The Influence of Active Safety Characteristics of a Bus on Driver Working Conditions (By the Example of Vladivostok, Russia)

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Abstract: Passenger transportation security depends on reliability of drivers, vehicles, road conditions and environmental factors. 1.5-3% of all traffic accidents in Vladivostok are caused by vehicles’ malfunction. However, the parameters of vehicle’s design influence drivers, who are to blame for most of traffic accidents happened on the road. As to the rate of accidents with urban buses, more than a half of all traffic accidents occur caused by bus drivers. That is why to raise passenger transportation safety and safety of road traffic in general, it is necessary to raise reliability of drivers and provide them with optimal working conditions. Working conditions and reliability of passenger transport drivers are determined by a number of factors. In this paper we study the factors relevant to a vehicle – noise, vibration and microclimate parameters at the working place of drivers of different classes of buses.

Key words: Bus • Passenger capacity • Driver • Traffic accident • Safety • Working conditions • Noise • vibration

INTRODUCTION

Automobile transport performs of more than 90% of all the urban passenger transportation in Vladivostok. Accident rate analysis shows, that more than a half of all traffic accidents with urban passenger transport occur through bus drivers’ fault. According to the research, drivers spend more than 60% of their working time driving a bus [1]. That is why driver reliability and passenger transportation safety in many respects are determined by working conditions at a working place.

Quality of Bus Fleet and Accident Rate of Passenger Transport in Vladivostok: Urban buses have an interior layout that allows transporting a lot of passengers, both sitting and standing, in the conditions of intensive passenger exchange. Buses are classified by a number of technical and operating parameters. In terms of driver working conditions, passenger capacity and the year of manufacture of a bus are most important.

By passenger capacity urban buses fall into classes [2]:

- Small (15-45 passengers);
- Medium-sized (46-80 passengers);
- Large (81-115 passengers);
- Especially large (116 and above passengers).

Today Vladivostok bus fleet consists of about 1000 vehicles, but it includes only four classes of buses – especially small, small, medium-sized and large (Picture 1).

As we can see from the picture, most of the fleet are medium sized buses with passenger capacity of 46-80 passengers. These are mainly Korean buses - DAEWOBS-106, HYUNDAI AEROCITY 540. Use of especially small buses is determined by the necessity of working on the routes with poor passenger traffic and the earth’s surface pattern of Vladivostok (the city is settled on bald mountains).

As to the age structure of the bus fleet, several years ago the average age of the buses was 12.5 years. In 2012, thanks to the release of new buses, the average age of the fleet was 11 years, in 2013 – already 6 years.

One of the most important indicators of passenger transportation quality is its safety [2, 3]. Safety is measured by accident rate.

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In 2012 during 12 months 1234 traffic accidents were registered on the territory of Vladivostok. During the same period the city saw 25 traffic accidents with urban buses (including 16 occurred through bus drivers’ fault). Thus, urban buses participated in a little more than 2% of the total number of traffic accidents. The research shows, that the number of traffic accidents with urban buses is relatively small, because it is generally acknowledged, that public transport increase road traffic safety by decreasing traffic rate [4].

In the same time more than 60% of all road accidents with urban passenger transport are caused by bus drivers’ fault. Therefore safety of passenger transportation to a great extent depends on the reliability of drivers which in its turn depends on the working conditions of drivers.

**The Influence of Active Safety Characteristics of a Bus on Driver Working Conditions**

**Factors Influencing Driver Reliability:** Driver’s reliability is an ability of a driver to drive a car during a certain period of time without mistakes. Factors influencing driver reliability may be divided into external (route characteristics), internal, connected with a vehicle and social, determined by the qualities of a driver [5].

External factors are determined by characteristics of the route, on which the driver works. Complexity of the route depends on its length, the state of the traffic-bearing surface, provision of engineering facilities (traffic signs, road marking), as well as traffic lanes number and road traffic. Pollutant concentration is in direct proportion to road traffic. Accident rate on passenger transport routes in many respects depends on traffic rate on parts of a route, as well as availability and a number of accident clusters. Taking into account current growth of motorization, it is practically impossible to influence external factors. However, it is possible to decrease their effect upon a driver by following regime of work and rest.

Social factors are determined by psycho-physiological and personal characteristics of a driver. It is possible to provide the necessary level of social factors (age, working experience, state of health, qualification, personal psychological features, etc.) by careful professional selection of drivers.

Separately, we would like to consider the influence on a driver of internal factors, which are connected with a vehicle.

**Safety of a Vehicle’s Design and its Influence on Working Conditions and Reliability of a Driver:**

The term “vehicle safety” includes a complex of constructive and performance parameters of a vehicle which provide traffic safety. There are active, passive, post-accident and ecological safety. Characteristics of active safety of a vehicle must provide prevention of an accident, passive safety must provide prevention or decreasing of accident participants’ injury and providing of vehicle restorability, post-accident safety is aimed at prevention of aggravating consequences of an accident, ecological safety – at reduction of harmful impact of a vehicle on the environment [6].

Active safety characteristics of a bus include performance particularities of a bus (braking, engine power, speed, stability, controllability, informativity, reliability of construction, etc.) and parameters of a driver’s working place (cabin microclimate, noise, vibration, ergonomic features). Working place’ parameters influence directly psycho-physiological state of a driver. Their deviation from the rated values cause fast physical tiredness, reduction of mental activity, slowing down of reactions and, as a result, safety level decrease.

Microclimate is determined by temperature, air velocity and relative humidity, barometric pressure, thermal radiation. If the temperature in a driver cabin is below 17°C, body starts to cool down, reduction of efficiency and fast tiredness of muscles take place, inaccuracy and constraint of movements are observed. If the temperature above 25°C, reactions slow down, physical tiredness quickens and at a temperature above 30°C mental activity worsens as well.

Industrial noise produces a harmful effect not only on hearing. Noise weakens attention and slows down psychological reactions which in the conditions of driving a vehicle can result in traffic accident occurrence.

When a driver is exposed to vibrations visual perception worsens, attention quality declines, accuracy of actions decreases. Durable impact of vibrations causes
tiredness, headache. Combined with noise, negative impact of vibrations on a human organism significantly increases.

Driver’s seat is a good vibration absorber provided that it is relatively hard, doesn’t have springs and correlates well with anatomic particularities of a human body. Comfortable driver’s seat, ergonomic location of devices and a control board are the most important factor of safety driving.

**The Methodology of Assessment of Influence of Bus Active Safety Characteristics on Driver Working Conditions:** Thus, reliability and working conditions of drivers are influenced by such active safety characteristics of a bus as noise, vibration and microclimate parameters of driver’s working place. In order to assess influence of mentioned factors on urban bus drivers, authors of the present paper had been conducting a research on assessment of working conditions during a year. In addition, we used the results of working places’ certification in regard to working conditions which was carried out in motor transport enterprises of Vladivostok-city by other organizations accredited in the system of working conditions assessment.

The most common brands of middle-sized and especially small buses, as the most numerous, were compared (Picture 1). The most common among middle-sized buses are DAEWOO BS-106 (50% of the total number of buses of this class). The most common among especially small buses are buses HYUNDAI GRACE (about 40% of the total number of buses of this class). In the warm period of the year the following indicators were assessed at working places of drivers (buses were manufactured in 2007): cabin microclimate (temperature, air humidity, air velocity), noise and vibration.

**Results of the Research:** Assessment results showed that microclimate parameters at driver’s working places of DAEWOO BS-106 and HYUNDAI GRACE differ insignificantly and don’t exceed maximum permissible levels [7]. At the same time, noise and vibration levels at working places of DAEWOO BS-106 and HYUNDAI GRACE differ significantly (Picture 2).

As we can see from the picture, noise and local vibration levels are higher at a working place of a driver of a middle-sized bus DAEWOO BS-106 and general vibration is higher at an especially small bus HYUNDAI GRACE. At the same time, the levels of all the indicators don’t exceed maximum permissible levels [7, 8]. However, noise level at driver’s working places of both buses is close to maximum permissible value. Thus, it may be concluded that passenger capacity of a bus affects working conditions and driver reliability significantly.

In 2011 the authors of the present paper conducted similar researches on buses of different age groups. As a result, buses which were manufactured earlier appeared to have significantly higher noise and vibration levels which confirms influence of vehicle operation period on driver working conditions. However, by now Vladivostok bus fleet has been renovated more than by half. Almost all buses were manufactured not earlier than in 2000, that is why there is no point in dividing them into age groups.

**Summary:** As the research of driver’s working conditions of urban passenger transport showed, factors relevant to active bus safety characteristics, - levels of noise, vibration and microclimate conditions at driver working places, - don’t exceed maximum permissible levels. At the same time, working conditions of middle-sized bus drivers may be considered to be the least favorable. But it is impossible to imagine urban passenger transportation without these buses, as only middle-sized and large buses
are able to transport a large number of passengers, especially during the rush hour. At the same time, significant decrease of noise and vibration levels at newer buses lets us conclude that one of the ways to upgrade driver working conditions and, as a result, increase road traffic safety, is renewal of the urban bus fleet.

**CONCLUSION**

Driving is a very hard job [9]. In recent years, the situation worsened even more because of traffic rate increase and passengers’ complaints [10]. That is why to raise passenger transportation safety it is important to provide drivers with maximum comfortable working conditions.

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