Burlington Northern; Atchison, Topeka & Santa Fe; Kansas City Southern; and Southern Pacific railroads. Unless otherwise noted, all our work schedule findings are expressed as estimates and apply only to these four railroads.

engineer work shifts at the four railroads did not exceed 10 hours, and the average work shift was about 8 hours long.

-- Start time variability---the change in work period start times from shift to shift---may be a more significant factor in train crew fatigue. We estimated that the start times for about half of the engineer work shifts at the four railroads varied by at least 2 hours and 30 percent of these shifts varied by at least 6 hours. On the basis of scientific research and our own analyses of engineer work schedules and accident data, we believe that start time variability, particularly when combined with early morning work hours, may intensify fatigue and reduce an engineer's ability to perform. For the four railroads, we estimated that the rate of human-factor-caused accidents was higher from 2 a.m. to 6 a.m. than at other times, and that engineers working these hours had pronounced start time variability.

Engineer fatigue is a factor that can influence performance negatively; we therefore urge caution in changing the Hours of Service Act. Changes that could introduce greater schedule variability and thereby increase the potential risk of fatigue, particularly in early morning hours, should be avoided. However, we cannot estimate compliance with the Hours of Service Act or engineer schedule variability beyond the four railroads in our review that account for 36 percent of U.S. freight rail traffic.

We are currently analyzing more extensive work schedule data that should allow us to estimate compliance for about 70 percent of the rail industry. We will also be able to explore in more detail the relationships, if any, between engineer schedules and accident rates. In our report, planned for issuance in early 1993, we hope to offer suggestions for improving rail safety through changes in the work- and operations-scheduling processes.

FOUR RAILROADS COMPLY WITH THE HOURS OF SERVICE ACT

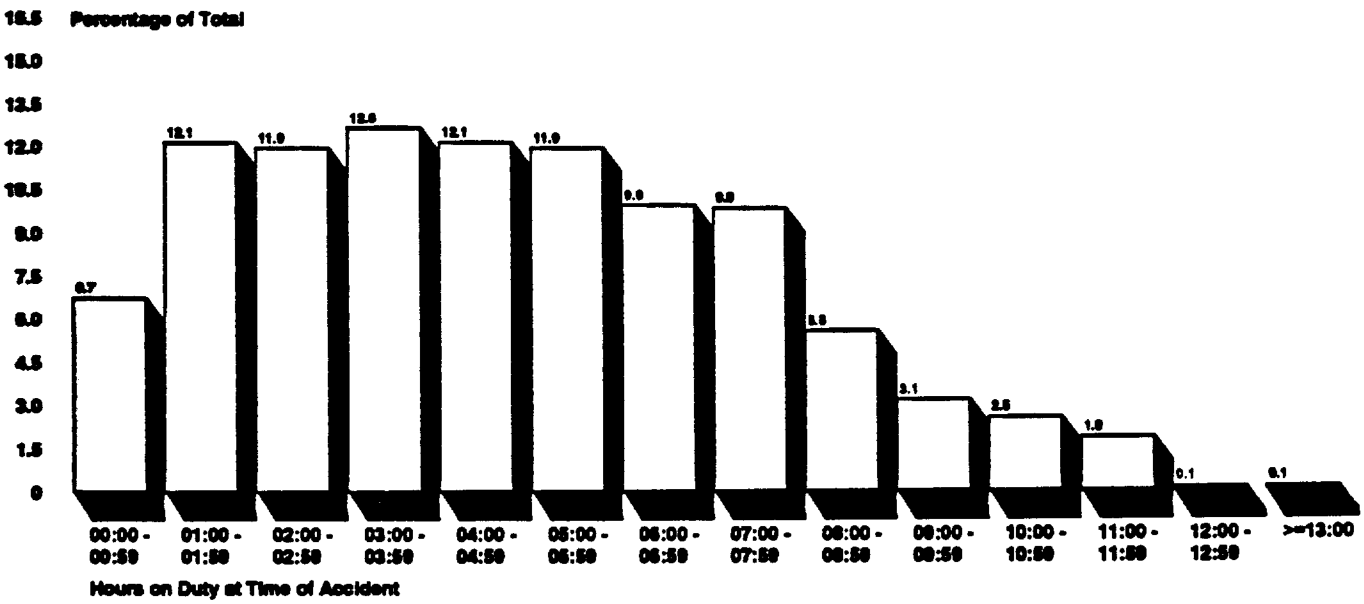
The four railroads we reviewed are essentially complying with the Hours of Service Act. As part of our analyses of engineers' work schedules, we tested the railroads' compliance with provisions of the act requiring that engineers who work 12 hours in a work period must have a minimum of 10 hours off duty. For the four railroads, we estimated that 3.1 percent of the work periods were greater than 12 hours, and that only 0.6 percent of the work periods greater than or equal to 12 hours were not followed by off-duty periods of 10 or more hours. We also tested the railroads' compliance with the act's requirements that engineers have at least 8 hours off duty in every 24-hour period. We found no instances in which an engineer received less than 8 hours off duty in any 24-hour period.

We found virtually no evidence that railroads were requiring engineers to stop working after 11 hours and 59 minutes to avoid the 10 hours rest requirement of the act. We estimate that less than 1 percent of the engineers' work periods lasting between 11 and 12 hours were followed by off-duty periods of less than 10 hours.

RAIL ACCIDENTS OCCUR EARLY IN ENGINEERS' SHIFTS

At the time we were conducting our analyses, the Brotherhood of Locomotive Engineers suggested that the longer engineers work, the more tired they become, and the more likely they are to have an accident. However, we found that human-factor-caused accidents do not often occur in the 10th and 11th hours of an engineer's shift. Our analyses showed that over 95 percent of the human-factor-caused accidents in 1989 and 1990 occurred before an engineer worked 10 hours in a particular shift. Furthermore, the highest accident frequencies appeared in the second through the sixth hours of the shift, as can be seen in figure 1.

Figure 1: Human-Factor-Caused Accidents, 1989-90 - Distribution by Hours on Duty at Time of Accident



Numbers may not add to 100 because of rounding.

Source: GAO analysis of FRA accident data.

The small number of accidents after 10 hours of work may be explained by the fact that most engineers work less than 10 hours in each work period. For the four railroads we studied, we estimated that about 83 percent of the engineers' work periods were no more than 10 hours long and that over 60 percent were no more than 8 hours long. Furthermore, our analyses of engineers' schedules during randomly selected 10-day periods in 1990 showed that most engineers worked about the same number of hours in total with about the same time off as regularly scheduled (e.g., 8 a.m. to 5 p.m.) workers. They began an average of 6.4 work shifts and worked an average of 47.7 to 53.4 total hours.

WORK SCHEDULE VARIABILITY MAY INCREASE FATIGUE

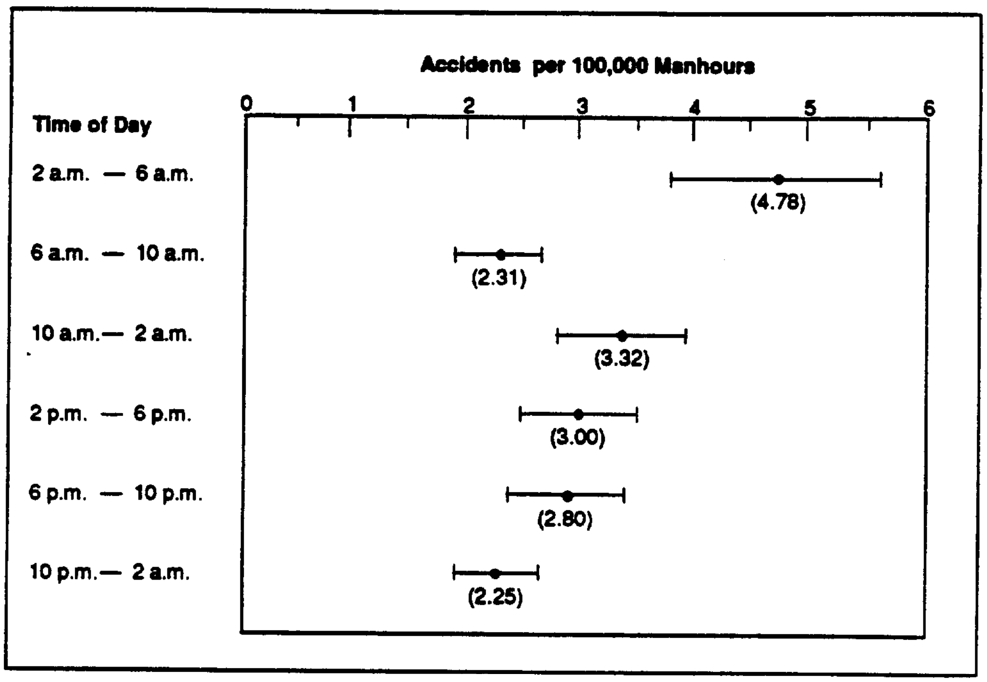
We believe that start time variability may increase fatigue for engineers. Especially when combined with other negative performance factors such as working during early morning hours, this variability may decrease performance.

While most engineers do not differ much from regularly scheduled workers in terms of the numbers and lengths of shifts worked, we identified a significant difference in the variability of work period start times. Regularly scheduled workers begin work at the same time each day and, as a result, experience no start time variability. On the other hand, we estimated that the start time for about half of the engineers' work cycles varied by at least 2 hours per work period for the four railroads. Furthermore, an estimated 30 percent of the start times varied by at least 6 hours.

As variability increases, start times can become quite erratic. For example, an engineer in our sample who had an average of 2 hours' variability over a 10-day period started consecutive shifts at 3:10 a.m., 1:35 a.m., 5:10 a.m., 5:25 a.m., and 1:55 a.m. Another engineer, with an average of 6 hours' variability over 10 days, started shifts at 8:30 a.m., 12:01 a.m., 5:15 p.m., 2:20 a.m., 8:30 a.m., 2:45 a.m., and 7:50 a.m.

In addition, we believe that accidents were more likely to occur in early morning hours for the four railroads we reviewed. In 1990 the highest number of accidents occurred in the 2 a.m. to 6 a.m. time period, and we estimated that the accident rate was higher in this period than at other times, as shown in figure 2. Our estimates also showed that the start time variability of engineers' work shifts that included hours between 2 a.m. and 6 a.m. averaged 4.3 hours (± 0.8 hours). Start time variability for shifts that did not include the hours between 2 a.m. to 6 a.m. averaged 3.6 hours (± 0.8 hours).

Figure 2: Accident Rate Estimates—Time of Day



Point estimates are in parentheses.

Note: Estimates were calculated from 1990 data from the four railroads included in our review.

Research has shown that work schedule variability can disrupt natural human sleep-wake cycles---circadian rhythms---and can lead to fatigue, even if a worker receives time to rest following a work period. At the same time, many types of performance have been shown to be less effective during early morning hours. For example, research on truck drivers and airline pilots, who may also have variable schedules, indicates that fatigue-related accidents are more likely to occur in the early morning hours.

A recent report by the Office of Technology Assessment (OTA) supports these research findings, stating that physiological changes caused by circadian rhythm disruption often interact with other stressors associated with variable work schedules--that is, fatigue, sleep deprivation, and social or family stress--to compound the effects on the performance and safety of the worker.[3] OTA also said that in some tasks--particularly monotonous ones, such as driving--circadian disruption may decrease performance and compromise productivity and safety.

While our findings showed that engineers have variable schedules and that research links such schedules to increased fatigue, many different factors can combine to cause human-factor-related accidents. These may include training, experience, traffic conditions, and the type and complexity of a route. Neither our own analyses nor other research could isolate or quantify to what

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[3]Biological Rhythms: Implications for the Worker, OTA-BA-463, Sept. 1991.

extent fatigue caused by variable schedules contributes to these accidents.

SHORTENING WORK PERIODS MAY INCREASE VARIABILITY

Because higher start-time variability appears to be a factor in causing fatigue, we analyzed the variability inherent in the current maximum-work/minimum-off-duty periods allowable under the Hours of Service Act. An engineer working a 12-hours-on, 10-hours-off work schedule would have a 22-hour work cycle and would experience a variability of 2 hours in every 24-hour period. Shortening the work period from 12 hours to 10 hours would reduce the allowable work cycle to 20 hours but would increase allowable variability within the normal 24-hour day to 4 hours.

In a worst-case scenario, engineers working this schedule could start work 4 hours earlier each time they came to work. With the current allowable 22-hour cycle, their start time would be only 2 hours earlier for each work period. (See table 1.) Shortening the work cycle allowable under the act could therefore increase variability, which, in turn could increase fatigue in engineers who regularly work 10-hours-on, 10-hours-off schedules.

Table 1: Allowable Work Schedules for 12-Hours-On, 10-Hours-Off Cycles vs. 10-Hours-On, 10-Hours-Off Cycles

Day	Start/stop time (12-on, 10-off)	Start/stop time (10-on, 10-off)
1	12 a.m. - 12 noon	12 a.m. - 10 a.m.
2	10 p.m. - 10 a.m.	8 p.m. - 6 a.m.
3	8 p.m. - 8 a.m.	4 p.m. - 2 a.m.
4	6 p.m. - 6 a.m.	12 noon - 10 p.m.
5	4 p.m. - 4 a.m.	8 a.m. - 6 p.m.
6	2 p.m. - 2 a.m.	4 a.m. - 2 p.m.
7	12 noon - 12 a.m.	12 a.m. - 10 a.m.

GAO IS CONTINUING TO ANALYZE ENGINEER WORK SCHEDULES

Our work to date suggests that, while railroads may be substantially complying with the Hours of Service Act, schedule variability may increase engineer fatigue. However, our review involved only four railroads and may not accurately represent the condition of the majority of the rail industry. We have obtained more extensive work schedule data from three additional major railroads. Together with the four we have already analyzed, these data will allow us to describe conditions for 70 percent of the 1990 freight rail traffic in the United States. We will also be able to explore in more detail the relationships, if any, between engineer schedules and accident rates.

In addition, there are important aspects of rail operations related to the differences between yard and road engineers that we were not able to analyze in our earlier work because of data limitations. With the additional data, we plan to explore the relationships between these types of engineers and the accidents they are involved in. We have also obtained detailed computerized data on every rail accident reported in the past 3 years to the Federal Railroad Administration. Because these data contain information about all types of accidents, we should be able to determine when in an engineer's work shift different kinds of accidents occur and whether there are meaningful differences in the characteristics of accidents involving yard and mainline engineers. When our analysis is complete, we hope to offer suggestions for improving rail safety through changes in the work- and operations-scheduling processes.

CONCLUSIONS

After analyzing human-factor-caused accidents, the time that these accidents occurred, and engineers' work schedules, we concluded that the length of the work period allowed by the Hours of Service Act may have little impact on rail safety. We also concluded that the variability of work period start times can lead to fatigue. When combined with other factors, such as work during early morning hours, variable schedules--some of which are rather extreme--may lead to decreased levels of performance.

Reducing the maximum number of hours allowed per shift from 12 to 10 would at best affect only a small percentage of rail accidents. More importantly, such a reduction has the potential for increasing schedule variability for those who regularly work such hours, which might actually contribute to increased fatigue and negatively affect performance. We therefore urge caution if any changes to the Hours of Service Act are considered that could introduce even greater engineer schedule variability and thereby increase the potential risk of fatigue, particularly in early morning hours.

We are now analyzing more extensive railroad accident and schedule data to (1) determine compliance with the Hours of Service Act for a larger portion of the rail industry, (2) more precisely describe the relationship between start time variability and accident rates, and (3) better understand whether reducing schedule variability may improve rail safety. We plan to report the results of our work in early 1993.

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This concludes my prepared statement. I will be pleased to answer any questions that you or the other Members of the Subcommittee may have.

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