Antilock Braking System (ABS)

You are approaching a green light in the right-hand lane of an intersection. As you get closer, you see someone about to turn into your lane. You honk your horn, but the other driver makes his turn anyway. In a panic, you apply your brakes – hard – and turn the wheel to try to avoid the impending collision. The attempt to steer, however, fails because your wheels have locked up from the heavy braking. Having lost the ability to manoeuvre out of harm's way, you helplessly skid straight towards the car that turned in front of you. Had your car been equipped with an antilock braking system (ABS), your wheels would not have locked up, and you would have retained the ability to steer your vehicle out of danger.

What is ABS?

An antilock braking system (ABS) is an active safety feature designed to prevent a vehicle's wheels from locking up after an instance of heavy braking, thereby reducing the risk of skidding and allowing the driver to retain steering control. On some wet or slippery roads, ABS can also reduce the distance required to come to a stop. When drivers hit the brakes in a vehicle without ABS, the wheels are prone to stop spinning altogether (*locking up*). When the wheels lock up, the driver no longer has any steering control and the vehicle may begin to skid. On rougher road surfaces, potholes or soft curbs could cause a vehicle to spin out if it is already skidding. If your ABS system senses that one or more of the wheels is at risk of locking up, it will automatically reduce the braking for that wheel, encouraging it to keep rotating.

ABS functions by effectively *pumping the brake*: applying and releasing the brakes in rapid succession. In the past, drivers were taught to use this technique on their own when they sensed their vehicle's wheels locking up. However, ABS is able to pump the brakes much more effectively and is more attuned to detect the threat of wheel-lock than most drivers. While ABS monitors the brakes and adjusts pressure as necessary, all drivers must do is continue to apply firm, consistent pressure on the brake pedal and steer in the direction where they want to go.

When would ABS be useful?

ABS is designed to be useful whenever a driver hit the brakes, particularly when road conditions are slippery or wet. In these conditions, a vehicle is more likely to slide or skid if the wheels lock. ABS is designed to help reduce the risk of collision in many relatively common situations, including the following:

- A vehicle suddenly veers in front of you, forcing you to brake and swerve.
- A large animal jumps into your path and you have to hit brakes.
- Bad weather results in slippery road conditions, making wheel lockage more likely in cases of heavy braking.

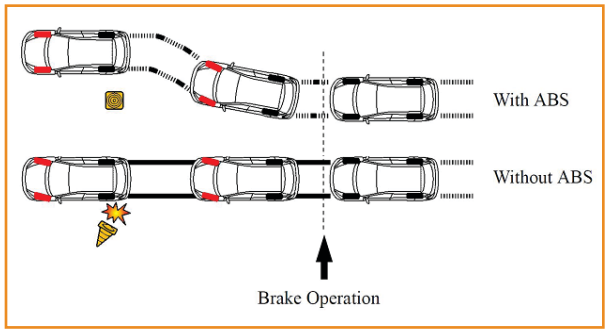
Since the primary function of ABS is to allow you to avoid skidding and retain steering control after hard braking, ABS can help reduce the risk of being involved in a head-on collision with a car or other object.

How does ABS work?

Slight differences exist between antilock brake systems, but all systems are comprised of three major components: wheel speed sensors (sensors that monitor the speed of wheel rotation), hydraulic units (the mechanical devices that actually release the brakes, as needed), and an electronic control unit (ECU) (the electronic controller that interprets information from the wheel speed sensors and gives commands to the hydraulic unit). In modern ABS setups, the hydraulic units and ECU are attached together so that while they have different functions, they are physically one unit. The ECU is designed to check for rapid wheel speed decelerations: indicators that a wheel is about to lock up. If your ABS computer detects, for example, that the front left wheel is experiencing a rapid deceleration, it will instruct the hydraulic

unit associated with the front left wheel to reduce the brake. The hydraulic unit will continue to reduce the braking force until the computer senses that the problem wheel's rate of rotation is accelerating. Once the wheel has begun rotating normally, the brakes are once again applied, and once again released if the wheel shows a risk of locking up. The process of releasing and applying the brake can happen several times a second.

ABS setups tend to differ among types of vehicles. On cars and sport utility vehicles



(SUVs), the most common setup is a four-wheeled system, where a speed sensor is placed on each wheel. When the risk of a lock-up is detected, four-wheeled systems will either release the brake force on the rear wheels, the affected front wheel, or the affected individual wheel, depending on the type of system. Pick-up trucks and cargo vans, in contrast, tend to have rear-wheel-only ABS setups. Rear-wheel systems have speed sensors installed only on the back wheels, and will only initiate antilock measures if one of those wheels is experiencing a rapid deceleration. Therefore, pick-up trucks and cargo vans are typically still vulnerable to front-wheel lockage (IIHS, 2010).

When ABS is activated, drivers experience a distinctive sound and/or sensation on the brake pedal. Some drivers may hear a groaning sound and feel the brake pedal pulse or drop under their feet. Other drivers may feel the brake pedal is harder to push down. Different ABS systems produce different effects, and drivers are encouraged to familiarize themselves with how ABS feels in their vehicle. A good way to do this is to practice hard braking in an open space (e.g., a vacant parking lot) at a speed of around 30km/h.

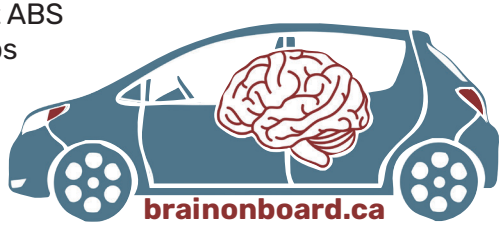
How effective is ABS?

The effectiveness of ABS has been a point of some controversy. Prior to equipping cars with ABS, the braking system was tested extensively and showed a ten metre (33-foot) reduction in the distance required for drivers traveling at 97 km/h to come to a complete stop (Farmer et al., 1997). In addition, the National Highway Traffic Safety Administration (NHTSA) found stopping distances on wet pavement were 14% longer for vehicles without ABS (51m with for cars with ABS vs. 58m for cars without it). The same kind of decrease in stopping distance was not seen on dry pavement (only a 5% decrease in stopping distance was noted for vehicles with ABS). This is most likely because on dry pavement the friction caused by locked wheels is still enough to still bring the vehicle to a stop. Therefore, ABS was advertised as being particularly useful in wet or slippery conditions. Other promising test results showed ABS was associated with a 35% decrease in frontal collisions with other moving vehicles on wet roads, and a 9% decrease in frontal impacts on dry roads (Farmer et al., 1997). In addition, under controlled test conditions, it was shown that 58% of drivers without ABS strayed from their intended path, whereas only 24% of drivers with ABS did the same (Farmer et al., 1997).

Despite the positive performance of ABS in controlled conditions, there is still lingering debate about how the benefits of ABS have panned out under natural driving conditions. The Insurance Institute for Highway Safety (IIHS) conducted a meta-analysis of reports on the effectiveness of ABS and found that having ABS was associated with no significant difference in a driver's risk of being involved in a fatal crash (Farmer et al., 1997). The absence of any decrease in fatal crash risk is somewhat surprising, however, there are convincing reasons why this is the case:

- First, studies have suggested many drivers with ABS on their vehicles are still under the impression that they should *pump the brakes* (Williams and Wells, 1994). This is problematic since pumping the brake on a vehicle with ABS can result in reduced braking effectiveness.

- Second, experts have suggested the steering control that ABS helps



maintain may be working against drivers who panic in emergency situations. In a panic, drivers may have the tendency to over-steer. In a vehicle without ABS where the wheels have locked, an extreme steering command would have no effect since the driver does not have directional control. However, since ABS prevents wheel lock, an equipped vehicle would respond to the driver's exaggerated steering input which may lead to an increased risk of losing control, rolling over, or running off the road.

- Third, some studies have suggested drivers with ABS modify their driving behaviour by driving faster in wet conditions or following other vehicles more closely. This behaviour would undermine the ability of ABS to help in situations where heavy braking is required (Farmer et al., 1997; Williams and Wells, 1994).

One notable area where ABS has been shown to have great success is in reducing motorcycle fatal crashes. Braking is much more difficult on motorcycles than other passenger vehicles due both to the method of braking on a motorcycle and the fact that motorcycles are inherently less stable than four-wheeled vehicles. Locked wheels are particularly dangerous for motorcycle riders since they almost always precede the rider falling off the bike. Motorcycles with ABS demonstrated a fatal crash involvement 37% lower than motorcycles without ABS (Teoh, 2011).

In summary, the demonstrated benefits of ABS on passenger vehicles are worth keeping in mind. ABS has been shown to:

- prevent wheels from locking
- keep drivers in control of their vehicles and
- in certain cases, reduce a vehicle's stopping distance.

The fact that having ABS does not seem to help reduce the most serious type of motor vehicle crash speaks to the need for drivers to fully understand what ABS is meant to do and their role interacting with it. The best way to realize the potential benefits of ABS is to combine the automatic braking assistance provided with consistently careful driving and controlled, decisive steering commands.

Are there any limitations with ABS?

Yes. As with many other safety technologies, realizing the potential benefits of ABS depends largely on whether drivers understand the design limits and how the technology works so they can use it appropriately. The discrepancy between the theoretical and practical effects of ABS highlights some important limitations of the system.

The main goal of ABS is to allow a driver to retain steering control after an incident of heavy braking by preventing the wheels from locking up. Drivers should be aware that reducing the distance required to stop is a secondary benefit of ABS, and that a reduction in stopping distance does not always result, even in cases where ABS has worked properly. There are two important implications of this:

- First, since panicking and over-steering may be behind the increase in fatal crashes associated with ABS, drivers need to know how to steer safely and decisively in emergency situations.
- Second, having ABS on a vehicle does not mean a driver can follow vehicles more closely. Since stopping distance may not necessarily be reduced, drivers are always urged to leave a safe distance between themselves and surrounding motorists.

Of importance, ABS is not designed to work below certain low speeds. At low speeds, drivers will typically be able to come to a complete stop before there is any threat of the wheels locking up. Therefore, ABS does not help prevent low-speed collisions resulting from driver inattentiveness. Similarly, beyond a certain speed threshold, a driver may be unable to combine ABS stopping power with safe steering input. If a vehicle is travelling too fast, a sudden

deceleration followed by a quick steering command will make it more likely the vehicle rolls over or runs off the road.

Drivers should always maintain a safe speed, no matter what kind of safety technologies are installed in their vehicles. Additionally, the condition of the vehicle is also a contributing factor to potential ABS limitations. In order for ABS to be helpful, the brakes and tires need to be properly maintained. Finally, drivers who own vehicles equipped with ABS must be aware that if any brake of ABS warning lights are illuminated on the dash but ignored, the ABS system will be disabled and the braking system will function only on the regular hydraulic system. As such, it is important to respond appropriately to all warning lights on the dash by having potential problems checked by a professional.

The effectiveness of ABS is heavily dependent on the skill and reaction time of the driver. Any factors that reduce reaction time or hinder a driver's skill will limit the potential benefits of ABS, and may actually increase the risk of a serious crash. Some of these factors include fatigue, distraction, excessive speed, and intoxication. Drivers are always encouraged to use safety technologies to complement their responsible driving practices, and not as a reason for driving less attentively or more recklessly.

Can I turn my ABS off?

Most ABS systems can be disabled. Sometimes this requires manually disengaging a fuse, whereas other ABS setups can be disabled by depressurizing the brakes from within the vehicle. Your owner's manual will have instructions on disabling ABS if this is possible on your vehicle. However, drivers are urged to use their judgment when deciding to turn off any safety feature. Disabling these features is generally discouraged. This is especially true in the case of ABS, where forgetting the feature has been disabled may result in the driver not using the proper braking techniques when confronted with an emergency situation (i.e., pressing down firmly on the brake instead of pumping the pedal).

How common is ABS on today's roads?

Since studies have not shown very significant benefits from having ABS on vehicles, it was never made a requirement by Transport Canada. Nevertheless, ABS is a very common feature in today's vehicles. Since its production in 1985, the number of vehicles with ABS as a standard or optional feature has risen steadily. By 1988, ABS was standard or optional on 90 domestic and foreign car models. By the model year 2010, ABS was on 89% of new cars and 99% of new light trucks. The IIHS predicts that by 2015, 95% of all registered vehicles will have ABS installed (IIHS, 2012).

How much does ABS cost?

The cost of ABS is estimated to be around $240.00 when it is installed in the factory. In addition, there is no evidence that equipping a vehicle with ABS reduces fuel efficiency significantly. Any slight overall weight increase that results from the addition of ABS has virtually no impact on overall fuel consumption.

References

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