

# All-Season Tires and their Inappropriate Selection Due to the Current Economic Shortage of Raw Materials

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## Abstract

The article informs about the current development of raw materials needed for the production of tires, while its main goal is to acquaint and warn readers about the inappropriate choice of preference for all -season tires. The choice of all-season tires and their preference over standard footwear is often chosen by car users, mainly because of financial savings. At present, this type of footwear can be chosen by other drivers due to the current shortage of raw materials for tire production. Therefore, the intention of the author of the article is to emphasize the controversy of preferring all-season tires in general, to specify their pros and cons with a focus on their reliability and safety.

**KEY WORDS:** *tire, all-season tires, raw material, tire life cycle, cost savings, braking distance, reliability, safety*

## 1. Introduction

Car drivers expect additional higher costs in connection with the operation of cars and trucks at the same time. With raw materials, necessary components, parts and commodities in the automotive industry, it was as if a bag had torn. It started with a lack of chips, followed by overpriced urea, then the waiting period for new cars exceeded 12 months for some manufacturers, to which was automatically added a sharp increase in used prices, fuel climbed to the price of 45 crowns per liter and we can expect an increase in tire prices in the future. Car mechanics are already observing that for many people, the car is becoming another luxury. After times of luxury in a globalized world, one can see what it looks like when the web of economic relations ruptures. According to economists, tires are a prime example. Today, probably few of us can imagine life without tires, in the past there were times when a tire was a rarity. In recent years, the demand for tires has increased in the world as a result of the company's development, especially in the context of a lack of material. And so economists rightly predict that tires may soon become scarce again due to various factors.

Financial analysts predict that the ongoing wave of price increases will not disappear and that rising prices will also affect tires, which may become a scarce global goods. The reason is several circumstances, such as the consequences of the Covid-19 epidemic, the rise in price of rubber and problems with the import of one of the important raw materials for rubber production. The rubber industry will soon know the shortage of raw materials only after the stocks are exhausted. The cause is also the war in Ukraine, which could cause the collapse of the automotive industry throughout Europe. Ukrainian factories supply parts for production, such as cable harnesses, while Škoda Auto a.s. has 13 suppliers in the affected country. The key producer of raw rubber is Thailand, where raw material prices have already risen by almost half. The Covid-19 epidemic in China, which is holding back shipping, increases the cost of the expedition. The third problem is the main filler of tires, which is industrial carbon black. Russia supplies more than a third of them.

The prices of winter and summer tires have risen by 6%, and therefore, not only because of the lack of commodities, car users are looking for possible savings. At the same time, drivers find year-round tires to operate cars as possible savings and alternatives.

## 2. Requirements, distribution, construction and material composition

The tire is the collective name for the tire, or tube (air tube), protective liner and valve. Different requirements are placed on tires, which are in particular:

1. Basic - high strength, high load capacity, high service life, low weight, suitable mass production technology, static and dynamic balance.

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2. Operating - easy assembly and inflation, low wear, puncture resistance, low purchase price, resistance to undressing, the possibility of driving in case of pressure loss.

3. Functional - vehicle weight transfer, radial elasticity, low rolling resistance, low vibration transmission, tangential force transmission, maximum coefficient of adhesion, suitable deformation characteristics, low noise.

The distribution or types of tires are shown in Fig. 1. For the reader, however, the division of tires according to the pattern and tread is essential and important.

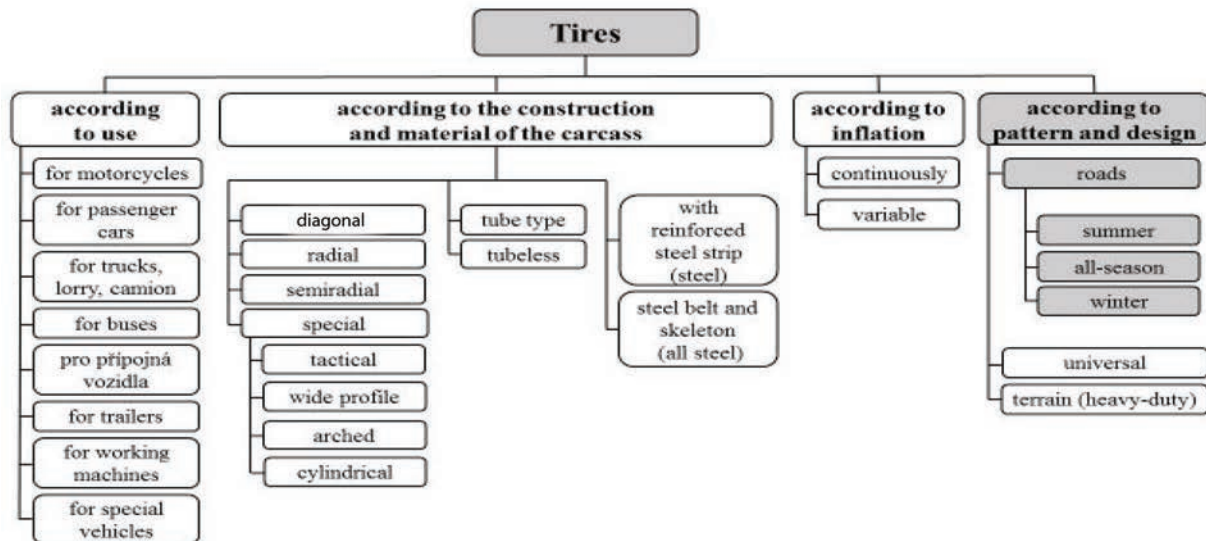


Fig. 1 Tire types [1]

### 2.1. Tire construction

The tire is the collective name for the tire, or. tube, protective liner and valve. A car tire consists of the following main parts: tread, bumper, tire carcass, sidewall, tire bead, and other parts (tube, valve, liner) [1][2][3].



Fig. 2 Passenger tire construction. Explanations to the Fig. 2.: tread (1), positive sample (2), negative sample - groove (3), tire arm (4), sidewall (5), tire carcass and tire bead (6), heel rope (7), bumper (8), PA bumper and flag (9) [4]

### 2.2. Material composition of the tire

The tire consists of various materials and structural components that contribute to improving their performance. The composition of the tires depends on their type. The number of different types of tires that are used in the Czech Republic is in the hundreds and with the introduction of new products is constantly increasing. Approximately 80% of the total weight of passenger car tires and 75% of the weight of truck tires are a mixture of rubber from vulcanized natural and synthetic rubbers, carbon black and other minor additives. Truck tires generally contain more natural rubber than passenger car tires. The reinforcing materials of the tires (reinforcement) are

steel and textiles. Previously used textile materials from natural raw materials (cotton) were gradually replaced by viscose, polyamides and also steel (all-steel casings). [5]

The structure and composition of the compounds used in the production of tires are often among the strictly guarded secrets of individual manufacturers. Very generally, from a material point of view, it consists of a tire volume: rubber, technical carbon black, cord, chemical additives, heel ropes, etc. [6]

However, these are only the most basic material components. If we look at the tire in more detail, from the material point of view, it consists of the volume of materials and components, which are shown in Fig. No. 3, which presents the percentage of raw materials in one tire.

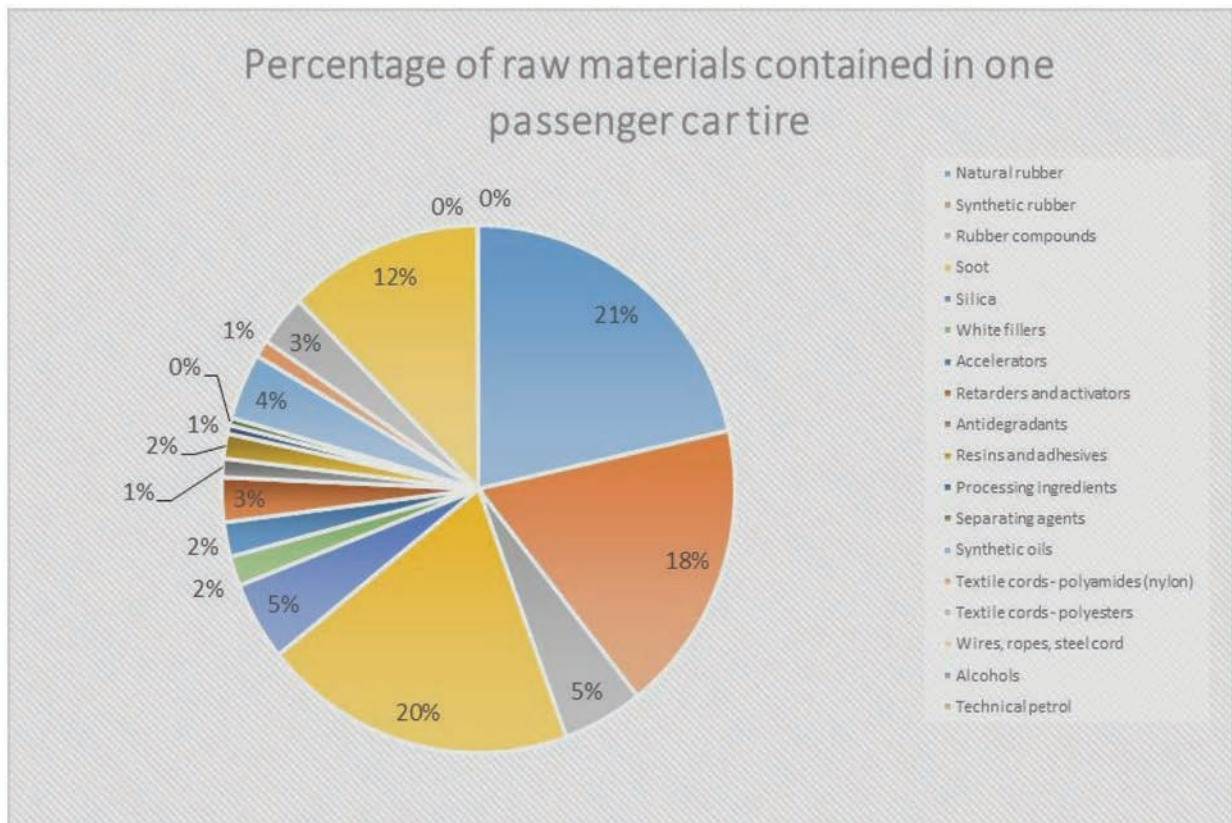


Fig. 3 Material composition of a standard passenger tire [4]

### 3. Tire life cycle

The tire, like any product, can be fully used throughout its life cycle. This applies from the conception stage and setting requirements, as well as to the operation stage, but also to the settlement (liquidation) stage.

#### 3.1 Operation and retreading of passenger tires

The service life of a standard passenger car tire, stated by the manufacturer (at the same time for the study), is set at 4 years of use or 40,000 kilometers. During this period of use, the tread, sidewalls, etc. are worn by about 12% of the tire (0.72 kg of the original tire), resulting in abrasion.

During the life cycle of a tire, summer and winter tires are replaced as standard during vehicle operation. When the vehicle is operated, the tires are changed twice a year, while the used passenger tire is removed once and fitted once a year, which means 4 complete changes (removal, fitting) throughout the life cycle. All-season tires also require retreading due to their even wear. This means that it is recommended to switch them regularly between the front and rear axle wheels, which means that even here the user cannot avoid shifting.

#### 3.2 Waste tire disposal methods

Every material and product have its own lifespan. What happens or how the product that is best used by the tire at the end of its life. If the tire does not end up unused and neglected somewhere thrown in nature or landfill,

which would be a pity, its use is undoubtedly useful. The path to tire reuse and further recycling leads to tire take-back, which is especially useful in connection with the described shortage of raw materials in the rubber industry. Tires placed on the market in the Czech Republic pursuant to Section 38 of Act No. 185/2001 Coll., On Waste, are subject to take-back.

### 3.3 Tire reuse

Retreading would be the most environmentally friendly way to recycle, but only if tires did not age. Even an unused tire becomes unsatisfactory in terms of safety after 6 - 7 years due to spontaneous degradation processes. At present, truck tires, which are in daily use and fully wear out in a relatively short period of time, are retreaded, which means that their aging processes have only partially taken place. The service life of the tires is also affected by their maintenance, the technical condition of the vehicle and the way of driving. By retreading, the service life of the tire can be extended to approx. 100 - 120 thousand km. Reuse methods include [7][8]:

1. direct re-use,
2. pruning,
3. and retreading [7][8].

### 4. Tire types by sample and design

We distinguish types of tires according to the pattern and tread into road, universal and off-road. We further divide the road ones into summer, winter and year-round. Summer and winter tires are already standard, but the fact is that the popularity of year-round footwear is growing year by year. In the last 6 years alone, according to estimates by insurance companies and car clubs around the world, their sales have doubled.

All-season tires are a topic that divides drivers and the public into two groups. For the first group, this is an interesting and simple way to save and at the same time provide a tire suitable for all climatic conditions. However, the second group takes the opposite view and points to the many shortcomings of all-season tires, which behave only averagely under all conditions, and even better. The claims of these opponents of year-round footwear are also confirmed by the evaluation of professional tests, which also brings an alarming finding that even year-round tires of renowned brands do not bring significantly better properties. Although for some drivers (laymen) all the tires may look similar or even the same on the outside, they are definitely not really identical, so what makes them different? The basic division is according to the sample and the tread mixture, then according to the number of grooves, cutting, shape of the sample. Based on these elements, the summer and winter tires of tires differ literally as night and day.

#### 4.1 Summer tires

The summer tire has a smaller number of grooves, large, firm ribs and a small tread depth. Thanks to these properties, the tire is more stable, has a longer service life, saves fuel and is less noisy. It also has larger tread blocks for this purpose. The summer tire compound is flexible, thanks to all this it has better grip and gives good performance especially when cornering and braking on dry and wet surfaces. It is also popular among sports drivers due to better cornering performance and sharp changes of direction. Due to better braking behavior, handling and grip, it still maintains a high level of comfort while maintaining low rolling noise, which often means lower fuel consumption due to lower rolling resistance. The summer tire has a high resistance to heat and a perfect response at high speeds, even with a minimum tread depth of 1.6 mm.

Objectively, summer tires work well at temperatures above 7 ° C, but as this temperature drops, the compound begins to harden. As a result, adhesion is reduced and in extreme cases the mixture may even crack. This is the main difference in properties between summer and winter tires. Overall, summer tires are generally a good choice for drivers who want better performance and greater safety when driving on wet or dry roads. Then the reasons to switch to a summer tire are in particular:

1. lower fuel consumption and higher mileage,
2. the special mixture, thanks to which the sample adapts perfectly even to extreme heat and does not soften,
3. subsequently, at mild temperatures, it subsides, thus adhering perfectly to a dry or wet road at a temperature above 7 ° C (which further significantly reduces rolling resistance),
4. perfect manoeuvrability and shorter braking distance, the tread is usually equipped with a simple pattern of blocks that hold different functions (their size also increases the contact area with the road),
5. disposition of excellent protection against aquaplaning (you will run wide channels and support grooves all over the tread, which are primarily designed for water drainage) etc

## 4.2 Winter tires

According to their name, winter tires are specially designed for use in cold climates, and especially if there is a lot of snow and ice. In the cold season, they are definitely a safe and recommended choice because they are designed for this time of year. Unlike summer and at the same time all-season tires, winter tires can withstand temperatures below  $7^{\circ}\text{C}$ . Winter tires remain flexible even at much lower temperatures. In contrast, winter tires are softer at temperatures above  $7^{\circ}\text{C}$ . They are completely unsuitable for operation in warm conditions and should therefore not be used due to the fact that they then lose their driving characteristics, which ensure safety. They may appear noisier than summer and year-round footwear. Due to improper use, winter tires wear faster. I prefer them to drivers in mountain or rural areas with lots of snow and ice, as their users are well aware that they can rely on winter tires.

Compared to all-season tires, winter tires have a much deeper tread. This deep tread allows winter tires to drain excess slush very well. They have edges, thanks to which they have higher grip on snow and, in addition, winter tires have a repeating pattern of thin notches. These repetitive notches are called lamellas. They catch the snow when a winter-wearing vehicle moves on it. Trapping snow in the slats improves grip, because the snow holds best on the snow. At the same time, the slats allow better traction on the ice surface, better handling and less noise.

According to Czech law, a winter tire is one that bears the M + S designation, but this is often not enough in practice. The M + S designation can also be found on all-season, universal and off-road tires, the mixture of which does not contain a sufficient amount of silica. Thus, from October 2024, only tires with the Alpine symbol will be allowed. The samples of these year-round, universal and off-road tires do not adapt to temperature changes and lose their driving characteristics quickly. Therefore, when choosing a winter tire, it is necessary to choose a product with the alpine snowflake symbol (3PMSF). All winter tires with a DOT of less than 3919 (week and year) have this symbol, which represents confirmation that the tire has undergone objective testing in accordance with UNECE regulations and meets safety limits. Then the reasons to switch to a winter tire and what its driving characteristics are:

1. excellent handling on snow, slush and frozen asphalt, thanks to the high content of natural rubber, which keeps the winter tire flexible even in sub-zero temperatures (the softer the tread, the better it adheres to the road),
2. perfect grip and short braking distance in winter conditions. Each tread block contains hundreds of small grooves that ensure fast water drainage and thus protection against aquaplaning. Thanks to their soft compound, winter tires can stick better on snow and ice. In addition, they dig into the snow and ice like claws and do not allow the tires to slip.
3. quality traction on snow and ice. The deep tread pattern picks up snow with each turn and stores it in wide channels. Snow takes up best on snow and ice.
4. high efficiency at temperatures below  $+7^{\circ}\text{C}$ .

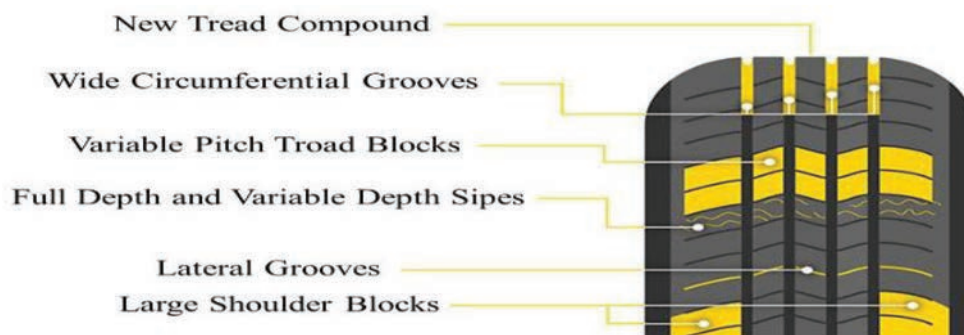


Fig. 4 Difference between summer and winter tire

## 4.3 All-season tires

The all-season tire has a tread with several fixed blocks, which are classically arranged in the shape of double arrows. As this is a compromise, the tread depth is not as small as for summer tires, or as deep as for winter tires. All-season tires usually use a summer tire design and a winter compound and tread, which means it's always a middle ground. All-season tires are softer, for example, due to the higher proportion of silica than summer tires. Therefore, it heats up faster and wears faster in the heat than seasonal summer coats. On the other hand, winter tires contain even more silica and are therefore best able to withstand snow and low temperatures. So if we want to talk about certain advice and advantages (but not recommendations) that year-round tires offer, then they are especially suitable for holiday drivers who do not use their car daily and who live in flat positions. Here it is possible to deduce

the justification and possible use of year-round tires.

All-season tires have a harder compound than winter tires, but softer than summer tires to better withstand colder conditions. As a result, the designs are more durable and less prone to wear than winter tires. This hard compound also reduces rolling noise, but on the other hand they sacrifice the durability of winter tires for better grip in summer. At low temperatures, their mixture hardens faster than the mixture in winter footwear. It is important to note that all-season tires always mean poorer braking and handling in extreme driving conditions. However, all-season tires work well at average temperatures and on a light layer of snow. However, it must not be forgotten that this is still a compromise between the summer and winter samples. In practice, this means that all-season tires can hardly match the driving characteristics of summer footwear in summer and winter in winter. All-season tires are ideal for driving on paved roads in suitable climatic conditions.

All-season tires are usually marked with one or two marks indicating their performance in winter. One of these marks is the M + S symbol (Mud + Snow), which means that they should work well on both of these surfaces. It is necessary to state that this symbol is not certified. Only the second symbol of the Alps is certified (3PMSF - "Peak Mountain Snow Flake"), so for this reason, from October 2024, only winter and all-season tires with this symbol will be allowed to be used in the winter months. So let's take a look at what leads drivers to choose the use of year-round footwear, for whom it pays off and what its driving characteristics are:

1. lower fuel consumption than dry winter tires (year-round sample is designed with fewer sipes, which reduces rolling resistance),
2. use in case of unexpected weather changes, when the used special mixture playfully adapts to certain temperature fluctuations,
3. save time and money on seasonally changing and storing the second set of tires (However, this cost saving is questionable for many drivers, because if summer / winter tires have their own disc, many drivers will do the self-help).
4. faster heating of the tread in the colder temperatures of the summer season,
5. for drivers with a mileage of less than 15,000 km and not driving in mountainous areas.

#### 4.4 Comparison of all-season tires with summer and winter tires

A summary of the recognized advantages and disadvantages of using summer and winter tires compared to year-round tires is clearly shown in Figure 5. The following Table 1 presents a list of the decisive and most important different factors.

<b>COMPARISON OF ADVANTAGES AND DISADVANTAGES SUMMER (ST), ALL-SEASON (AT) AND WINTER TIRES (WT)</b>	
<p><b>SUMMER TIRE - Advantages over a all-season tires:</b></p> <ul style="list-style-type: none"> <li>➤ better (shorter, safer) braking distance,</li> <li>➤ special mixture, thanks to which the sample adapts perfectly to extreme heat and does not soften</li> <li>➤ have a larger mileage (an advantage for SUVs),</li> <li>➤ are proven, recommended and safe.</li> </ul>	<p><b>WINTER TIRE - advantages over all-season tires:</b></p> <ul style="list-style-type: none"> <li>➤ higher grip on snow and ice,</li> <li>➤ reasonable investment in security,</li> <li>➤ they remain flexible even at much lower temperatures,</li> <li>➤ they are proven, recommended and most importantly safe.</li> </ul>
<p><b>SUMMER TIRE - disadvantages due to all-season tires:</b></p> <ul style="list-style-type: none"> <li>➤ acquisition costs,</li> <li>➤ changing costs (replacement),</li> <li>➤ tire storage costs (necessary storage space).</li> </ul>	<p><b>WINTER TIRE - disadvantages due to year-round tires:</b></p> <ul style="list-style-type: none"> <li>➤ acquisition costs,</li> <li>➤ changing costs (replacement),</li> <li>➤ tire storage costs (necessary storage space).</li> <li>➤ at higher temperatures higher noise and faster wear.</li> </ul>
<p><b>ALL-SEASON TIRE - Advantages over summer and winter tires:</b></p> <ul style="list-style-type: none"> <li>➤ cost savings,</li> <li>➤ for driving mostly around the city,</li> <li>➤ for a raid rather less km - up to 15000 km per year (for so-called holiday drivers).</li> </ul>	<p><b>ALL-SEASON TIRE - disadvantages due to summer and winter tires:</b></p> <ul style="list-style-type: none"> <li>➤ the construction of all-season tires places more emphasis on the properties required in the summer</li> <li>➤ weaker adhesion - tend to overheat and do not hold as well in corners to a summer tire, - insufficient warm-up in winter compared to winter tires,</li> <li>➤ worse drainage of water or slush on the snow, including worse grip,</li> <li>➤ in summer and winter conditions it loses or has a longer braking distance,</li> <li>➤ necessity (obligation) of tread depth at least 4 mm and marking M + S,</li> <li>➤ have a smaller (shorter) mileage,</li> <li>➤ in the evaluation of professional magazines and car clubs in the tests is not ideal.</li> </ul>

Fig. 5 Comparison of (in) advantages of all-season tire with summer and winter tire

Table 1.

The decisive and most important factors of summer vs. all-season vs. winter tires

Factors	Summer	All-season	Winter
Mixture density	hard	medium	soft
Recommended temperature	> 7.0 °C	mild temperatures	< 7.0 °C
Wet operating power	rain: + snow and ice: -	wet and light snow: + deep snow: -	snow and ice: + rain: -
Braking and turning	+ (wet and dry)	~	+ (snow and ice)
Tread life	+	+	-

## 5. Braking distance and safety reliability

As all-season tires work all year round, they combine the best of summer and winter footwear. Therefore, all-season tires have a longer braking distance than summer tires on dry and wet surfaces. The braking distance is still shorter than for winter tires. The opposite is true for snow. Although all-season tires brake well in the snow, they cannot be compared to winter footwear. If the driver does not have a set of tires on the vehicle corresponding to the specified season, this will be reflected primarily in the different longer braking distances. This value of longer braking distance may not seem so significant to some drivers, but it is important to explain the danger.

At the point where the vehicle with the prescribed (recommended) tires stops, the vehicle equipped with all-season tires (still in the case of summer and winter tires) is still moving at the residual speed. At this speed, in the event of a collision, there would be a primary contact and then a secondary contact of the pedestrian or cyclist.

The primary contact represents the moment when the moving contact of the moving vehicle with the pedestrian figure occurs on the road. The pedestrian leans on the hood and the laws of physics decide whether this is his final position, or another movement or impact with the surroundings will follow. Secondary contact represents the collision of a pedestrian's body with the environment, which may be grassy areas at the scene of an accident, mature vegetation, building elements such as curbs, railings, barriers, culvert fronts, public lighting, etc. [12].

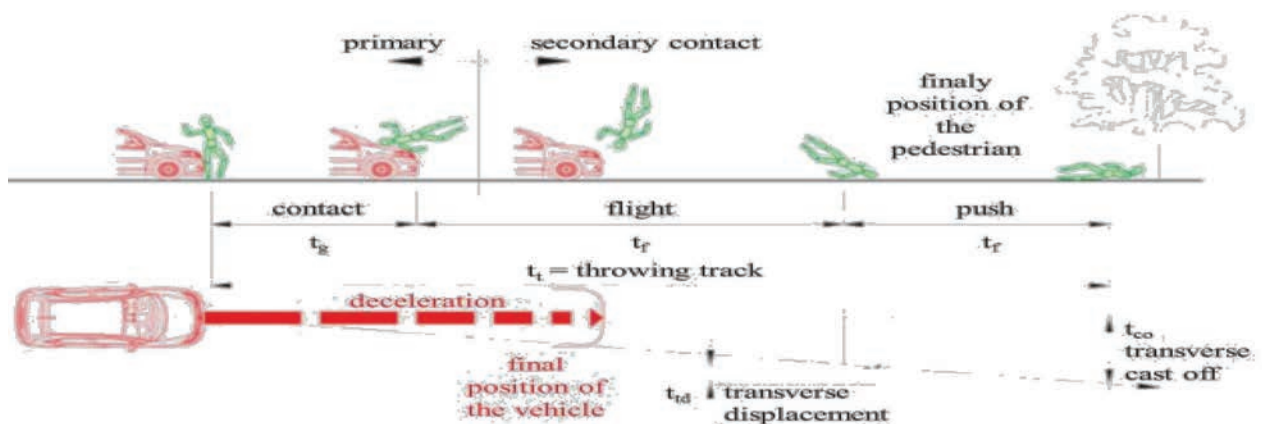


Fig. 6 Primary and secondary pedestrian contact with the vehicle [13]

Pedestrians or cyclists will thus suffer at least serious injuries, if not injuries with permanent consequences, the passengers in the car would probably be injured as well. Then he's really upset when the perpetrator of the traffic accident asks the court if the savings in buying all-season tires were really worth it, if in the best case he would be forced to spend financial costs to compensate the injured parties. Figures 7 and 8 show a comparison of the braking distance of seasonal and all-season tires in different climatic conditions.

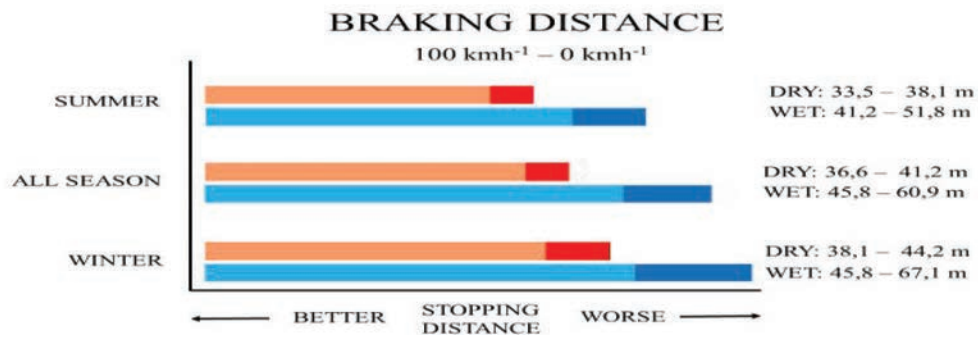


Fig. 7 Braking distance in meters on dry and wet asphalt

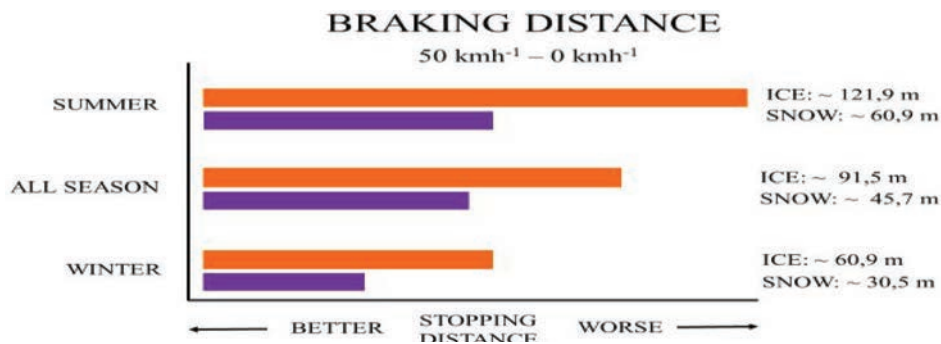


Fig. 8 Braking distance in meters on snow and ice

## 6. Discussion

All-season tires represent an attractive product offer with regard to their financial advantage. This attractive product offer with the idea of some savings presents the use of tires all year round, i.e. acquisition of only one set of footwear without the need to change shoes (although it is recommended to switch regularly between the front and rear axles only due to wear). The findings of the car club's tests clearly show that the results support the claim that when you try to know everything, in the end you do nothing good. In operation, it is clear that the ideal combination of all the properties of all-season tires is not realistic. The savings and prospective savings on tire costs are always an expense at the expense of safety and do not have to pay off for the vehicle user. Two year-round things are needed after all-season tires: they have to work in the winter, when snow and temperatures are below zero, and in the summer, when the sun heats up the asphalt until the quality "flows". All-season tires increase fuel consumption, wear out quickly and have longer braking distances in summer and winter. In any case, these all-season tires cannot be compared to specialized winter tires on snow and summer tires on dry and wet. Economy and profitability are also often confirmed by high expected mileage. Although the development of all-season tires is still moving forward and their quality is improving, they are still unable to compete with summer and winter tires at the time of the year.

Furthermore, the increased growth and demand for all-season tires would also have a negative impact on garages and tire repair shops, which few people are aware of. This statement can be demonstrated in the following case in Germany, where year-round footwear is used by about 14% of all German motorists and their number is still rising. It is therefore clear that all-season tires are becoming increasingly popular here. In 2011, a total of approximately 3 million year-round footwear was sold in the Federal Republic of Germany, and subsequently this sale in 2017 rose to 8.2 million units. This is about 16% of the total tire market. This was a 17% year-on-year increase, which was mainly at the expense of sales of summer footwear, while sales of winter tires remained approximately stable for the time being. If this growing trend were to repeat itself by 2030 and reach about 50% of demand, which is possible and certainly cannot be ruled out, then in Germany it would mean that 14 million potential customers will only need one set of bikes and sell with 20 million fewer winter tires. This possible prediction would represent a loss of the given market of around 40% and car repair shops and tire repair shops would lose 30% of their margin in the bicycle and tire segment. This is also associated with a significant loss of turnover related to the exchange service, which consists of spring and autumn wheel changes and tire retreading.



It is also important to note that winter tire laws apply in some countries. They stipulate when to use winter tires for a certain season, which means that the arbitrary use of only all-season tires does not pass everywhere. Before the driver decides between all-season and winter tires, it is therefore necessary to make sure that their use is not regulated by local legislation. If your local law allows, the circumstance of the area in which the driver will operate his vehicle and therefore use all-season tires should be considered. It makes a difference whether it is the countryside or the city. This difference lies in the weather. Urban areas and their surroundings tend to be warmer, so snow and ice are less likely to occur. Furthermore, there is a presumption that cities will also better maintain their roads through dredging and dusting. As for the weather, there is again a difference in whether the driver drives in a more mountainous area or somewhere in the lowlands. If he faces extreme weather conditions, he should choose winter tires. Furthermore, when temperatures do not drop below zero and drive on a light layer of snow, you can theoretically consider all-season tires, but it is still necessary to take into account and take safety into account.

When all the above points are clear, it is a question of how much the driver is willing to invest in tires at the same time. There is little saving with all-season tires (purchase of only one set, costs of storage and replacement of tires), however, if the driver obtains self-help, then it is only a matter of saving time and comfort. All-season tires are usually more expensive than one set of seasonal tires, but instead of two, one set is enough. But it is important to keep in mind that the driver will have to change them for new ones more often.

## 7. Conclusion

The article presented the current state of raw materials needed for the production of tires, which in the future may lead to a general shortage of tires on the market and to the inappropriate choice of tires by the user. Drivers of passenger cars can experience this shortage of raw materials and the overall shortage of tires on the market as early as the autumn of 2022. A significant increase in the prices of all tires (summer, winter, year-round) can already be predicted, and in connection with the increase in prices, the search for savings in the form of an alternative can already become a year-round tire. In connection with this issue, the article describes the differences in the use of summer, winter and all-season tires in relation to the possible shortcomings and risks that arise during the use of the footwear. Finally, in the discussion, he evaluates the individual pros and cons of the tires described above.

## References

1. **Pacejka, H. B.** Tyre and Vehicle Dynamics. 2nd Edition. Oxford: Butterworth-Heinemann, Elsevier, 2006. 641p. ISBN-10: 0-7506-6918-7.
2. **Marcín, J.** Pneumatika - výroba, použití, údržba. 1. vydání, Státní nakladatelství technické literatury, Praha, 1976.
3. **Pavlíček, J.** odborné konzultace, jan.pavlicek@barum.cz, Barum Continental, spol. s.r.o., Otrokovice, 2009.
4. BARUM CONTINENTAL AG – kolektiv autorů. Life cycle assessment of a car tire. Vnitropodniková LCA studie, Barum Continental, a.s., Germany, 1999. Pneumatiky. Odpadové fórum. 2004, č. 01, s. 10-19.
5. Stanovení procenta recyklace pneumatik ve vazbě na technické a ekonomické možnosti získaných produktů: Projekt VaV/720/4/03. Praha: ECO trend s.r.o., 2004. 170 p.
6. **Koleček, P., Růžička, B.** Pneumatiky pro váš automobil. Nakladatelství Brno: CP Books, Brno, 2005. ISBN 80-251-0561-X.
7. **Banerjee, B.** Tyre Retreading., Smithers Rapra Technology, 2015. 254 p. ISBN-13: 978-1847356895.
8. **Mullineux, N.** Light Vehicle Tyres. Rapra Technology Ltd. 2004. 132 p. ISBN: 978-1859574843
9. **Limbachiya, C. M., ROBERTS, J., JOHN J. ROBERTS, J. J.** Used/Post-Consumer Tyres. Thomas
10. **Cumming, R.** Indiarubber and Pneumatic Tyre Factories., Forgotten Books, 2019. 26 p. ISBN-13: 978-1332017805.
11. [www.czrso.cz](http://www.czrso.cz)
12. [www.chodci.cdvinfo.cz](http://www.chodci.cdvinfo.cz)