Research Article

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Laboratory studies of the influence of the working position of the passenger vehicle air suspension on the vibration comfort of children transported in the child restraint system

<https://doi.org/10.1515/eng-2021-0050>

Received Sep 16, 2020; accepted Jan 03, 2021

Abstract: The article presents the results of laboratory tests on the influence of the choice of the vehicle suspension position and the method of mounting child seats on the vibration comfort of children transported in them. Two child seats were used in the work. The B seat was attached to the vehicle with the ISOfix system, while the A seat was attached in the classic way (with seat belts). During the tests, the values of vertical vibrations were recorded on the seats of child seats, the rear seat of the vehicle and on the basis of ISOfix. The analyzed systems, depending on the method of mounting a child seat, may be characterized by two different vibration transmission chains. They depend on the method of fixing the child seat (the classic way of fixing the seat and the ISOFIX system). The article presents the results of empirical tests carried out at the EUSAMA SA.640 stand, which in these tests acted as a vibration generator with a frequency of 0 to 25 Hz. The analysis of the obtained results confirmed the observations published in previous articles about the negative impact of the use of the ISOfix base on the vibrational comfort of children.

Keywords: child restraint system, comfort, vertical vibration

with the exception of a situation where a child of at least 135 cm cannot travel in a child seat due to its mass and height. According to the European safety certificate ECE R44-04, the child seat must be adapted to both the height and mass of the child. This seat should comply with the requirements set out in the EU regulations or the UNECE regulations concerning child restraint systems in the vehicle [1]. The minimum requirement for the seats to be used is to be approved in accordance with the aforementioned ECE R44 / 04 certificate. Additional requirements for child seats are described in Regulation No. 44 of the United Nations Economic Commission for Europe (UN / ECE) [2]. This document distinguishes five groups of vehicle seats classified according to the child's mass. The classification is presented in Table 1.

Table 1: Classification of vehicle seats according to Regulation 44 ECE / UN [2]

Group	Mass Child, kg
0	< 10
0+	< 13
I	od 9 do 18
II	od 15 do 25
III	od 22 do 36

1 Introduction

In Poland, according to the Road Traffic Act, children under 150 cm tall may only be transported in a vehicle in a safety seat or other restraint [1]. This obligation applies to traveling in vehicles of categories M1, N1, N2 and N3,

Currently, most passenger vehicles are equipped with the ISOFIX system. The technical requirements for this system are contained in the provisions of Regulations No. 14 and No. 16 of the United Nations Economic Commission for Europe [3, 4]. Each vehicle seat with the ISOFIX system should be attached with the use of specially adapted holders, and also have a Top Tether fastening or a support. Pursuant to Regulation No. 129 of the United Nations Economic Commission for Europe (the so-called i-Size), the use of ISOFIX systems is promoted. The provisions of this standard also require rearward-facing transport of children

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under 15 months of age, which provides better protection in collisions. The i-Size standard also introduces an additional classification of seats according to the child's height [5].

Many studies and studies devoted to the analysis of accidents involving children show how important it is for safety reasons to transport children in child seats [6–8]. Scientists also pay attention to choosing the right vehicle seat and properly fastening the child. The results presented in [9] show that less than half of children aged 0–3 years involved in accidents were properly fastened. Similar conclusions were presented in [10]. Much work and projects were devoted to the development of instructions and applications that help to properly install the vehicle seat in the vehicle. Examples can be found, among others in [11, 12].

Vehicle child seats are constantly being developed and improved. Manufacturers of vehicle seats and scientists are trying to increase the protection of the child while driving and ensure a comfortable journey. The study [13] investigated the relationship between the design features of the seat and the arrangement of the belt and the comfort of driving in a group of children aged 4 to 8 years. The articles analyzed the LATCH seat mounting system [14, 15]. In [16], four methods of fastening seat belts in a rearward facing seat were analyzed. Moreover, the displacement of the seat and physical injuries of the Q1 dummy as suffered during the crash tests are discussed. The article [17] presents the results of analyzes of forces acting in the belts of belts supporting a child in a safety seat. A prototype of a vehicle seat for children weighing more than 20 kg has been presented in [18].

Currently, a lot of research is being conducted to investigate the behavior of a child's body in a forward-facing or rear-facing seat during tests simulating a collision using dummies. The results of these studies can be found, among others in [19–21]. The results of the crash tests presented, among others in the works [22–24] showed that improper fastening of the child in the seat may cause additional injuries.

The main function of the seat is to ensure the child's safety while traveling and to reduce the effects of possible road incidents. However, the issue of comfort is also important. As the results of the research presented in [25] show, the child's organism shows different resonance frequencies than that of an adult. In the works [26, 27], indicators based on the course of acceleration as a function of time were used to assess the comfort of the child traveling in the seat. Much work and research has been devoted to examining the frequencies of vertical vibrations transmitted from the rear seat vehicle and seat to the child's body. Examples can be found, among others in the works [28–30]. The suspension of the vehicle is an important aspect in considering

the issue of passenger comfort. Vibrations originating from the places of contact of the wheels with the surface are transferred to the body and are felt by the vehicle users. This is confirmed by the research results presented in the works [30–32]. Increasingly, vehicle owners decide to purchase vehicles with active, semi-active, hydropneumatic or pneumatic suspension, which significantly improve the vibration comfort of driving. The paper [33] shows a comparison of active and passive suspension. Based on the test results, it was found that the determined values of the RMS index of accelerations recorded on the seat of a vehicle equipped with active suspension were lower than in the case of a vehicle with passive suspension. The article [34] analyzes the accelerations and longitudinal displacements of selected parts of the human body. The authors concluded that better driving comfort can be obtained by using a semi-active suspension.

Currently, in terms of comfort, an important issue is the impact of vibrations on the child's body depending on the type of seat used and the child's mass. In this study, an analysis of the influence of vertical vibrations transmitted from the body on the body of a child seated in various types of vehicle seats was undertaken. Tests were carried out with different settings of the vehicle air suspension.

2 Measurement methodology

The experimental studies were conducted under laboratory conditions. During the tests, the wheels of the rear axle of an Audi A6 passenger vehicle equipped with air suspension were vibrated by means of measuring plates of the EUSAMA SA device. 640. The EUSAMA SA640 device is used to test shock absorbers using the EUSAMA method and is part of the Bosch Beissbarth diagnostic line. The Eusam method is based on the kinematic excitation of the road wheel to vertical vibrations with a constant amplitude in the range of 4 to 8 mm and a frequency varying from the initial value of about 25 Hz to zero. In the experimental research, the EUSAMA SA640 device acted as a vibration generator.

The main objective of the experiment was to measure and analyze the propagation of vertical vibrations in two subsystems: vehicle body – vehicle seat – child seat, which differed in the method of mounting a child seat, taking into account three different positions of the passenger vehicle suspension. The first method of fixing the seat was to use the ISOfix base, which allows for quick and stable mounting of the child seat in the vehicle without the use of standard seat belts. However, the second method of fastening a child

seat in a passenger vehicle requires the use of standard seat belts. Two seats were used in the experiment (Figure 1):

- Seat A – Avionaut Pixel – designed for transporting children weighing up to 13 kg and height 45–86 cm. The vehicle seat's own mass is 2.5 kg. The seat is mounted directly to the rear seat of the vehicle using standard seat belts
- Seat B – Avionaut AeroFIX – is designed to transport children with a height of 67–105 cm and a mass of up to 17.5 kg. The vehicle seat's own mass is 4 kg. The seat is mounted on the rear seat of a passenger vehicle in the direction of travel using the Avionaut IQ ISOfix base. The base was connected to the vehicle's ISOfix system.

Figure 1: Tested child seats: a) seat for transporting children up to 17.5 kg – “A”, b) seat for transporting children up to 13 kg – “B”

During the experimental tests, the Avionaut AeroFIX “B” seat was placed on the left side of the rear seat, which was attached to the ISOfix base (Figure 2), while the Avionaut Pixel seat was placed on the right side of the rear seat of the passenger vehicle, which was attached in a classic way, *i.e.* behind with the 3-point seat belts.

During the experiment, the vehicle seats were loaded with a mass imitating the mass of a child. The tests were carried out for the masses: 5, 7.5, 10, 12.5 and 15 kg. During the tests, the vehicle was equipped with 255/35 ZR19 tires. The tires were balanced before the tests. The experimental tests were carried out for the nominal pressure in the tires and for the value of pressure reduced and increased by 15 % taking into account three suspension configurations (Figure 3).

The research vehicle was a passenger vehicle with an air suspension system. In this vehicle, the user can adjust the suspension setting to the road conditions. This allows to reduce vibrations generated by uneven road surface, and

Figure 2: IQ ISOfix base for attaching child seats

Figure 3: View of the air suspension height control panel in an Audi A6 passenger vehicle

thus improve driving comfort. The vehicle was equipped with an air suspension that can take one of three positions: dynamic, comfortable and upper. The air suspension uses air bags supplied with air by the compressor. The work of the suspension system is coordinated by an electronic module that works with the pressure distributor and valves to regulate the height of the body. During the research, acceleration was recorded using three-way acceleration sensors. Sensors using semi-flexible measuring discs are placed on: on the rear seat of the vehicle, on the seat and backrest of the child seat and in the case of the A seat based on IQ ISOfix. The research used the LMS SCADAS Recorder SCR02 digital recorder, which enables automatic operation after setting the measurement parameters. Data was recorded directly to the measuring computer.

The rms, VDV and SEAT indicators were used to analyze the truncated vibrations recorded on the seat of the child seats, the ISOfix base and the rear seat under the A seat.

The main assessment of the influence of vibrations on the vibration comfort while driving is the rms value of accelerations acting in the vertical direction (1). For accelerations

$a(t)$ registered as the occurring stationary realization of the rms stochastic process, it is most often an indicator of the vibration comfort assessment.

$$r.m.s = \left[\frac{1}{T} \int_0^T a^2(t) dt \right]^{\frac{1}{2}} \quad (1)$$

where:

$a(t)$ – vertical acceleration value m/s^2 recorded as a function of time t

T – segment of the measurement duration, p.

The VDV (Vibration Dose Value) indicator was developed for vibration analysis of the whole human body. The rms and VDS values are not correlated with each other, because they accentuate the measured acceleration amplitudes in different ways. Both indicators do not estimate the impact of momentary shocks.

$$VDV = \left[\int_0^T a^4(t) dt \right]^{\frac{1}{4}} \quad (2)$$

where:

$a(t)$ – the frequency weighted acceleration as a function of in time, m/s^2

T – is the duration of measurement in (s).

Using the accelerations recorded in selected points of the tested subsystem, the SEAT index was determined. This index allows to assess the degree of damping of vibrations transmitted to the seat [5, 18]. This demonstrates the ability of the seat to damp vibrations in the vehicle in such a way as to protect the driver and passengers from excessive vibration. The SEAT value (3) is used to describe the vibration isolation of the vehicle seat [27].

$$SEAT = \frac{V.D.V_F}{V.D.V_P} \quad (3)$$

where:

$V.D.V_F$ – Vibration Dose Value determined for the vehicle seat

$V.D.V_P$ – Vibration Dose Value determined for the surface to which the vehicle seat is attached

3 Data analysis

The results of the measurements were used to determine the time courses of truncated accelerations. Examples of vertical vibrations recorded on the seat of the tested seats are presented in Figures 4 to 11. When comparing the courses of vertical vibration acceleration for the two tested seats,

Figure 4: Vertical accelerations recorded on the seat B and ISOfix base (suspension in a dynamic position, the seat is loaded with a mass of 5 kg)

Figure 5: Vertical accelerations recorded on the seat B and ISOfix base (suspension in a raised position, the seat is loaded with a mass of 5 kg)

Figure 6: Vertical accelerations recorded on the seat B and ISOfix base (suspension in a dynamic position, the seat is loaded with a mass of 15 kg)

Figure 7: Vertical accelerations recorded on the seat B and ISOfix base (suspension in a raised position, the seat is loaded with a mass of 15 kg)

Figure 8: Vertical accelerations recorded on the seat A and ISOfix base (suspension in a dynamic position, the seat is loaded with a mass of 5 kg)

Figure 9: Vertical accelerations recorded on the seat A and ISOfix base (suspension in a raised position, the seat is loaded with a mass of 5 kg)

Figure 10: Vertical accelerations recorded on the seat A and ISOfix base (suspension in a dynamic position, the seat is loaded with a mass of 15 kg)

Figure 11: Vertical accelerations recorded on the seat A and ISOfix base (suspension in a raised position, the seat is loaded with a mass of 15 kg)

it should be noted that higher acceleration values were recorded on the seat of the vehicle seat. red B. In addition, the vertical accelerations recorded from the ISOfix database were greater than the vertical accelerations recorded on the rear seat of the test vehicle. The greatest difference in the acceleration of vertical vibrations recorded on the seat of child seats occurs when the seats are loaded with a mass of 5 kg and when the Audi A6 suspension is in the raised position. The smallest difference in the acceleration of vertical vibrations recorded on the seats of child seats occurs when the suspension is set in a dynamic position and the seat is loaded with a mass of 15 kg.

Above, you should compile next to each other graphs of the time courses of vertical accelerations for different (preferably extremely different) suspension work positions but for identical loads. This time, the differences in the

acceleration values resulting from the position in which the suspension works should be emphasized in the paper.

The rms, VDV and SEAT indicators were used to analyze the propagation of vibrations on the seats of child seats, the rear seat and the ISOfix base. The values of the rms

index of accelerations recorded on the seats of the tested child seats are summarized in Table 2. The highest values are marked in red, and the lowest in green. The highest rms values of 2.61 m/s^2 for seat A and 3.053 m/s^2 for seat B were recorded when the vehicle was suspended in the

Table 2: Summary of RMS values for the tested child safety seats

Suspension position	Mass child, kg	Tire pressure	Child seat A Location of the acceleration sensor Seat of Child seat	Child seat B Seat of Child seat
Dynamic	5	85% of nominal pressure	1.278	2.388
		Nominal pressure	1.307	2.490
		115% of nominal pressure	2.524	2.872
	7,5	85% of nominal pressure	1.225	2.122
		Nominal pressure	1.319	2.201
		115% of nominal pressure	1.584	2.260
	10	85% of nominal pressure	1.572	1.891
		Nominal pressure	1.606	1.935
		115% of nominal pressure	1.620	1.934
	12,5	85% of nominal pressure	1.107	1.324
		Nominal pressure	1.117	1.358
		115% of nominal pressure	1.076	1.296
	15	85% of nominal pressure	1.066	1.306
		Nominal pressure	1.089	1.341
		115% of nominal pressure	1.016	1.236
Raised	5	85% of nominal pressure	1.149	1.971
		Nominal pressure	2.610	3.053
		115% of nominal pressure	2.578	2.848
	7,5	85% of nominal pressure	1.292	2.112
		Nominal pressure	1.356	2.118
		115% of nominal pressure	2.051	2.459
	10	85% of nominal pressure	1.308	1.696
		Nominal pressure	1.521	1.924
		115% of nominal pressure	1.619	2.014
	12,5	85% of nominal pressure	0.928	1.000
		Nominal pressure	0.972	1.125
		115% of nominal pressure	0.988	1.123
	15	85% of nominal pressure	0.793	0.921
		Nominal pressure	1.034	1.182
		115% of nominal pressure	1.074	1.214
Comfortable	5	85% of nominal pressure	2.481	1.122
		Nominal pressure	2.509	1.262
		115% of nominal pressure	1.895	1.297
	7,5	85% of nominal pressure	1.378	1.221
		Nominal pressure	1.399	1.258
		115% of nominal pressure	1.372	1.184
	10	85% of nominal pressure	1.647	0.978
		Nominal pressure	1.852	1.051
		115% of nominal pressure	1.897	1.084
	12,5	85% of nominal pressure	1.122	0.997
		Nominal pressure	1.262	1.144
		115% of nominal pressure	1.297	1.184
	15	85% of nominal pressure	1.221	1.015
		Nominal pressure	1.258	1.027
		115% of nominal pressure	1.184	0.998

Table 3: Results of the VDV and SEAT indicators

Suspension position	Mass child, kg	Tire pressure	Child seat A		Child seat B	
			Location of the acceleration sensor			
			Seat of Child seat		Seat of Child seat	
			VDV	SEAT	VDV	SEAT
Dynamic	5	85% of nominal pressure	3.812	2.259	1.883	0.843
		Nominal pressure	3.873	2.246	2.196	1.004
		115% of nominal pressure	3.326	2.190	2.264	0.483
	7,5	85% of nominal pressure	2.405	1.388	3.977	1.012
		Nominal pressure	2.490	1.425	4.229	1.030
		115% of nominal pressure	6.071	3.727	4.505	1.265
	10	85% of nominal pressure	2.166	1.214	3.413	0.914
		Nominal pressure	4.749	3.608	4.629	1.538
		115% of nominal pressure	5.457	3.621	4.473	1.368
	12,5	85% of nominal pressure	2.532	1.608	2.101	1.027
		Nominal pressure	2.594	1.629	2.173	0.947
		115% of nominal pressure	2.507	1.662	2.062	0.725
	15	85% of nominal pressure	1.966	1.210	3.265	1.241
		Nominal pressure	2.206	1.314	3.394	1.242
		115% of nominal pressure	2.930	1.761	3.505	1.270
Raised	5	85% of nominal pressure	2.253	1.731	3.561	1.717
		Nominal pressure	2.386	1.667	3.456	1.459
		115% of nominal pressure	3.737	2.680	3.865	1.612
	7,5	85% of nominal pressure	2.626	1.111	3.525	2.071
		Nominal pressure	3.124	1.087	3.809	2.020
		115% of nominal pressure	3.162	1.073	3.877	1.872
	10	85% of nominal pressure	2.877	0.735	3.098	1.556
		Nominal pressure	2.978	0.760	3.165	1.584
		115% of nominal pressure	2.997	0.761	3.134	1.600
	12,5	85% of nominal pressure	2.408	0.727	2.729	1.528
		Nominal pressure	2.598	0.782	3.064	1.498
		115% of nominal pressure	2.937	0.766	3.239	1.628
	15	85% of nominal pressure	1.883	1.082	3.176	1.395
		Nominal pressure	2.196	1.119	3.666	1.558
		115% of nominal pressure	2.264	1.117	3.789	1.452
Comfortable	5	85% of nominal pressure	1.984	0.548	2.240	0.988
		Nominal pressure	1.986	0.548	2.259	0.917
		115% of nominal pressure	1.981	0.547	2.228	0.684
	7,5	85% of nominal pressure	1.790	0.534	1.819	0.743
		Nominal pressure	1.982	0.428	2.060	0.330
		115% of nominal pressure	1.930	0.506	2.013	0.599
	10	85% of nominal pressure	2.101	1.166	3.342	1.599
		Nominal pressure	2.173	1.166	3.389	1.254
		115% of nominal pressure	2.062	1.131	3.157	0.993
	12,5	85% of nominal pressure	1.920	0.564	2.300	1.198
		Nominal pressure	1.943	0.557	2.363	0.897
		115% of nominal pressure	1.817	0.526	2.115	0.682
	15	85% of nominal pressure	1.543	0.528	1.683	0.750
		Nominal pressure	2.042	0.578	2.255	0.680
		115% of nominal pressure	2.093	0.575	2.302	0.551

raised position and the seats were loaded with a mass of 5 kg. These values prove that for children weighing 5 kg, setting the suspension in the raised position is unfavorable.

Table 3 presents the results of the VDV and SEAT indicators. The highest value of the VDV index was $6.071 \text{ m/s}^{1.75}$ for the A car seat with a mass of 7.5 kg. On the other hand, the highest value of the SEAT indicator is 3.727, also for the seat A with a load of 7.5 kg.

The maximum values of the indexes were recorded during the dynamic suspension adjustment of the passenger car. On the other hand, the smallest value when adjusting the suspension comfortably. It should be noted that the lowest value of the VDV index is $1.543 \text{ m/s}^{1.75}$ for the seat A, and was recorded for a mass of 15 kg. On the other hand, the lowest value of the SEAT indicator is 0.330 for seat B with a mass of 7.5 kg

Assuming that the pressure in the tires will be maintained at the nominal level, for children weighing 5 kg in the A vehicle seat, the most advantageous in terms of vibration comfort turned out to be the dynamic position of the suspension, while for children transported in the B seat, the most advantageous position was to set the suspension to the comfort position. The most unfavorable suspension setting from the point of view of vibration comfort for children weighing 5 kg turns out to be the best for children weighing 15 kg, provided that the pressure in the tires is

reduced by 15%. With the nominal air pressure in the tires, the most advantageous for children weighing 15 kg in the B seat (fixed in the classic way) is to set the suspension to the comfort position, while for children of the same mass but transported in the A seat (fastened with the ISOfix system), the best is to shift the suspension into dynamic position.

The ISO 2631-1 standard, in addition to the effective rms values, also provides for the use of the VDV index to assess the impact of vertical vibrations on a person in a sitting position [35]. The values of this index for all (forty) measurement tests are presented in Figures 12–16. They illustrate the influence of the suspension position and air pressure in the tires of the test vehicle on the values of the VDV index of accelerations recorded on the seats of the tested child seats. The influence of the operating position of the suspension and air pressure in the tires on the VDV index values was analyzed for four different load variants of the tested seats.

Figure 12: VDV index for the tested seats, loaded with a mass of 5 kg during the tests

Figure 13: VDV index for the tested seats, loaded with a mass of 7.5 kg during the tests

Figure 14: VDV index for the tested seats, loaded with a mass of 10 kg during the tests

Figure 15: VDV index for the tested seats, which were loaded with a mass of 12.5 kg during the tests

Figure 16: VDV index for vehicle seats that were loaded with a mass of 15 kg during the tests

Figure 17: SEAT indicator on the seat of the tested child seats with a load of 7.5 kg

Figure 18: SEAT indicator on the seat of the tested child seats with a load of 10 kg

Figure 19: SEAT indicator on the seat of the tested child seats with a mass of 12.5 kg

Figure 20: SEAT indicator on the seat of the tested child seats with a mass of 15 kg

The analyzes of the VDV index show that when the B (red) seat was loaded with a mass less than or equal to 7.5 kg, it is more advantageous in terms of vibration comfort to set the vehicles suspension to the comfort position. For other load variants, it is more advantageous to set the suspension in a raised or dynamic position in terms of vibration comfort. The situation is completely different when we analyze the values of the VDV index for the A (gray) seat. This time, in four out of five cases where the seat is loaded (5 kg, 7.5 kg, 10 kg, 15 kg) at nominal air pressure in the tires, it is more advantageous in terms of vibration comfort to set the suspension in a dynamic or raised position. In the case where the A (gray) seat is loaded with a mass of 5 kg, the best comfort in terms of comfort is setting the suspension in the raised position, assuming that the air pressure in the wheels will be reduced by 15% compared to the nominal pressure. In most cases, as the pressure in the vehicle wheels increases, the VDV values also increase.

Figures 17–20 show the values of the SEAT indicator for seats with a mass of 7.5 kg, 10 kg, 12.5 kg and 15 kg. The analysis shows that in the vast majority of cases, the values of this index determined for the B (red) seat were higher than the values determined for the A (gray) seat. This shows that the vibrations transferred from the ISOfix base to the red seat were reduced to a greater extent than the vibrations transmitted from the rear seat cushion to the A (gray) seat, which was attached in a conventional manner. The opposite was observed in only ten out of thirty-six cases. It should be emphasized that most of these cases (nine) were reported when the vehicle seats were loaded with a mass of 7.5 kg.

4 Conclusions

The subject of the research is part of the issue of the vibration comfort of children transported in child seats. The presented research is a part of a whole series of research carried out by employees of the Department of Motor Vehicles and Transport of the Kielce University of Technology. They concern the spread of vertical bastards in the following system: vehicle (vehicle floor) – vehicle seat cushion – child seat. In the conducted research, it was noticed that the position of the suspension of a vehicle equipped with air suspension may have a significant impact on the transmission of vibrations from the road surface to the seat of the child seat.

The review of literature items allowed to state that child seats are the subject of many studies and analyzes in terms of the passive safety of children transported in them, while static (comfort) and vibration comfort seem to be completely overlooked. This can be proved by a very modest number of publications describing these issues. The authors of these publications (regarding the comfort of children transported in child seats) focus mainly on the place, position and method of fastening the seats.

The authors of this study decided to draw attention to two elements, overlooked by the authors of other publications, which significantly affect the assessment of the vibration comfort of children transported in child seats. These elements include: the mass of the child and the characteristics of the car suspension in which the child seats are attached.

Laboratory tests of child seats, in terms of vibration comfort, are quite troublesome to carry out because the applicable regulations exclude the possibility of children

participating in them. Therefore, the authors plan to carry out a series of operational tests involving children of various mass and anthropometric dimensions, as permitted by the regulations. The research results obtained in this way will be used to develop a concept and build an innovative vibration reduction system that will be integrated into the child seat mounting system. In addition, it is planned to develop the currently missing criteria for assessing the vibration comfort of children transported in child seats.

The paper presents the results of empirical tests carried out at the EUSAMA SA.640 stand, which in these tests acted as a generator of vibrations with a frequency of 0 to 25 Hz. It should be noted that the air suspension from the assembly is to improve the traction parameters of the vehicle. Such solutions are to ensure optimal reduction of vibrations coming from the road surface. Consequently, the air suspension is to improve driving comfort. The ISOfix base separates the seat from the rear seat of the vehicle. This system enables quick and stable mounting of a child seat in the vehicle. In addition, together with the seat, the ISOfix base creates a system that is subject to acceleration from the vehicle's floor plate. Consequently, it contributes to the deterioration of the vibration comfort of children carried in the seat. The negative impact of separating the child seat from the rear seat of a passenger vehicle with the ISOfix base is confirmed by the r.m.s and VDV values determined for the B seat, which were higher than the rms values and VDV values determined for the A seat fitted in a classic way.

They found that in most of the tests conducted for the A seat, the comfort position was less favorable in terms of vibration comfort than the dynamic suspension position. In turn, for children weighing from 7.5 kg to 15 kg transported in a red seat, it is more advantageous in terms of vibration comfort to set the suspension in the comfort position. Noteworthy is the fact that it has a significant impact on the vibration comfort, the mass of the child carried in the seat and the pressure in the tires of the vehicle.

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