CANALERT'95

Alertness Assurance in the Canadian Railways

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Appendices C, D, E, F
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CIRCADIAN TECHNOLOGIES, INC.

A Report on

"CANALERT '95"

A Study Into

Alertness

And

Fatigue

On

Canadian Locomotive Engineers

Acknowledgments

The Irish Locomotive Drivers Association would like to acknowledge the assistance received from Mr. George Hucker, Vice President and National Legislative Representative of the Brotherhood of Locomotive Engineers in Canada. Without which, this report could never have been completed.

Foreword

CANALERT '95 is a report on a study into Alertness and Fatigue on Canadian Locomotive Engineers and the countermeasures developed to lessen the effects of fatigue on these Engineers. While it is true that these Engineers work to a different rostering system than ourselves, this study is still of great interest to us. As you know from the previous report **"Fatigue, Do you suffer from it?"** it is excepted worldwide, that the nature of railway working requires that trains run on a 24 hour basis, 7 days a week, 52 weeks of the year. It was also proven that this type of work by its nature leaves Locomotive Drivers susceptible to bouts of fatigue, severe stress and digestive disorders.

Fatigue has been endemic to the round the clock operations of railways for their entire history and has characteristically been managed by a combination of, hours of work and rest regulation, collective bargaining, on-board automated warning devices and disciplinary action. However, none of these approaches has addressed the root causes of Locomotive Driver fatigue and as a result, fatigue continues to remain a significant safety hazard on the Railway.

When charged with the duty to enhance Railway safety by addressing concerns about excessive driver fatigue, in an enlightened approach, Transport Canada (the Regulatory Body), invited Canadian Pacific, Canadian National and VIA Railways in conjunction with the Brotherhood of Locomotive Engineers, to evaluate alternative approaches to ensuring alertness on the footplate. As a result of this enlightened approach, a company called Circadian Technologies Inc., was contacted and given the opportunity to apply to the railway industry, it's experience in developing and implementing fatigue countermeasures. The result was CANALERT, a comprehensive program developed by Canadian Railways and Unions with the support of CTI, which applied current scientific knowledge to solve the practical problem of Locomotive Driver fatigue. The report on the results of this program is called CANALERT '95.

A complete copy of this report has been sent to each of the Associations seven Divisional Secretaries and will be, on request, available for loan to any Association member.

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Canalert '95.

As we already know, those of us involved in the Railway Industry are highly susceptible to accidents and errors brought on by fatigue and loss of alertness. We are also susceptible to severe stress and ill health. The reason for this is that the Railway Industry is different from all other occupations because of several operational factors. From experience, we know that we are required to operate train services 24 hours a day, with rostering which can be classified at best as "irregular" and at worse "unnatural". As drivers we are required to sustain high levels of alertness over long duty periods. The factors which influence alertness have been well documented. They include the cycle of our biological clock, the duration, quality and timing of our previous sleep period and finally, individual differences such as age and any medical differences. These factors directly and indirectly affect a driver's ability to be alert and attentive in his work place.

Down through the years various different approaches have been made to try and improve alertness within the Railway Industry. Each of these has been found to have it's own inherent faults;

- **Regulation of Hours of Work and Rest;** These do not and cannot take into account many of the physiological factors described above.

- **Disciplinary Action;** Fails to address the problem of alertness because it treats it as a disciplinary issue when it is in fact a physiological one.

- **Reliance on the "Iron Man" Syndrome;** supposes that alertness can be maintained through sheer force of will. This is simply just not the case.

- **Dependence on In Cab Alerter Technology (Vigilance Systems and C.A.W.S.);** These fail to ensure alertness because it is possible to operate these devices without conscious thought (Automatic Behavior). It is also possible to drift into microsleeps between alarms, awakening only long enough to reset the device.

- **Collective Bargaining;** fails to address the issue since alertness cannot be negotiated. There are physiological imperatives which must be respected if alertness is to be assured. Relegating these safety issues to the bargaining table invites incomplete and inadequate solutions.

- **Treating the issue as a Medical Problem;** Does not acknowledge the fact that the task of operating in a 24 hour environment poses significant challenges to all Drivers, not simply those suffering from a medical disorder. For example, in the course of this project, 92% of the participants reported having been awakened by one of the in-cab alerters at least once while operating a train.

Physiological Determinants of Alertness.

A number of independent variables which influence alertness have been well documented in both laboratory and field studies. Therefore any study involving alertness assessments in the Railway Industry must take into account their role in determining alertness at any given time in the operators' schedules.

Time of Day (Phase of Circadian Pacemaker).

One of the most important determinants of alertness is the time of day, or more accurately, the biological clock time (circadian phase) of the individual. For most people synchronised to the normal day / night schedule, the nadir, or low point of alertness, is between 3 a.m. and 7 a.m. this is the time of nocturnal body temperature minimum. This nadir in alertness coincides with the time of day during which most railway collisions attributed to fatigue occur. Most people experience a second low point of alertness in the early afternoon. Although this secondary low is commonly called the "post-lunch dip" it occurs even when lunch is not eaten.

Elapsed Time since Last Consolidated Sleep Period.

In addition to these circadian factors, alertness also tends to deteriorate as a function of time since the last sleep period. In a person on a normal day/ night schedule the reason why alertness levels are still relatively high in the late afternoon, after about 10 hours of wakefulness, is because this time of day coincides with the peak of the circadian curve. In other words, as the time-since-last-sleep effect brings alertness down, the time-of-day effect brings alertness up. When the hour of habitual sleep approaches, both the circadian and the homeostatic influences (length of prior wakefulness) work together promoting sleep. This is why alertness and performance deteriorates rapidly after 16-20 hours of continuous daytime wakefulness.

Duration Period of Last Sleep

Reductions in nocturnal sleep length cause systematic reductions in alertness levels on the following day. These reductions need not be extreme for their effect to be felt. For example even after 6 hours of sleep, the performance of a Driver is impaired when compared to that of a Driver sleeping 8 hours.

Quality of Last Sleep Period.

The quality of the last sleep episode, measured by sleep efficiency, fragmentation (number of awakening episodes) and by sleep architecture (REM characteristics) also determines the alertness during the next day. Therefore, a disturbed sleep period in a bedroom which is noisy and insufficiently dark during daytime hours can significantly affect a Locomotive Drivers alertness on his next turn of duty.

Timing of Sleep Periods.

Another factor affecting alertness is the timing of sleep periods. Daytime sleep is considerably less recuperative than nighttime sleep for a variety of reasons. Sleeping out of phase with your circadian clock results in shorted sleep episodes. Sleep organisation is also affected i.e. Both stage 2 and REM are reduced. This already fragile sleep is more likely to be disturbed by

ambient factors, such as light, temperature, and sound disturbances, which are more likely to prevail during daytime hours. Consequently locomotive drivers experience poorer quality of sleep during daytime hours, which leaves them less refreshed on waking. This can result in chronic sleep deprivation and increased fatigue.

Regularity or Irregularity of Sleep Periods.

The more sleep is regular, that is, the more it is taken at the same time with respect to the circadian cycle of the individual, the more it is efficient (i.e. less sleep is needed to achieve a given level of alertness and performance). The irregular work schedules of locomotive drivers cause disruption in their sleep regularity as well as in their waking performance and alertness levels. The circadian system is not able to adapt instantaneously to the changes imposed by work schedules. This is especially relevant when schedules are made very irregular, as is the case with locomotive drivers. Moreover, the adaptation is made more difficult by the tendency of drivers to return to diurnal orientation (active during the day and sleeping at night) during their days off for family and social reasons.

Cumulative Effects of Sleep Restriction.

Alertness is also reduced as a result or the cumulative effect of consecutive nights of sleep restriction (nights of shortened sleep). When sleep is reduced to 4 or 5 hours per night on a sequence of seven consecutive nights, the alertness gradually drops on each consecutive day from the first to the seventh. Therefore, in railway operations, the cumulative effects on alertness of reduced sleep time each day must be considered when determining the overall effects of a schedule which limits sleep opportunities and / or sleep duration.

Physical Work Environment.

Environmental factors also contribute to the maintenance or loss of alertness on the job. Light levels, ambient noise, temperature and vibration all play a role in this equation. Noise has been found to affect performance and make communication difficult: vibration makes it difficult to read "control panels". Both factors are present in locomotive cabs and are likely to effect performance. An overly warm locomotive cab can induce sleepiness as can the vibration and droning of an engine at a high throttle setting. On the other hand, cool air, music with a beat, or an interesting conversation can stimulate a fatigued individual.

Recognising the Need for a Cultural change.

As has been already noted, fatigue in railway operations has been a persistent problem since the 1800's. It is a fact of life in railway operations, and a culture has developed which keeps the problem hidden, not through an overt cover-up, but rather because fatigue is so prevalent that it simply goes unnoticed.

Fortunately, there is now a growing awareness, worldwide, of the fatigue problem in the railway industry, and the fact that viable fatigue countermeasures can be developed which offer the promise of significant improvements in safety, health, and human performance.

Reducing Driver fatigue requires a fundamental change in cultural attitude to one where the realities of the problem are acknowledged and openly discussed, and where a joint Union / Management commitment is made to systematically address the root causes of fatigue.

Study Design.

Before any countermeasures could be developed and tested, an evaluation of the baseline levels of alertness in Locomotive Drivers had to be determined.

In evaluating the countermeasures there were three key questions to be answered;

1. Did each of the countermeasures work operationally.

2. Did the combined set of countermeasures result in reduced fatigue and increased alertness.

3. How did each countermeasure contribute to the overall effect on Locomotive Drivers' alertness.

Forty volunteer Drivers were recruited from 2 sub-divisions (depots), Calgary and Jasper. They were committed to the project for a total of 6 months, which included;

a. 1 month of baseline testing.
b. 3 months of countermeasure implementation and adaptation.
c. 1 month post – countermeasure testing.

The sixth month was available for any driver who wished to remain in the program after the completion of the countermeasure evaluation testing.

Drivers were asked to keep a record of their sleep-wake-work patterns in a sleep-wake-work log book. Each day during the 1 month of baseline testing and each day during the 1 month of post-countermeasure testing, the Drivers were asked to record their times off duty (awake, asleep.) and times on duty (driving, not driving) in intervals of 15 minutes. They were also asked to rate the quality of their sleep at home. Their activity/rest patterns were also continuously recorded by wrist activity monitors through out each of the testing periods and acted as an objective validation to the information provided in the sleep-wake-work logs.

Each Driver also agreed to be "wired up" to a portable EEG (brain wave) recorder for 3 round trips, selected at random, during both the baseline and post countermeasure testing periods. Naturally, no prior notice of a "wired up" trip was given, so the Drivers could not specially prepare themselves for the following days study. This way, the researchers obtained a realistic snapshot of the drivers' lifestyles and their alertness levels. Electrophysiological measurements were continuously recorded for the entire trips using portable recorders. These recordings were used for measuring, drowsiness, analysing microsleeps, analysing naps, and for evaluating pre- and post run alertness of Drivers. Sleep architecture was also analysed, with particular attention paid to the measurement of disruption of sleep continuity.

Evaluation of Baseline Alertness Levels.

Prior to implementation of the countermeasures, the alertness of the Drivers in each of the two locations, Calgary and Jasper, was determined during the baseline evaluation period.

On duty alertness measures showed a clear "time of day" effect. As would be expected, alertness was highest for daytime departures and lowest during the early part of the night. On arrival drivers were more sleepy in the latter part of the night and early morning hours. Analysis of the sleep logs indicated that while the total amount of sleep was not much different from that of the general population, sleep per day averaged 7.25 hours, sleep was

frequently split into two or more episodes per day. Because of this it was found that temporary sleep deprivation was a problem on some working days.

While operating trains, extreme sleepiness was particularly observed at night. Drivers in Calgary reported that they "nodded off" on 46% of the outbound runs and 37% of the inbound runs. Drivers in Jasper reported fewer runs with "nodding off" episodes, reporting episodes in 29% of outbound runs and 30% of inbound runs.

After completing the baseline alertness levels, when all the data was processed, it was shown that fatigue was indeed a problem in the two test areas. Fatigue levels varied between the two test areas, Locomotive Engineers in Calgary appeared more fatigued than their colleagues in Jasper and indeed their workload stress was also greater. The reasons for this seemed to be that the Engineers in Calgary, despite similar lengths of runs, drove for longer periods; they also worked older locomotives. Additionally, on average, Engineers in Calgary required longer commuting times i.e. a 15 to 30 minute drive compared to a 10 to 15 minute walk for their colleagues in Jasper.

Evaluation of Fatigue Countermeasures.

The countermeasures drawn up for locomotive engineers were as follows;

a. **TIME POOLS.**
b. **IMPROVEMENTS TO BUNKHOUSE FACILITIES.**
c. **NAPPING FACILITIES AND POLICY**
d. **.LOCOMOTIVE CAB AUDIO SYSTEMS**
e. **.LIFESTYLE TRAINING PROGRAM AND INDIVIDUALISED COUNCELING.**

Time Pools;

As with most North American Railroads, Canadian Locomotive Engineers working freight trains operate a system that is known as "Unassigned Pools". Under this system Engineers do not know what time of day they will be called out to work a train. By devising a system where Engineers knew in advance the approximate times in which they would be called out, and also a time pool where they would not be called out on, it was found that Engineers overall sleep patterns improved, as did sleep quantity and quality. This in turn lessened their chances of

suffering from fatigue while at work.

Improvement to Bunkhouse Facilities

As with all Railway Bunkhouse and Canteen facilities, these were usually situated in or near Shunting Yards or Maintenance Sheds. These areas lead themselves to being susceptible to excessive noise levels. This noise level was deemed to be stress inducing so therefore it was decided to sound proof these buildings. This in effect helped to reduce Engineers stress levels.

Napping Facilities and Policies.

As it was proven that a short 20 minute nap would have the effect of boosting an Engineers "alertness bank" it was decided to introduce a policy of terminal and enroute napping. It was important that Engineers did not exceed the 20 minutes as they would then be inclined to suffer from what's known as sleep inertia. This is what causes you to feel groggy after a deep sleep.

Terminal Napping

In order to facilitate terminal napping a room in each location was equipped with comfortable chairs and couches. These rooms would be sound proofed or situated in quiet areas of terminals. The rooms also had a phone installed so as the Engineer could be called when his train or locomotive was ready for service.

Enroute Napping

Whenever a train was shunted into a siding or delayed in a loop, an Engineer was allowed, with the permission of the Traffic Regulator, to go for a nap. Again this nap was restricted to 20 minutes and the Engineers would be awakened by the Regulator calling him using the in cab phone.

Napping was judged to be effective in increasing alertness levels in Engineers. Surprisingly this countermeasure was also found to be non-disruptive to train operations.

Locomotive Cab Audio System.

In much the same way as a car radio provides stimulation to a tired motorist it was decided to provide Locomotive Engineers with similar stimulation to assist them to remain alert through out their trip. In conjunction with a specialist company, a battery powered, custom built intercom/music program system was developed for use in the locomotive cab. This specialist company also developed special high fidelity head sets to provide sound attenuation to reduce disturbances and hearing damage from locomotive cab noise. Music was provided from an attached tape/cd player. These head sets provided an average of 23 decibels noise reduction. A muting program was installed into the system to ensure that the Engineer could hear all communications from the RTC.

Lifestyle Training Program.

To compliment the other countermeasures with education about human circadian physiology and coping strategies for shift workers, CTI developed a four hour training program called "Managing a Railroad Lifestyle". The program was designed to acquaint Engineers with information relevant to performing work in a round the clock railway environment. This training program, which was provided to all Engineers and their spouses/partners, covered issues ranging from biological clocks to sleep to nutrition and family issues. In addition it provided general education relevant to workers on erratic schedules.

Effectiveness of Combined Set of Countermeasures.

Overall, alertness was found to be much higher during post countermeasure testing as compared to baseline alertness. The physical health of Engineers was found to have improved significantly. During post countermeasure testing a clear reduction in frequency of digestive problems was observed. Disturbed appetite, heartburn, stomach ache, and complaints about flatulence all dropped significantly. Also the Companies reported a drop of 60% in absenteeism due to illness.

Conclusions.

CANALERT'95 was by far the largest and most comprehensive investigation of alertness, sleep and fatigue that has ever been conducted in Locomotive Engineers and it was the first study to implement and evaluate a comprehensive set of fatigue countermeasures in actual operating conditions. The results of this project show that it is feasible to implement in railway operations a specially designed set of fatigue countermeasures based on alertness and sleep physiology, and thereby achieve broad ranging improvements in Locomotive Engineer alertness, morale, health and absenteeism, without impeding traffic flow or other operational factors. It also found that

a. Fatigue is a Real Issue in the Railways.

b. Hours of Work and Rest Regulations Cannot Guarantee Protection Against Fatigue.

c. Fatigue Countermeasures Can be Successfully Implemented in Railway Operations.

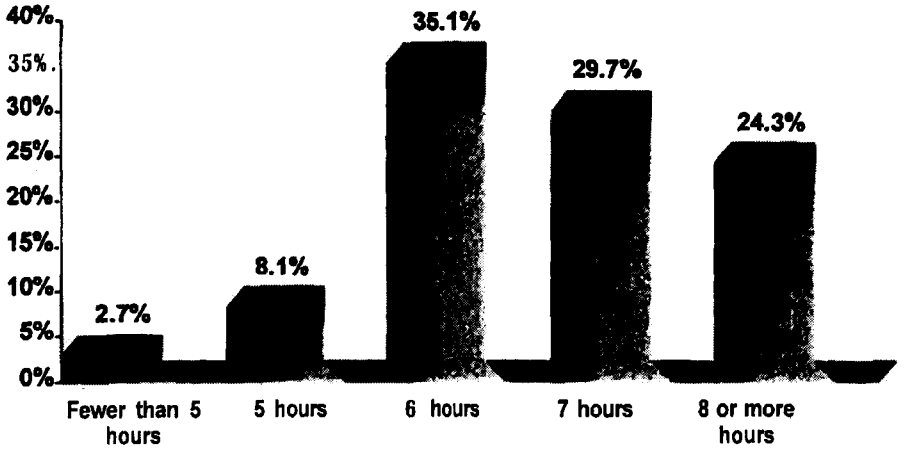
d. Circadian Sleep and Alertness Principles are Effective in Addressing Employee Fatigue in Railway Operations.

e. Maintaining Alertness is a Joint Responsibility of Employee and Management.

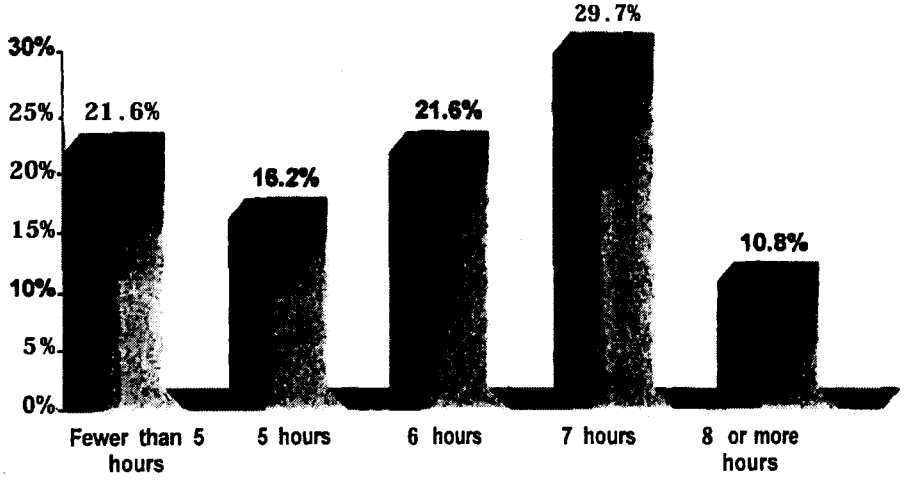
Appendix C

CANALERT PROJECT
Stage II Volunteer Survey
Overall Totals

67. How many hours of sleep per day do you feel you need to feel alert and well rested?

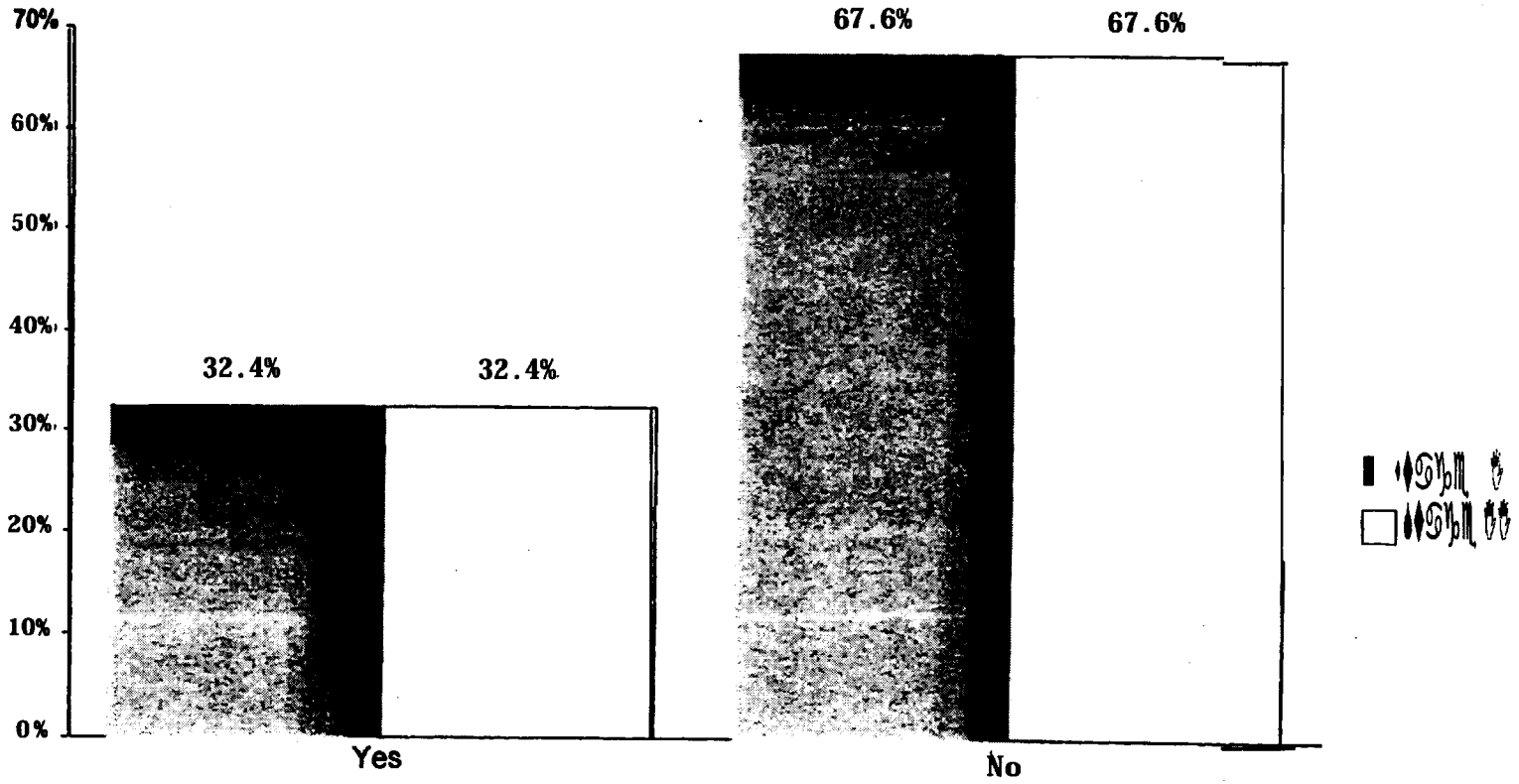


68. How many hours of sleep per day on average are you actually getting on days that you work?



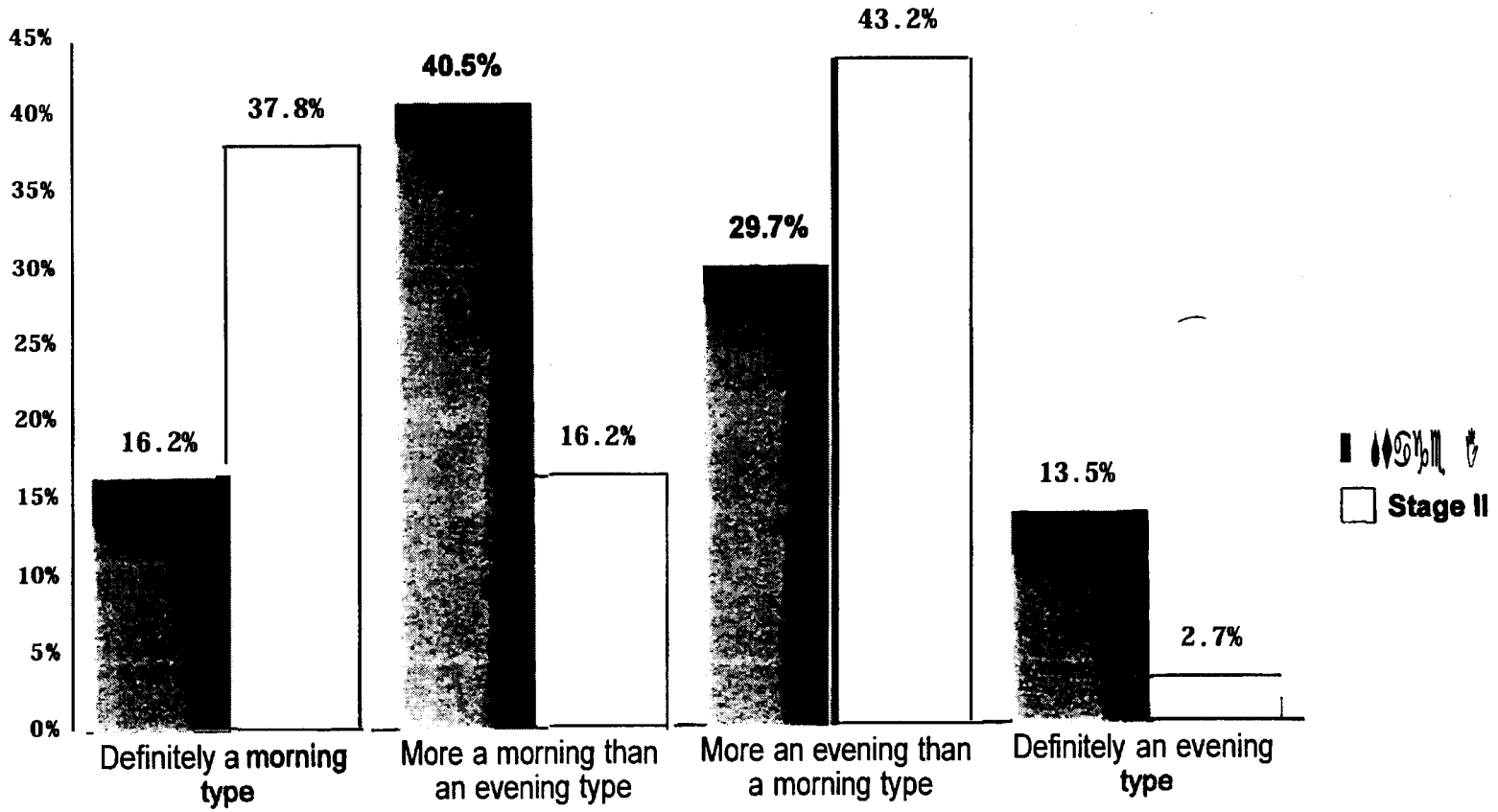
CANALERT PROJECT
Volunteer Survey
Comparison Report - Stage I vs. Stage II

76. vs 77. Do you find it easy to get good sleep during the daytime hours?



CANALERT PROJECT
Volunteer Survey
Comparison Report - Stage I vs. Stage II

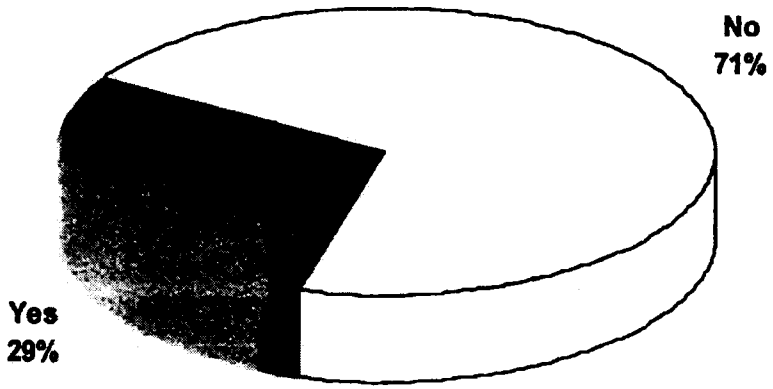
99. vs 127. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?



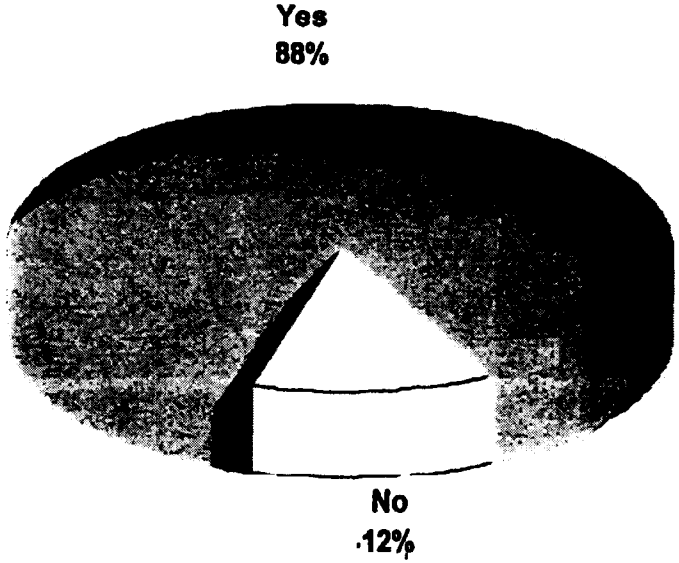
CANALERT Confidential Survey

Freight vs. Passenger

83. vs 8 1. Do you find it easy to get good sleep DURING THE DAYTIME hours?



FREIGHT

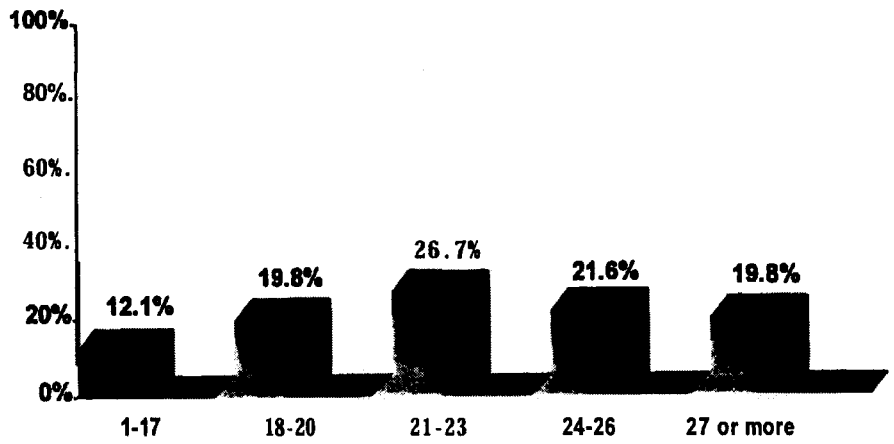


PASSENGER

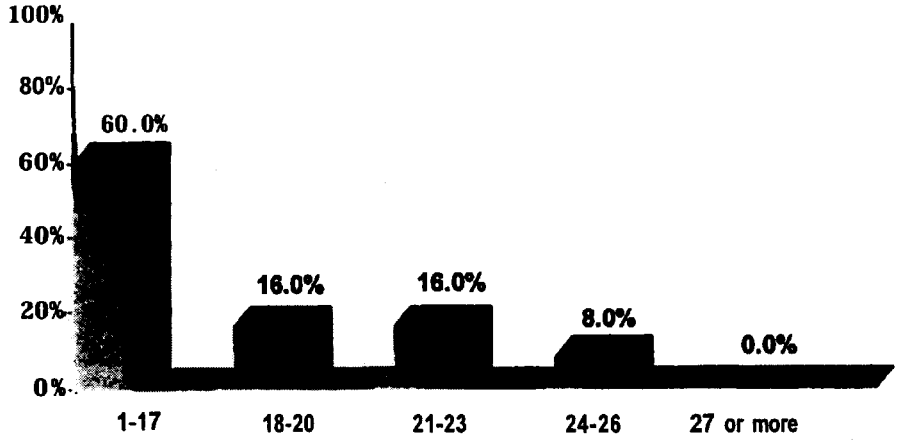
CANALERT Confidential Survey

Freight vs. Passenger

89. vs 87. During the last week or two that you worked, what was the longest number of hours you went WITHOUT SLEEP?



FREIGHT

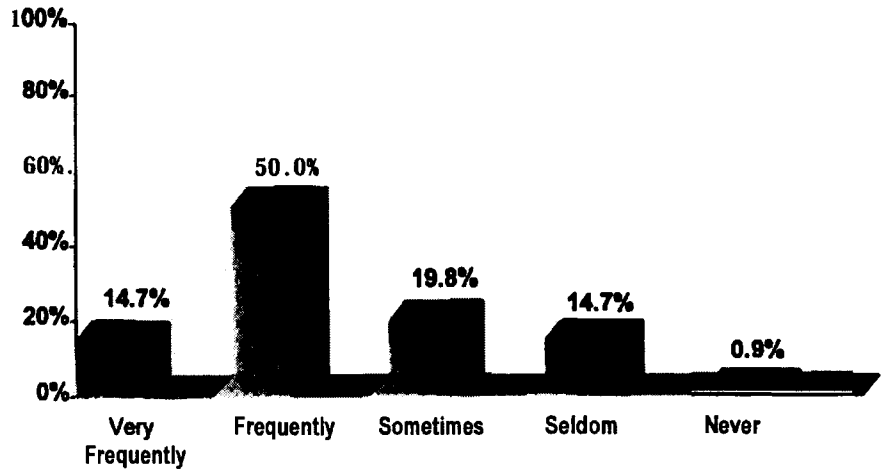


PASSENGER

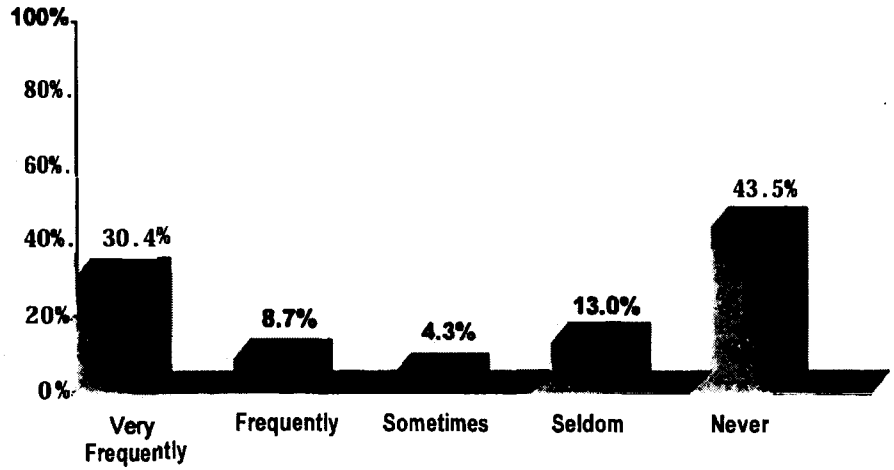
CANALERT Confidential Survey

Freight vs. Passenger

115. vs 112. How often do you receive a proper call?



FREIGHT



PASSENGER