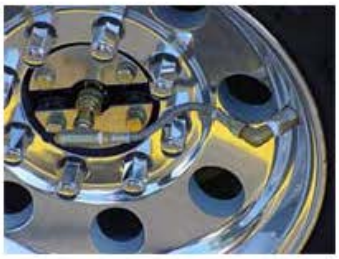
How Self-inflating Tires Work

BY LEE ANN OBRINGER AUTO | WHEELS

Browse the article How Self-inflating Tires Work



Hummer CTIS lines.
PHOTO COURTESY MANNY'S HUMMER SWAMPERS

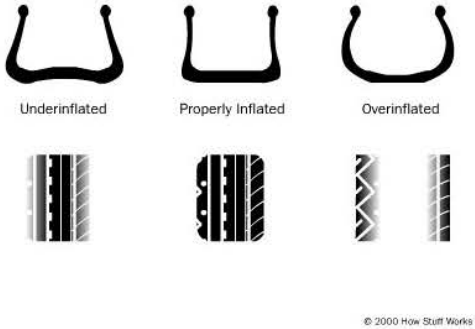
James Bond has them, Hummers have them, most truckers have them and the **military** has had them for years. Self-inflating tires allow a vehicle to adjust to the current terrain for ideal performance and safety in those conditions.

Currently, lots of consumer vehicles are equipped with pressure-monitoring systems, but there's no way for the driver to do anything about it without an external air source. There are lots of self-inflating-tire systems on the market, but most of them are only available for commercial and military applications. The exception, of course, is the CTIS system on the Hummer.

In this article, we're going to learn about some of the tire-inflation systems out there and see when there might be one on the market for us regular people who drive regular cars.

PHOTO COURTESY GOODYEAR

According to **AAA**, about 80 percent of the cars on the road are driving with one or more **tires** underinflated. Tires lose air through normal driving (especially after hitting pot holes or curbs), permeation and seasonal changes in temperature. They can lose one or two psi (pounds per square inch) each month in the winter and even more in the summer. And, you can't tell if they're properly inflated just by looking at them. You have to use a **tire-pressure gauge**. Not only is underinflation bad for your tires, but it's also bad for your **gas mileage**, affects the way your car handles and is generally unsafe.



When **tires** are **underinflated**, the tread wears more quickly. According to Goodyear, this equates to 15 percent fewer miles you can drive on them for every 20 percent that they're underinflated. Underinflated tires also overheat more quickly than properly inflated tires, which causes more tire damage. The faded areas below indicate areas of excessive tread wear.

Because tires are flexible, they flatten at the bottom when they roll. This contact patch rebounds to its original shape once it is no longer in contact with the ground. This rebound creates a wave of motion along with some friction. When there is less air in the tire, that wave is larger and the friction created is greater -- and friction creates heat. If enough heat is generated, the rubber that holds the tire's cords together begin to melt and the tire fails. See **How Tires Work** to learn more.

Because of the extra resistance an underinflated tire has when it rolls, your car's **engine** has to work harder. AAA statistics show that tires that are underinflated by as little as 2 psi reduce **fuel efficiency** by 10 percent. Over a year of driving, that can amount to several hundred dollars in extra **gas purchases**.

Tire-inflation System Basics

Tire-inflation systems have three general goals:

- **Detect** when the air pressure in a particular tire has dropped - This means they have to constantly (or intermittently) monitor the air pressure in each tire.
- **Notify** the driver of the problem
- **Inflate** that tire back to the proper level - This means there has to be an air supply as well as a check valve that opens only when needed.

While the available tire inflation systems vary in design, they share some common elements.

- They all use some type of **valve** to isolate individual tires to prevent airflow from all tires when one is being checked or inflated.
- They have a method for sensing the tire pressures. This is addressed in most cases with **central sensors** that relay information to an electronic control unit and then to the driver.

- They have an **air source**, which is usually an existing onboard source such as braking or pneumatic systems. When using an existing system, however, they have to ensure that they don't jeopardize its original function. For this reason, there are safety checks to ensure that there is enough air pressure for the source's primary use before pulling air for tire inflation.
- There has to be a way to **get the air from the air source to the tires**, which is usually through the axle. Systems either use a sealed-hub axle with a hose from the hub to the tire valve or else they run tubes through the axle with the axle acting as a conduit.
- There has to be a **pressure relief vent** to vent air from the tire without risking damage to the hub or rear-axle seals.

Now, let's look at how each of the main self-inflating tire systems on the market uses these elements to make the system work, starting with the Central Tire Inflation System (CTIS).

PRESSURE-MONITORING SYSTEMS AND SELF-INFLATING VS. RUN-FLAT

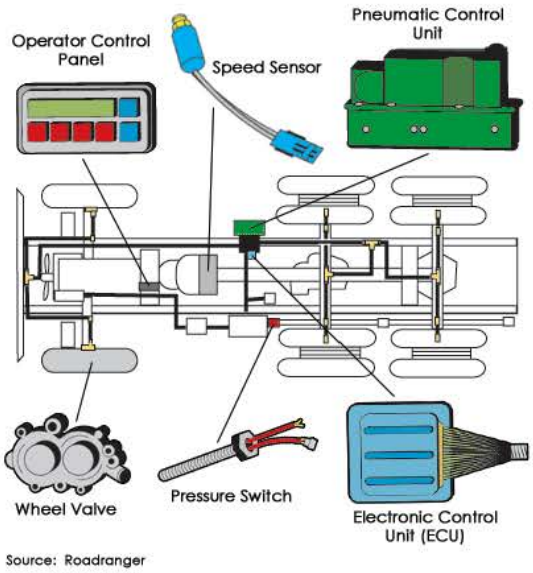
There are lots of tire-pressure technologies currently on the market and some soon to be on the market. Because of the TREAD Act, all vehicles will soon have to have a tire-pressure monitoring system so all drivers know when their car's tires are losing air pressure.

These types of pressure-monitoring systems have been around for decades and are already standard in some car models. They simply monitor the air pressure in each of the car's tires and notify the driver if a tire drops below a preestablished, optimum pressure point.

Our tires aren't what carry the weight of our cars and trucks -- it's the air inside the tires. Run-flat tires use a strong sidewall material that supports the car even if there is no air in one or more of the tires. This makes it possible to get where you're going even if a tire is punctured and deflated. Run-flat tires are constructed using alternating layers of heat-resistant cord and rubber and usually crescent-shaped wedges of weight-supporting material, strengthening the sidewalls to prevent them from folding over when there is no air pressure.

Self-inflating tires, on the other hand, are designed to constantly maintain tire pressure at the proper level. Self-inflating systems are designed more for slow leaks and for optimizing performance and safety than for keeping a vehicle moving on a tire that will no longer hold air.

Central Tire Inflation System



The idea behind the CTIS is to provide control over the air pressure in each **tire** as a way to improve performance on different surfaces. For example, lowering the air pressure in a tire creates a larger area of contact between the tire and the ground and makes driving on softer ground much easier. It also does less damage to the surface. This is important on work sites and in agricultural fields. By giving the driver direct control over the air pressure in each tire, maneuverability is greatly improved.

Another function of the CTIS is to maintain pressure in the tires if there is a slow leak or puncture. In this case, the system controls inflation automatically based on the selected pressure the driver has set.

There are two main manufacturers of the CTIS: U.S.-based Dana Corporation and **France**-based Syegon (a division of GIAT). Dana Corporation has two versions, the CTIS for **military** use (developed by PSI) and the Tire Pressure Control System (TPCS) for commercial, heavy machinery use.

CTIS: Inside

Here is a look at the overall system:

A **wheel valve** is located at each wheel end. For dual wheels, the valves are typically connected only to the outer wheel so the pressure between the two tires can be balanced. Part of the wheel valve's job is to isolate the tire from the system when it's not in use in order to let the pressure off of the seal and extend its life. The wheel valve also enables on-demand inflation and deflation of the tires.

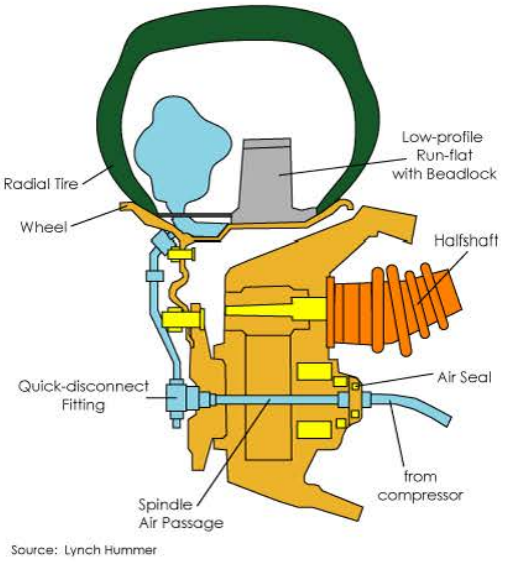
An **electronic control unit** (ECU) mounted behind the passenger seat is the **brain** of the system. It processes driver commands, monitors all signals throughout the system and tells the system to check tire pressures every 10 minutes to make sure the selected

pressure is being maintained. The ECU sends commands to the **pneumatic control unit**, which directly controls the wheel valves and air system. The **pneumatic** control unit also contains a sensor that transmits tire-pressure readings to the ECU.

An **operator control panel** allows the driver to select tire-pressure modes to match current conditions. This dash-mounted panel displays current tire pressures, selected modes and system status. When the driver selects a tire-pressure setting, signals from the control panel travel to the electronic control unit to the pneumatic control unit to the wheel valves.

When vehicles are moving faster (like on a highway), tire pressure should be higher to prevent tire damage. The CTIS includes a **speed sensor** that sends vehicle speed information to the electronic control unit. If the vehicle continues moving at a higher speed for a set period of time, the system automatically inflates the tires to an appropriate pressure for that speed.

This type of system uses air from the same compressor that supplies air to the **brakes**. A **pressure switch** makes sure the brake system gets priority, preventing the CTIS from taking air from the supply tank until the brake system is fully charged.



Hummer self-inflating tire system: At the wheel

A Closer Look

Here is what happens on the road: The electronic control unit tells the pneumatic control unit to check current pressure and either inflate or deflate the tire to the pressure selected by the driver. If the system determines that inflation is needed, it first checks to make sure that brake pressure reserves are where they should be; if they are, it applies a slight pressure to the wheel valve to allow inflation. If the tires are overinflated, the system applies a slight **vacuum** to the wheel valve. When the pneumatic control unit

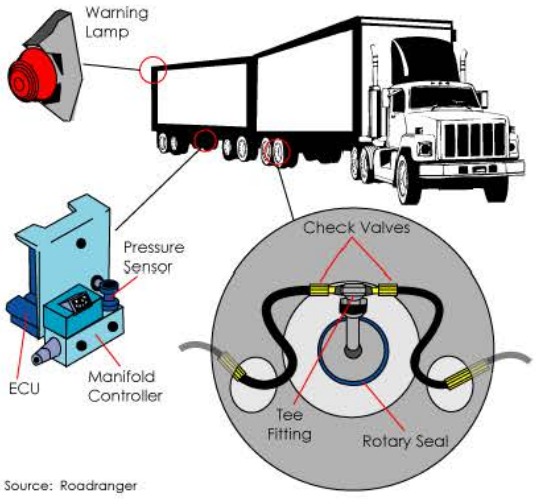
reads that the appropriate pressure is reached, the valve closes.

In this illustration, you can see the pathway that the air travels for inflation or deflation once it gets to the wheel. The tubing runs from the vehicle's air compressor through the wheel hub and then to the tire valve. The "quick disconnect fitting" allows the tire to be separated from the CTIS system for removal or servicing. (This diagram also shows the Hummer's run-flat feature, which allows the tire to continue supporting the vehicle even when it will not hold any air.)

EARLY CTIS

As early as 1984, GM offered the CTIS on CUCV Blazers and pickups. CUCV stands for Commercial Utility Cargo Vehicle, and these trucks have been used by the U.S. military since the mid-1980s. They are essentially full-size Chevrolet Blazers and pick-ups that have special equipment added for military applications.

Tire Maintenance System and AIRGO



Dana Corporation's Tire Maintenance System (TMS) is a "smart" system for tractor trailers that monitors **tire** pressure and inflates tires as necessary to keep pressure at the right level. It uses air from the trailer's **brake** supply tank to inflate the tires.

The system has three main components:

- The **tire hose assembly** provides the air route to inflate the tire and has

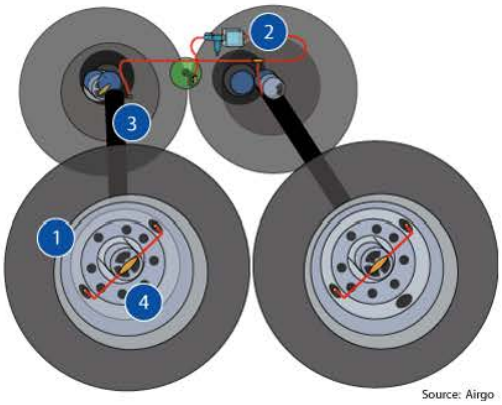
check valves so that the air lines and seals do not have to be pressurized when the system is not checking or inflating the tires. This cuts down on wear and tear on the seals.

- The **rotary joint** is comprised of air and oil seals and bearings and connects the air hose from the non-rotating axle to the rotating hubcap. Its air seals prevent leakage, and the oil seal prevents contamination. The rotary hub also has a vent to release air pressure in the hubcap.
- The **manifold** houses the pressure protection valve, which makes sure the system doesn't pull air if the brakes' air supply is below 80 psi. It also houses an inlet filter to keep the air clean, a **pressure sensor** to measure tire pressures and solenoids that control airflow to the tires.

Like the CTIS, this system also has an **electronic control unit** that runs the entire system. It performs checks to make sure the system is operational, notifies the driver via a warning light on the trailer (visible through the rear-view mirror) if a tire's pressure drops more than 10 percent below its normal pressure and performs system diagnostics.

The system performs an initial pressure check and adds air to any tire that needs it. The check valves in each tire hose ensure that the other tires don't lose pressure while one tire is being inflated. After an initial pressure check, the system depressurizes to relieve pressure from the seals. Every 10 minutes, the system pressurizes the lines and rechecks tire pressures.

The system measures tire pressure using a series of air pulses in the air lines. If the target pressure in the line is not reached after a certain amount of time, the system begins inflating the tire(s) until the correct pressure is reached.



Source: Airgo

AIRGO System

The AIRGO system is a constant monitoring system that uses a series of **check valves** to detect a loss in air pressure.

Unlike some of the other systems, AIRGO doesn't use air from the vehicle's braking system. When air seepage has occurred at any of various points in the system (1), the system draws air (2) from the vehicle's **pneumatic system** (not shown) and sends it by way of the vehicle's axles (3) -- through the axles themselves if they're pressurized or by way of tubing if they're not -- through the hubcap assembly (4) and into the tire requiring inflation.

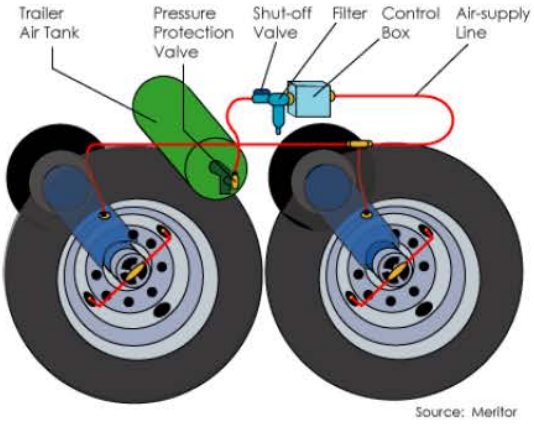
A **warning light**, located on the trailer but visible through the driver's rearview mirror, illuminates when the system has inflated a tire.

Since this is a **constant monitoring system**, which puts a lot of wear and tear on the seals, AIRGO uses carbon-graphite and case-hardened steel for its seals rather than rubber.

OTHER SYSTEMS

- **PressureGuard**: The PressureGuard system routes air from the trailer's air supply through the axles, to the hubs and then to the tire valves. (For more information, see PressureGuard.)
- **TIREMAAX**: The TIREMAAX system uses the trailer's air supply to maintain a specific level of tire inflation. When it detects low tire pressure, it signals the operator and then directs air from the trailer air tank to the tire needing inflation. (For more information, see Henrickson TIREMAAX.)

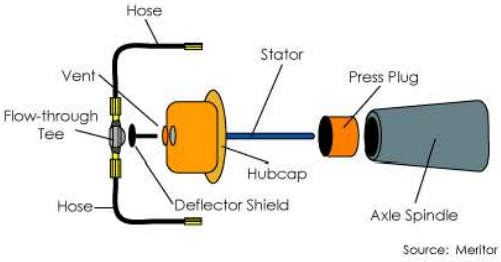
Meritor Tire Inflation System



The Meritor Tire Inflation System (MTIS) is designed for use on tractor trailers. It uses compressed air from the trailer to inflate any tire that falls below its appropriate pressure. Air from the existing trailer air supply is routed to a control box and then into each axle.

The air lines run through the axles to carry air through a rotary union assembly at the spindle end in order to distribute air to each **tire**. If there is significant air-pressure loss, an indicator light informs the driver.

The overall system is made up of a wheel-end assembly and a control module.



Wheel-end assembly

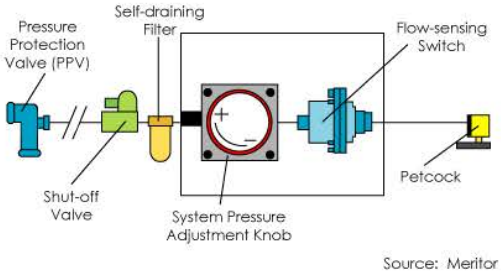
Wheel-end Assembly

The wheel-end assembly includes a **flexible hose** with check valves. The **check valves** only allow air to flow into each tire; this ensures that while one tire is being inflated, the other tires don't lose air pressure.

This assembly also incorporates a stator (a non-rotating part) inside the axle spindle and a **flow-through tee** that is attached to the hubcap. The flow-through tee has a dynamic seal to allow rotation while preventing pressure loss when pressurized air passes from the axle to the hub, which occurs through a tube that runs from the stator into the tee.

In the hubcap assembly, there is a **vent** to make sure pressure does not build up in the wheel end. A **deflector shield** keeps contaminants such as dirt and water from entering the wheel end.

For axles with hollow spindles, a **press plug** seals the pressurized axle interior from the wheel end in order to secure the stator.



Source: Meritor

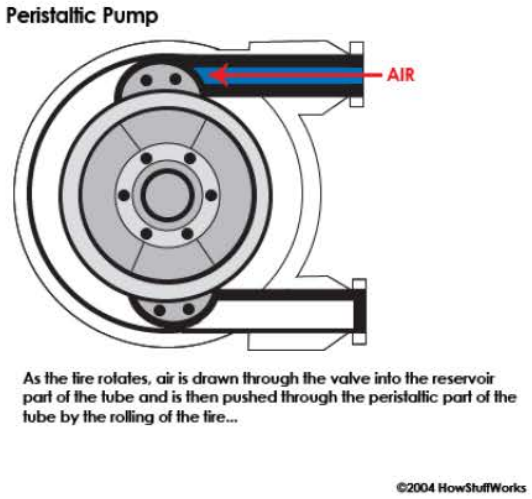
Control System

Controls

The system control module has a **shut-off valve** to stop air from being sent to the system, as well as a **filter** to remove moisture and contaminants. The **petcock** releases system pressure so maintenance can be performed. Like some of the other systems that use onboard air supplies, this system has a **pressure protection valve** so that it won't pull air if the air supply is below 80 psi.

A **system pressure adjustment knob** allows for adjustments to the overall system air pressure. A **flow-sensing switch** activates the **indicator light** to let the driver knows if a significant amount of air is being pumped into a tire, which would indicate a potential puncture.

The Future of Self-inflating Tires



Michelin is working with several other companies to develop an active pressure-management system called **TIPM** (Tire Intelligent Pressure Management), due to be

available sometime in 2005. This system has a compressor that automatically adjusts the pressure in each **tire** while the vehicle is in operation to compensate for leaks and slow-leak punctures. The driver will be able to adjust the pressure depending on the desired driving mode: comfort, sporty, all-terrain or over-obstacle.

There are at least two other systems in the early development stages that are oriented toward the consumer market -- the **EnTire** system and the Cycloid **AirPump** system.

The EnTire Self-Inflating Tire system uses a valve that pulls in air from the **atmosphere**. It then pumps the air into the under-inflated tire using a peristaltic-pump action. The goal is to constantly maintain a specific pressure.

The AutoPump tire-inflator system by Cycloid has a small, wheel-hub-mounted pump that is powered by the turning of the wheels. When the system's monitor detects a drop in pressure of 2 to 3 psi, it pumps air into the underinflated tire. AutoPump has a warning system that is activated when there is a puncture.

For more information on self-inflating tires and related topics, check out the links on the next page.

Related HowStuffWorks Articles

- How Tires Work
- How Tire Pressure Gauges Work
- Could anti-lock brakes detect a flat?
- How do 30 pounds of air in your tires hold up 2 tons of car?
- Why don't they use normal air in race car tires?
- How to Drive Economically

More Great Links

- Nakano Self-Inflating Bicycle Tires
- ArvinMeritor MTIS
- GM Goodwrench Videos

Sources

- EnTire
- Got Air? Wacky Weather Wages Tire Woes
- Trends in Japan: Building a Better Bicycle
- Lynch Hummer: Central Tire Inflation
- Roadranger: Central Tire Inflation System Goodyear Investor Relations: 2001 Annual Report

- Meritor Tire Inflation Systems (MTIS) by P.S.I
- Dana Spicer Tire Management Systems
- CM Automotive Systems: CTIS Specs
- U.S. Department of Transportation: 49 CFR Part 571
- CarandDriver.com: The Anti-Geneva Show
- Heavy Duty Trucking: Air Apparent
- LandLine: Tire monitoring and inflation systems
- Gerald's Hummer Page: Central Tire Inflation System
- The Groves: U.S. Army Trucks To Feature New Technology from Dana Corp.
- Michelin Innovation in Tire Electronics
- "Surface rutting of thin pavements and gravel roads under standard and reduced tire inflation pressures," by Ahmed Shalaby and Alan Reggin, Canadian Journal of Civil Engineering, 29, 679-691, 2002.
- "Under (Controlled) Pressure," by Carol Ludorf, Transportation Communications, Fleet Equipment, August 2002.
- "Air as Needed," by David Cullen, Fleet Owner, September 2003.
- Integrated Publishing: Central Tire Inflation System
- Forester.net: Breathing New Life Into Your Tires