

## PROFESSIONAL DRIVERS AND WORKING TIME: JOURNEY SPAN, REST, AND ACCIDENTS

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### ABSTRACT

Shift work is a reality in many sectors of industrial societies. Unfortunately, it is associated with several problems. Within this context, we highlight fatigue caused by extended working hours and the resulting increase in the risk of accidents. This is also a reality on Brazilian roads, with increasingly alarming rates of accidents involving intercity drivers. A significant number of such accidents is related to sleepiness caused by disruptions in the circadian rhythm. The necessity to drive for many consecutive hours without a pause, extended working hours, and mainly driving in the early hours of the morning may affect the driver's wakefulness state and performance. This may be due to a lack of synchrony with the temperature curve, as well as melatonin levels. To minimize the risk of accidents, work schedules should include regular pauses during the work journey. Moreover, such schedules should prevent professional drivers from working for more than 10 consecutive hours, as the risk of accidents increases significantly after the 8th hour at the wheel.

**Keywords:** Shift work; Accidents; Intercity drivers; Circadian rhythm; Fatigue.

### INTRODUCTION

Society-induced pressure for productivity and performance has caused a continuous work schedule, the so-called "24-hour society" (1). This implies a series of adaptations regarding the physical and psychological structures of humans, which may not always reach satisfactory levels.

In a 24-hour industrial society, the effects of work activities on sleep and general health have been the object of extensive inves-

tigation in the last decades (2). Night workers, for example, have less refreshing diurnal sleep, show lower alertness and performance levels, and also exhibit higher rates of accidents compared to daily workers (3,4).

Particularly for individuals whose profession involves driving, this is a problem that deserves special attention due to the alarming rates of accidents and their respective costs to society (5,6). According to a study conducted by Instituto de Pesquisas Econômicas Aplicadas (7) (Institute of Applied Economic Research), the

average cost of an accident involving injured people amounts to R\$90.000,00, and one involving fatal casualties amounts to R\$421.000,00. This study was based on data collected between 2004 and 2005, and found that the total cost of traffic accidents reaches R\$24.6 billion – R\$8.1 billion for accidents occurring on Brazilian federal roads and R\$16.5 billion for those occurring on Brazilian estate roads. The government agency (DENATRAN) responsible for traffic administration nationwide estimates that 34,000 people die each year as a consequence of road accidents. Similarly, data from the Ministry of Health (SVS/MS) indicates that in Brazil 35,674 people die each year due to traffic accidents; such deaths represent 28% of total deaths in Brazil and 81% of these deaths are males.

The highest risk of accidents does not always occur during the peak traffic hours, but rather tends to occur when people experience a decline in the body/core temperature curve, which usually occurs between 12:30-02:00 pm and 10:00 pm-06:00 am. The period between 03:30 am-05:30 am represents the critical hours most associated with sleepiness. Traffic accidents are related to fatigue and sleepiness, and are a consequence of the increasing pressure for productivity and excessively long work journeys (8). The latter, coupled with inadequate shift organization, can contribute to an increased potential for road accidents (9).

Shift work usually triggers sleep deficit, which is called acute or chronic sleep deprivation. The conditions involved may increase fatigue and the risk of making mistakes. Nevertheless, financial needs frequently cause drivers to perform under sub-optimal conditions (10). Unfortunately, extended work journeys without pauses for rest or consecutive extended work journeys and consuming chemical substances or other drugs to help maintain alertness are becoming quite common.

In an attempt to minimize the negative effects of such conditions, some strategies, such as exposure to light and consumption of products containing caffeine and other substances, such as melatonin, as suggested by Goh et al., have been used to promote adaptation to work (11).

Other less complicated strategies, such as taking naps, have also been suggested. In this respect, pauses during the work journey have shown to be quite effective for improving performance and reducing risk rates, thus contributing to increased safety (12).

Nevertheless, it is important to point out that great efforts have been made to develop models which would help estimate the benefits of work schedules that substantially contribute to reducing the incidence of road accidents and, at the same time, improve the quality of life for night and shift workers (3,4).

## BIOLOGICAL AND CIRCADIAN RHYTHMS

According to Menna-Barreto (13), environmental cycles, such as day and night and the seasons of the year, are examples of factors capable of establishing synchrony between the body's functions and the external environment. The bodily functions that are repeated with a specific periodicity are called biological rhythms. These cycles can be circadian (period of approximately 24 hours), ultradian (more frequent than one cycle in 20 hours), and infradian (less frequent than one cycle in 28 hours).

According to Menna-Barreto (13), our body establishes a series of temporal relations with environmental processes and maintains a series of independent processes, as observed in the production of certain hormones. Regular work schedules may act as an environmental synchronizer. The morning shift (6 am to 2 pm) leads workers to wake up earlier than office employees (who work from 9 am to 6 pm). Day/night and noise/stillness cycles are examples of synchronizers that affect human being internal temporal organization.

An abrupt change in the scheduled work period, as occurs when there is a change in shifts, brings about a change in some biological rhythms, such as the sleep-wake cycle and body/core temperature, triggering an "internal disruption" (13). When such disruption occurs, it is usually due to changes in work shifts or intercontinental trips. Thus, 'jet lag' is a result of an abrupt change in time zone, and may cause discomfort, fatigue, and difficulty in falling asleep. To accelerate synchronization and minimize the impact of jet lag, melatonin and light pulses have been utilized (14). Shift workers who perform on a rotating system display symptoms similar to those generated by jet lag, and are called "shift lag."

Another aspect that changes or has a direct influence on adaptation to the work journey is the chronotype. Horne and Ostberg (15) determined that the number of morning people is greater than that of evening people, who have a higher level of tolerance to shift work. Nevertheless, experience with shift work and the development of studies and clinical research in the field of sleep have demonstrated that people above 55-60 years of age show a reduction in their total sleep time (TST). Thus, a prevalence of morning people can be observed among older individuals. As such, investigation into chronotype may not reflect a person's actual characteristics (biotype), as these data may change or be masked as an individual ages. Thus, an elderly individual may be considered a morning person as a result of a reduction in his/her TST, which did not occur in earlier years.

Several authors have investigated the impact of shift work on the circadian rhythm. Dahlgren et al. (16) found that there is a significant reduction in cortisol secretion in worn-out individuals. Danel and Tuitou (17) demonstrated the extremely negative impact of alcohol on biological rhythms. Pasqua and Moreno (18) observed that the seasons of the year exert a negative influence on the nutritional habits of workers. Finally, lab and field studies conducted by James et al. (14) demonstrated that light and dark promote circadian adaptations, and that such factors should be considered in the observation of any other phenomenon or variable, as they are powerful agents, capable of altering biological rhythms.

According to Arendt (19), the circadian pattern of melatonin production usually begins late at night, simultaneous with the onset of sleepiness and a reduction in core temperature. The peak melatonin production occurs between 2:00 am and 4:00 am. As per Cagnacci et al. (20), the light-dark cycle is the major synchronizer of our biological clock, exerting a direct influence upon melatonin production, which is physiologically involved in the regulation of our core temperature. Menna-Barreto (21) observed that the core temperature shows a reduction during sleep, dropping to its minimum value around 04:00 am and reaching its maximum around 06:00 pm (Figure 1).

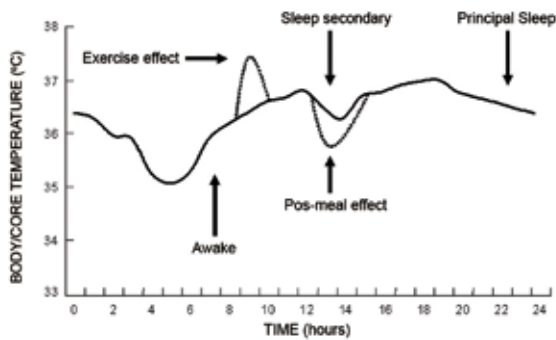


Figure 1: Body/Core Temperature Hypothetical Curve (21)  
 Source: University of São Paulo. Institute of Biomedical Sciences. GMDRB –Multidisciplinary Development Group and Biological Rhythms. Body/Core temperature hypothetical curve. São Paulo: USP. [quoted on June 12, 2006]. Available on: <http://www.crono.icb.usp.br>.

In the context of this article, it is interesting to note that according to Winget et al. (22), there are several performance components that are influenced by the circadian rhythm, such as reaction time, psychomotor coordination, and cognitive processing, all of which are critical for driving. The same authors demonstrated that there are other factors that may influence the variation in circadian performance and which may, consequently, affect drivers. Among these factors are work load, psychological stress, motivation, and the chronotype in itself. In general, all these factors are influenced by the light-dark cycle, as well as by cycles of melatonin release and body/core temperature.

## WORK SCHEDULES

Work schedules are schemes that allow maximal productivity. A poorly organized work schedule may cause acute or chronic sleep deprivation, as well as a series of other disturbances that may affect the worker's performance (1,5), particularly if that worker is a professional driver.

Professional drivers face serious problems concerning work schedules and working conditions.

According to several studies (1,5,23), it is recommended that a work schedule:

- Allows the worker to have a pause for rest every two or three hours during the working time;
- Provides conditions for the worker to have light stimulus so sleepiness is minimized;
- Includes a rotation between shifts occurring clockwise;
- Organizes work such that night shifts are less frequent than day shifts, as the former induces greater fatigue and sleepiness; and
- Minimizes extended work journeys, as after being awake for more than 19 hours, an individual feels the same sensation as felt in the initial stage of drunkenness. Data show that after the 9th hour of work the risk of accidents increases significantly.

Well planned work schedules may offer a great contribution to the driver's psychophysical balance, minimizing the effects caused by fatigue and, consequently, reducing the risk of accidents.

Thus, the work schedule should be carefully planned, taking into consideration principles and theories involving shift work.

## WORK JOURNEY TOTAL TIME

Despite the planning of work schedules, there can be a necessity for long working hours in order to accomplish certain tasks, and thus, an increase in the relative risk of accidents and other similar events can be observed in several areas, including roads.

It is important to point out that few studies have investigated the risk of accidents as a function of the number of consecutive hours the individual is at the wheel, as most accident records do not contain such information. In this regard, two studies were distinct. Pokorny et al. (24) investigated the risk of accidents involving bus drivers, and observed that the peak risk occurs at the beginning of their shift, around the 3rd and 4th hour, followed by a period of relatively low risk until the 8th hour, when risk increases again.

In the study conducted by Hamelin with truck drivers, it was observed that the risk of accidents as a function of the number of consecutive hours driving was higher in the first 4 hours (25). Additionally, for individuals driving for more than 12 consecutive hours, there is an exponential increase in the risk of accidents. Thus, a potential strategy would be to include pauses between the risk periods, that is, for a driver who is supposed to work for 9 hours, pauses for rest should take place after 2 and 4 hours of driving, with a final pause between the 6th and 7th hours, close to the end of the working day.

Compiling the results of several studies, Folkard (9) found a substantial reduction (approximately 30%) in the relative risk during the second half of an eight-hour shift. Extending the work journey for more than 8 hours resulted in an exponential increase in the relative risk of accidents, which may double when comparing the 12th and 8th hours (Figure 2).

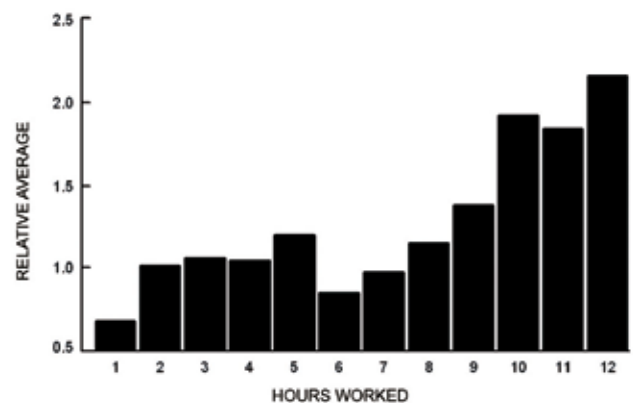


Figure 2: Relative average risk over the number of hours worked (26).

A study by Rajaratnam and Arendt noted that a reduction in motor and cognitive capacities are among the consequences of sleep deprivation (2). Williamson and Feyer observed that staying awake for more than 17-19 hours impairs the driver's performance in the same way as if the driver's blood alcohol concentration was around 5% (26). For some tasks, including driving, remaining

awake for 20-25 hours results in a 10% decrease in performance (Figure 3).

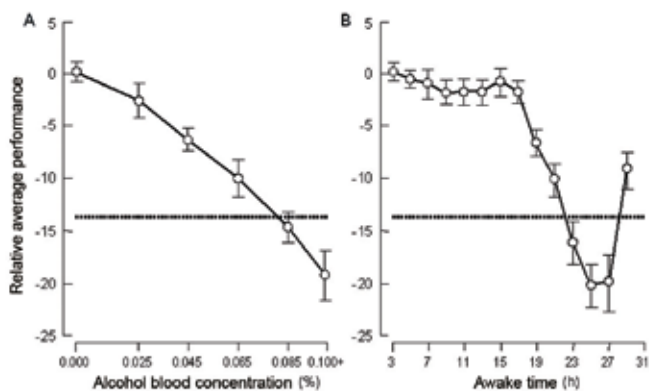


Figure 3: Comparison between the effects of alcohol concentration in the blood and wakefulness during performance (2).

It was also observed that the time of day and number of hours an individual remains awake both influence the alertness state (4). Figure 4 shows that the alertness state reaches its lowest level between 3:30 am and 6:00 am. It also shows an almost linear decrease with relation to the time the individual remains awake; such time is coincidental with the reduction in the body/core temperature curve, which is also associated with peaks of melatonin, a hormone that induces sleep, release. Thus, extended work journeys framed into specific schedules may substantially increase the risk of accidents.

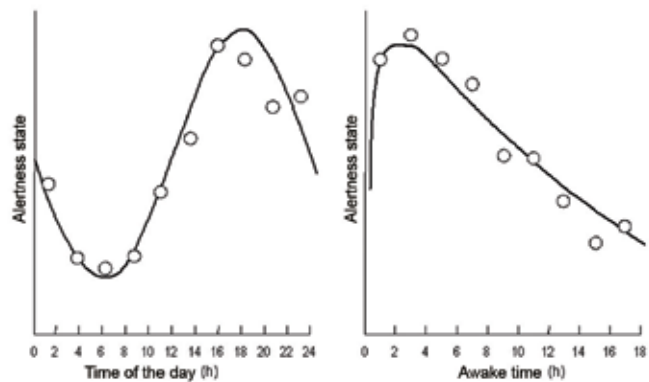


Figure 4: Influence of the time of the day and the number of hours the individual remains awake upon his/her alertness state (4).

### SLEEPINESS, NUMBER OF HOURS WORKED, AND ACCIDENTS INVOLVING TRUCK DRIVERS AND BUS DRIVERS

According to Folkard (9), changes in environmental conditions, particularly light levels and temperature, exert a clear influence on our “biological clock”. They are partially responsible for the circadian rhythms that dictate biochemical and physiological processes, specifically the transition between sleep and wakefulness.

Folkard observed that the risk of accidents increases significantly at dawn or in the early morning (02:00–04:00) (9). He also observed a secondary peak in the early afternoon, which is attrib-

uted to a reduction in body/core temperature; such a reduction may be brought about by the performance of a monotonous, unending task (Figure 5). The study conducted by Lavie indicates that sleepiness was higher at dawn or in the early morning (between 02:00 and 05:00) (27). Therefore, an association between road accidents and sleepiness has been observed by several authors (28).

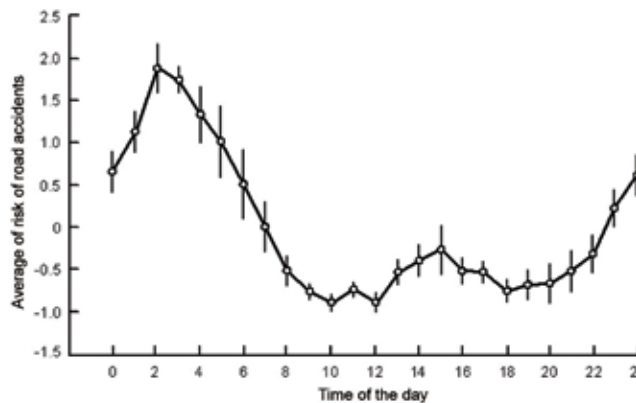


Figure 5: Average estimates on risk of road accidents along the 24 hours of the day (9).

As per Philip et al., fatigue is a complex state characterized by a deficit in the alertness level and a reduction in physical and mental performance, frequently accompanied by sleepiness (8). The main factors that generate fatigue are the time of the day (between 00:00 and 06:00 am), number of hours the individual has remained awake (more than 17h from the main sleep period), and number of hours performing a task without any break.

In a study conducted by Souza et al. with 260 truck drivers, it was found that in Brazil 85% of the drivers work for more than 11 hours straight, and 43,2% drive for more than 16 consecutive hours (29). Even more troublesome, 23,8% of drivers sleep less than 5 hours on working days, and 13,1% have been involved in accidents in the last five years. These are alarming figures, as they clearly demonstrate how the need to stop for rest is neglected and how heavy the professional driver work load is.

An extended work journey may significantly increase fatigue levels. In a study conducted by Phillip et al., young drivers (18-24 years old) were submitted to sleep deprivation and simple reaction tests (30). An increase in the reaction time equivalent to 650 ms was observed when compared to control conditions (without sleep deprivation), which represents an increase of 23 meters in the distance for braking at a speed of 75 miles (120 km) per hour.

According to Akerstedt, professional drivers (bus and truck drivers) are typically affected by sleep disorders, and 20-30% of road accidents involving this population are caused by sleepiness while driving, as a consequence of this type of disorder (31). In a study conducted with 3,268 professional drivers, Howard et al. (32) found a high prevalence of excessive sleepiness (24%) and sleep disorders. According to Garbarino et al., between 19 and 21% of road accidents were due to sleepiness while driving (33).

Estimates on traffic accidents related to sleepiness vary widely. In a study conducted by McCartt et al., the conclusion was that 55% of the drivers felt sleepy during the working time, and 3% fell asleep while driving (34). According to Hakkanen and Sum-

mala, 40% of wagon truck drivers reported problems in maintaining alertness state after driving for periods of 5 consecutive hours, and approximately 20% confessed that they took more than one involuntary nap at the wheel (35). Interviews with long-haul wagon truck drivers showed that 47% fell asleep while driving (36). Two additional Brazilian studies show important and alarming data. Mello et al. (37) demonstrated that 16% of interstate bus drivers confessed that they sometimes fall asleep while driving (an average of 8 naps per journey), and Santos et al. (5) demonstrated that 48% of interstate bus drivers from a single company of mass transport felt fatigue and tiredness during their working time. In Van Den Berg and Landstrom's opinion, the difference between the drivers' testimonies on sleepiness while driving and the statistics on accidents related to sleep should be carefully analyzed, since sleepiness is broadly identified as the main cause of accidents in transport operations (31). Sleepiness symptoms (sight problems, yawning, difficulties in maintaining the alertness state, and concentration on the task) are well known and have been frequently investigated; thus, continuing to drive after manifestation of such symptoms is not justified (38). The symptoms emerging from a state of chronic fatigue in truck drivers were investigated by Milosevic, who observed that the most common were pains in the legs and back, sleepiness, irritation, moroseness in performing activities, pains throughout the body, and problems related to eyesight (38).

In order to prevent drivers from falling asleep during the work journey, many strategies, such as exposure to light (39), consumption of caffeine (40), balancing the work and rest periods (10), scheduled naps (41), and consumption of energetic beverages (42) have been studied. Nevertheless, the safest preventive measure is to stop driving (12), as the drivers should be aware of the risk involved in continuing to drive when they feel sleepy.

## PAUSES AND STRATEGIES FOR RECOVERING WORK CAPACITY

Regular pauses are recommended to prevent accidents during performance of extended or continuous activities (43). Several studies have investigated the effect of pauses on the potential risk in function of the task time duration.

In a study conducted by Tucker et al. (12), an eight-hour work journey was analyzed, and a 15-minute pause was introduced after each continuous 2 hour working period. Every 2 worked hours the number of errors committed at every 30 minutes was calculated. It was observed that the risk increased substantially in a regular pattern, and that it doubled in the last 30-minute period preceding the pause. It was not observed that this trend is different for daily and night shifts, nor for the three consecutive 2-hour periods within an 8-hour work shift.

Some studies suggest that short and frequent pauses (10 min/hour) can improve work performance. In the study conducted by Phillip et al., where a pause for rest was introduced every hour and a half (90 minutes), no significant differences were found in the reaction time when comparing control conditions (without sleep deprivation) to the results after a 9-hour journey subsequent to a full night's sleep (20). The result was attributed to the model that

included pauses, which can minimize the effects of fatigue.

European traffic regulations recommend a driving period shorter than 10 hours within a 24 hour, and a driving period shorter than 4.5 consecutive hours. Such recommendations, compared to the study conducted by Souza et al., where 85% of the truck drivers worked more than 11 hours per day, call for deep reflection and consistent actions (29). In Brazil, the Law Project n° 2.660/1996, whose purpose is to regulate the limit of consecutive hours truck and bus drivers should work, has followed the procedures of the National Congress for more than 10 years. Nevertheless, the driving time and work suggested in the above law project or in other work schemes do not match what is recommended by researchers and scientists from several countries.

Thus, strategies that may help reduce the negative impacts caused by sleep deprivation have been proposed by several scholars. Purnell et al. observed that for a surveillance task, a 20-minute nap taken on the first working night significantly improved the response time at the end of the work shift (44). Matsumoto and Harada also demonstrated that short naps were effective at lessening the effects of sleepiness, consequently improving performance (41). Naps can, thus, be beneficial for counteracting sleepiness at the wheel (45). They may have a short duration (10 minutes), which significantly improves the alertness state in the short term, or a long duration (20-30 minutes), which is quite effective for improving general performance and reducing fatigue (6).

Lenné et al. (46) quoted several studies that recommend the adoption of short naps as a way to reduce sleepiness and, consequently, the rate of accidents. Two important factors should be considered:

- The first is sleep inertia (reduction in performance and / or in alertness state immediately after arousal, characterized by hypoalertness and sleepiness transient state), which may substantially reduce the benefit of naps;
- The second is the possibility that the nap takes place in a noisy environment, which may not bring the same benefits as in a quiet environment.

Thus, pauses during the work journey are extremely important, and recommended. It should be considered, though, that only well planned pauses, not just a random nap, can help improve the driver's performance along the work journey, contributing to the recovery of alertness and performance levels.

## CONCLUSION

Educational and informational programs have been proposed to increase awareness about the risks of driving while tired. Nevertheless, such programs haven't been enough, and a lot more work should be done.

Meanwhile, the driver must acknowledge the sleepiness symptoms (eyesight problems, yawning, difficulty to remain mentally alert and concentrated on the job, pains in the legs and back, irritability, and slow performance), in order to avoid taking risks and performing the job under unsafe conditions. As for the employers, it is extremely important that they orient their employees (drivers) so that they avoid driving when sleepy and /or weary, develop sensible work schedules, and check to ensure drivers do not have

any sleep disorders that may impair sleep efficiency, which is critical for the process of physical and cognitive recovery.

According to the National Sleep Foundation (NSF), an optimal alertness level, which encourages good performance throughout the journey, depends on the fulfillment of two conditions:

a) satisfaction of the biological need to sleep, which implies sleeping the necessary number of hours free from disturbances and sleep fragmentation;

b) synchronizing the waking period with the circadian biological clock, thus avoiding waking up too early.

The NSF believes that several problems are responsible for the fact that drivers rarely sleep an average of 8 hours between their work shifts. These problems are related to other activities involved, such as eating, vehicle replenishing, etc, and so it recommends:

- A minimum of a 10-hour rest period within a 24-hour period;
- Reducing the work journey in the early hours, when the risk of accidents is maximized;
- Including an educational program on how to get refreshing sleep and how to recognize signs of a reduction in alertness levels;
- Encouraging drivers to have an effective medical examination to check for sleep disturbances and excessive sleepiness, and also recommend them to avoid consuming drugs that change sleep efficiency patterns.

Extended work journeys without adequate recovery routines, many times imposed by the need to achieve the targets intended, significantly increase the risk of accidents on Brazilian roads. Coupled with these factors are several other chronic external problems that affect the professional driver's performance, among them poor maintenance of our roads, problems related to the signaling system and layout of the roads, and intense traffic due to lack of alternatives for cargo flow.

In summary, the establishment of well-balanced work journeys that would ensure the driver's physical and psychological recovery, including pauses long enough to restore alertness and performance levels, critical for the task performed, would minimize the risk of accidents and improve the quality of life of professional drivers. In addition, it would help reduce the high costs of accidents currently incurred and the loss of Brazilian lives.

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