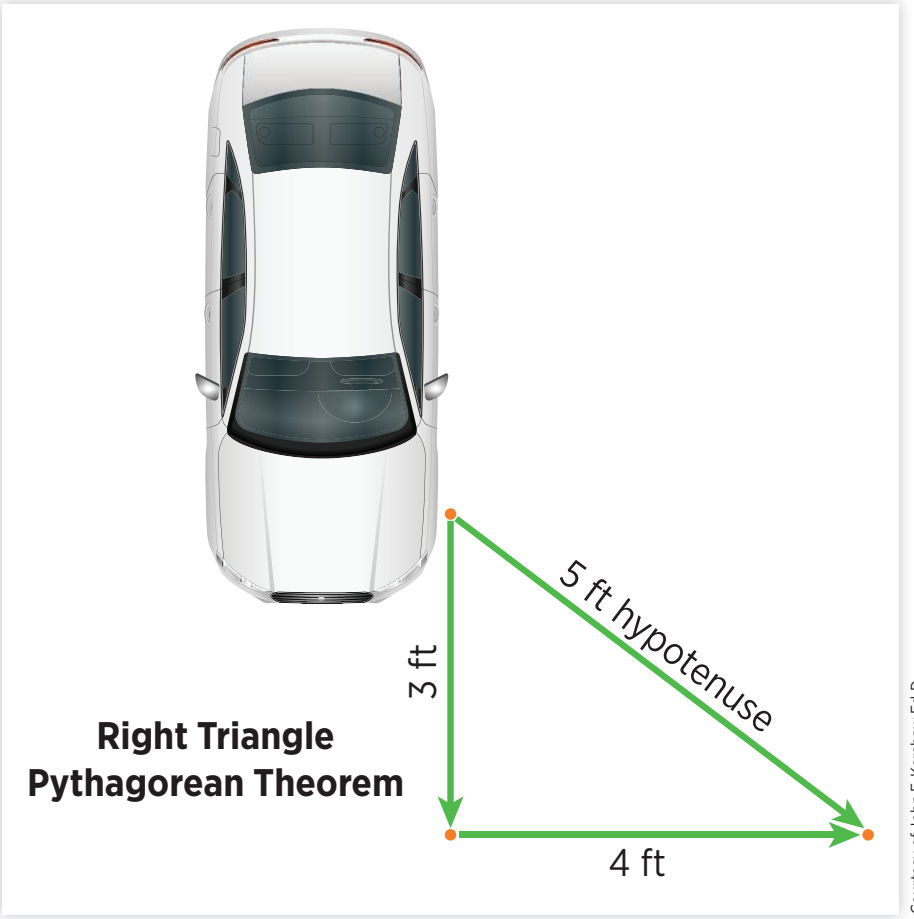
A

3-4-5 Accident Measuring Triangle

The accident measuring triangle is a measuring setup used by accident reconstructionist experts and automotive forensic engineers as a protocol for quantifying vehicle damages resulting from a collision. It is basically the creation of a carpenter's square or right angle. The triangle measurements from a right triangle can be used to form an exterior vehicle profile to assess the principal direction of force (PDOF). Figure A.1 shows the triangle laid against an exact duplicate vehicle to the one whose damage will be measured. You will compare measurements from the damaged vehicle to the duplicate vehicle. The hypotenuse of the triangle is placed at the center of the front wheel. Side b is the 5-foot side of the triangle. Side a, the 3-foot side, extends from the center of the wheel for 3 ft. Side b, the 4-foot side, goes across from the bottom of Side a to meet the bottom of Side b the hypotenuse. Using the Pythagorean theorem formula $a^2 + b^2 = c^2$, $9 + 16 = 25$ [see Equation (A.1)], the forensic engineer will take coordinate measurements like the ones taken at the scene of the accident. These measurements are taken along the base of the triangle and offset measurements inward from the vehicle base every 6 in. along the damaged area. You need to use a 4-foot level that provides a level plane for these measurements. For more information on this, see **J1674_201807** [1] and *Vehicle Accident Analysis and Reconstruction Methods, Third Edition* by Matthew Brach, Raymond M. Brach, and James Mason [2, 3].

$$a^2 + b^2 = c^2 \quad c = \sqrt{a^2 = b^2} \tag{A.1}$$

FIGURE A.1 Measuring triangle.



Courtesy of John F. Kershaw Ed.D.

4-Stroke Cycle (Spark Ignition)

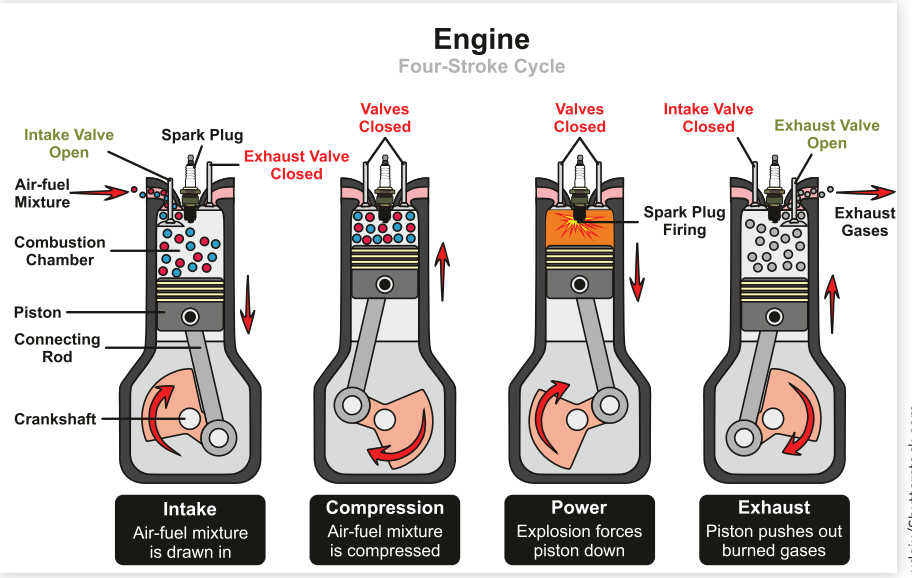
The intake stroke begins with the piston at the top spatial relation or top dead center (TDC). A lobe on the camshaft opens the valve either directly or through a disciple, pushrod, and valve rocker assembly. The piston moves down within the bore because of the rotation of the crankshaft. As the piston is moving downward, it pulls outside air through the air filter and into the intake manifold past the open intake valve and into the cylinder. The downward movement of the piston creates a low-pressure area above the piston because as the volume increases, the pressure decreases. Air rushes in to fill the space left by the downward movement of the piston because air pressure is greater than the pressure within the cylinder. The air-fuel mixture is consistent. During the intake stroke, an air-fuel ratio is inducted. The throttle valve controls the

atmospheric pressure entering the cylinder. The energy needed to maneuver the piston downward from TDC comes from overlapping power strokes on a multiple-cylinder engine or flywheel inertia. As the piston nears bottom spatial relation, it slows down nearly to a stop. When the piston reaches bottom spatial relation or BDC, the valve closes, sealing the cylinder, and the compression stroke will begin. The crankshaft is still revolving, forcing the piston upward toward TDC. Both intake and exhaust poppet valves are closed. The air-fuel mixture in the cylinder cannot escape, except past the piston rings. The cylinder volume is decreasing because, as the piston rises, the air-fuel gas mixture is compressed. The cylinder gas pressure is inversely proportional to the cylinder gas volume. This purports to Boyle's Gas law, which states that the pressure of a perfect gas varies inversely to its volume at a constant temperature or that the product of the pressure and volume is a constant within the compression of a gas. The volume is decreasing and so the pressure and temperature rise as external work is done on the gas.

Compression ratio is the ratio of the volume at BDC to the TDC clearance volume (compression ratio = volume BDC/volume TDC). A better compression ratio means higher thermal efficiency or that portion of the warmth supplied to the engine became work. When the compression ratio increases, the expansion ratio also increases; thus, thermal efficiency increases. The internal energy of the gas is increased as heat is added to the gas. Near the top of the compression stroke, a sparking plug will ignite the mixture. The power stroke begins right after the air-fuel gas mixture is ignited by a high-voltage (HV) electrical spark and combustion begins. The high gas pressures from combustion developed within the cylinder push the piston downward within the bore, which causes the crankshaft to rotate in the form of translation to rotation. The pressure falls because the volume increases. The temperature falls because the gas does external work. The oxygen and fuel burn and the nitrogen expands, pushing the piston down under power. As the piston continues downward, the combustion gases expand as they offer up their energy.

The power stroke is the only stroke where energy is extracted from the fuel. The cylinder pressure is the highest during the power stroke. As the piston nears the bottom of its movement, the exhaust poppet valve, operated by the camshaft lobe, begins to open. The piston then begins to rise within the cylinder, starting the exhaust stroke. The upward movement of the piston forces the spent gases past the open poppet valve and out the cylinder. The exhaust poppet valve is closed by spring pressure, shortly after the piston begins its downward movement. The exhaust stroke produces no work but uses some of the energy produced during the power stroke to push exhaust gases out of the cylinder. In a spark-ignited gasoline-fueled engine, we have flame speed which increases when engine speed increases. Therefore, the quantity of crank angles occupied by the combustion process is almost independent of engine speed.

FIGURE A.2 Spark-ignition ICS 4-stroke cycle.



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4-Stroke Cycle Diesel (Compression Ignition)

The diesel 4-stroke cycle is the same as the Otto 4-stroke cycle. There are differences in combustion, power control, and compression ratio. The 4-stroke cycle consists of intake, compression, power, and exhaust. When all four are completed, the diesel engine has completed the four strokes of one full cycle. The diesel intake stroke starts with the piston at top dead center, or TDC, where the piston is at the top of the cylinder. The camshaft lobe opens the intake poppet valve in the cylinder head. The piston moves down in the bore due to the rotation of the crankshaft. As the piston moves down, it pulls outside air through the air cleaner and into the intake, past the open intake valve and into the cylinder. The downward movement of the piston creates a low-pressure area above the piston (as the volume increases the pressure decreases, which is Boyle's Law). Air rushes in to fill the space left by the downward movement of the piston because atmospheric pressure is greater than the low pressure in the cylinder.

During the diesel intake stroke, only air is inducted; this is because no throttle valve is used, so the cylinder is completely filled with air at the inlet manifold pressure. The air mixes with residual gasses in the cylinder. The energy needed to move the piston from TDC downward comes from either the flywheel or overlapping power strokes from a multiple-cylinder engine. As the piston nears bottom dead center (BDC), it slows down nearly to a stop. When the piston reaches BDC, the intake valve closes, sealing the cylinder filled with air, and the compression stroke begins. The rotating crankshaft forces the piston

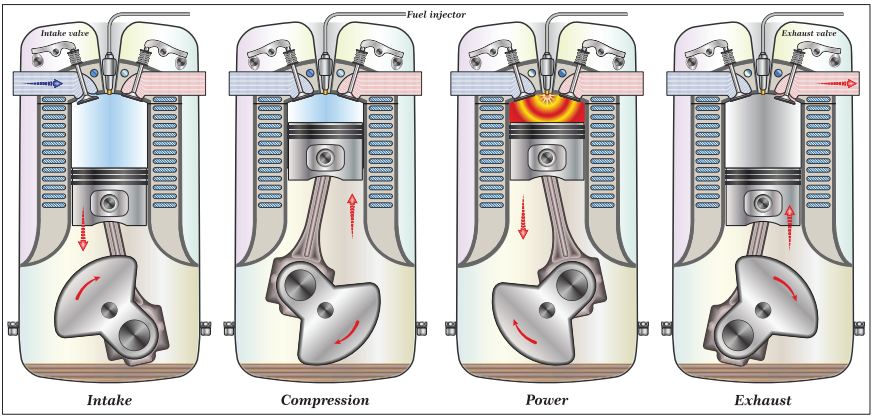
upward and both intake and exhaust poppet valves are closed so the air cannot exhaust. The volume is decreasing as the piston rises, so the air is compressed. The pressure is inversely proportional to the volume according to Boyle's Law. In the compression of a gas, the volume decreases and the pressure and temperature rise as the gas is pressurized. This causes collisions of the air molecules within the cylinder. For example, if a volume of air is compressed to 1/22 of its original volume as it is in diesel, the open space between the molecules is greatly reduced increasing the number of collisions and the pressure between them. These collisions cause heat due to the kinetic energy of the molecules.

Compression ratio is the ratio of the volume at BDC to the volume at TDC or the cylinder clearance volume. A higher compression ratio means higher thermal efficiency or that portion of the heat supplied to the engine that is converted into work. As the compression ratio increases, the expansion ratio also increases thus thermal efficiency increases. The internal energy of the combustion gas is increased as heat is added to the gas. The high heat generated by greater compression will cause the fuel when injected to atomize or break up into finely divided particles, allowing it to mix easily with the air. In the indirect injection (IDI) engine, mixing is further enhanced by the addition of more heat through the spinning action of a spherical shaped prechamber. Ignition will occur only at the interface where the air and fuel come together, which is called a diffusion flame. The temperature of the compressed air is approximately 1,000°F. The temperature is generally higher than the spontaneous ignition point of diesel fuel, which is 558°F (292°C). Near the end of the compression stroke, fuel will be sprayed into either the prechamber in an IDI engine or the combustion chamber in a direct injected (DI) diesel engine. In the DI engine, the compressed air will swirl in a toroidal piston cavity increasing the friction between air molecules, which will promote mixing with the fuel. The IDI diesel prechamber is joined to the main combustion chamber above the piston by a connecting flow passage. A swirl-precombustion chamber has a spherical shape that mixes the air and fuel by air swirl. This assists in promoting high turbulence by creating a swirling mass of air in the prechamber.

Turbulence is the extreme disturbance of the compressed air in the combustion chamber. It causes the air molecules to move in all directions. The air molecules collide with each other and cause friction and heat, which increases the transfer of heat between the cool liquid-fuel droplets and the hotter air. The power stroke begins after the fuel is sprayed into the direct combustion chamber or prechamber. The fuel nozzle sprays and atomizes the fuel in short bursts forming a fuel-rich core surrounded by air zones. During this period, fuel has entered the main combustion chamber from the prechamber but has not begun to burn. The temperature of the air is much higher than the fuel, so some of it has evaporated, but some has formed into very tiny droplets. It starts to vaporize and mix with the hot compressed air. After about 0.001 sec, any zones that are

hot enough and have the correct air-fuel mixture ratio will autoignite. It is important to note that ignition will take place only where air meets fuel. IDI diesel engines begin combustion in the prechamber, and combustion moves into the main chamber as fuel, air, and burned and burning gases while the piston descends on the power stroke. The first fuel burns very rapidly. This rapid burning of the air and fuel creates a sudden pressure causing a highly localized pressure. This localized pressure causes an audible noise, known as diesel knock, whose noise level centers on the pressure rise velocity. The cylinder high pressures force the piston down in the bore, which causes the crankshaft to rotate. The pressure falls as the volume increases. The temperature falls as the gas does external work. The oxygen/fuel burns and the nitrogen expands, pushing the piston down under power. As the piston continues downward, these gases in the cylinder expand and cool as they give up their energy. The power stroke is the only stroke in which energy used from the fuel and cylinder pressure is the highest. As the piston nears the bottom of its travel, the exhaust poppet valve is opened by a camshaft lobe. The piston then begins to rise in the cylinder, beginning the exhaust stroke. The upward movement of the piston forces the burned gases past the open exhaust valve and out of the cylinder. The exhaust valve closes due to spring pressure after the piston begins its downward movement [4].

FIGURE A.3 Diesel 4-stroke cycle in a compression-ignition engine.



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2WD (Two-Wheel Drive)

The term used to describe a 2WD car or truck. The number "2" indicates the number of wheels that are driven by the transmission/engine. Only the two wheels are propelling this vehicle through a horizontal driveshaft or propeller shaft to a set of bevel gears.

4WD (Four-Wheel Drive)

The term used to describe a 4WD vehicle. The number "4" indicates the number of wheels that are driven by the transmission from the internal combustion engine. Due to open differentials that slip, power goes to the wheel with the least amount of traction. It is also referred to as a 4 × 4.

4WD/AWD Shift Motor

This motor is used to engage the proper clutch to deliver power flow to the front driveshaft on a four-wheel-drive (4WD) vehicle to engage 4WD in high or low. A control module commands the shift motor to rotate to the correct position to apply a clutch. The shift motor turns the control actuator lever shaft and a brake to hold the control actuator shaft in full-clutch position. The control actuator lever shaft moves the clutch lever. The clutch lever pivots on the control lever pivot studs and moves toward the clutch apply plate, to apply the clutch plates. The inner clutch discs are engaged to the clutch hub, and the outer clutch discs are engaged with the clutch housing; the power flow is delivered to the clutch housing. The clutch hub is splined to the rear output shaft and the chain drive sprocket is splined to the clutch housing. Power will flow from the drive sprocket, through the chain, to the chain-driven sprocket to the front output shaft and power is delivered to the front driveshaft. The shift motor rotates the control actuator shaft lever to the 4WD positions. Rotating the control actuator to the various positions changes the clutch torque level. For more information on this, see **J3104_201811** [5].

ABS (Anti-lock Brake System)

A brake control system to prevent brake lockup using a computer that compares the vehicle wheel speeds using wheel speed sensors. ABS can apply the brakes using a modulated pump on the automotive or medium-duty truck hydraulic ABS or release brakes automatically. The system uses a dash indicator (telltale) to indicate failures. If a wheel spins at a faster rate than other wheels, or faster than designed, this indicates a wheel is starting to slip (via that same telltale) and is in danger of losing traction and locking. ABS will reduce the hydraulic pressure to the affected brake, which allows the wheel to speed up so it can regain traction. As traction is recovered, brake pressure is reapplied to again slow the wheel. The opposite is true in that pressure can be applied to a wheel that is faster than the others. SAE Paper 2017-01-1578 cites two control strategies: "Safety preferred control and master cylinder oscillation control, were designed for anti-lock braking on a novel integrated-electro-hydraulic braking system (I-EHB) which has only four solenoid valves in its innovative hydraulic control unit (HCU) instead of eight in a traditional one. The main idea of safety preferred control is to reduce the hydraulic

pressure provided by the motor in the master cylinder whenever a wheel tends to be locking even if some of the other wheels may need more braking torque. In contrast, regarding master cylinder oscillation control, a sinusoidal signal is given to the motor making the hydraulic pressure in the master cylinder oscillate in certain frequency and amplitude. Hardware-in-the-loop simulations were conducted to verify the effectiveness of the two control strategies mentioned above and to evaluate them. The simulation platform consists of the I-EHB hardware and software including CarSim and MATLAB/Simulink as well as LabVIEW serving as the communication tool. Conclusions can be reached in the light of testing results that both control strategies were able to achieve anti-lock braking under emergency situations. Compared with safety preferred control, master cylinder oscillation control performed better on the functionality of avoiding braking lock and the reduction of braking distance. Also, it is capable of working with electronic stability control systems (ESC) while safety preferred control cannot." [6].

ABS Truck Hydraulic Control Unit

This unit controls brake fluid pressure to the wheels during an anti-lock stop. It maintains, decreases, or increases the braking force as needed at each affected wheel. It is called a brake modulator on air ABS (anti-lock brake system). For more information on this, see **J2627_200908** [7].

ABS Truck Malfunction System

Medium- and heavy-duty trucks and buses are required to have anti-lock brake system (ABS) under Federal Motor Vehicle Safety Standards 121 and must use ABS malfunction indicator lamps (telltale). These lamps must be yellow and illuminate when the ABS management controller senses a malfunction that affects the generation or transmission of response or control signals from the wheel speed sensors. ABS malfunction indicator lamps do not illuminate for all malfunction codes, only specific safety-related codes. These lamps are required to illuminate for about 5 sec bulb check when the ignition or power switch is engaged. The warning lamps for tractor trailers and dollies are not required to illuminate for a bulb check unless the vehicle is stopped. For more information on this, see **J2627_200908** [7] and FMVSS 101 controls and displays.

Absolute or Dynamic Viscosity

Absolute viscosity is a measure of internal resistance in a liquid lubricant and the tangential force per unit area required to maneuver one horizontal plane

with reference to another horizontal plane with the liquid lubricant between them. This takes place at a unit velocity while continuing a unit distance apart within the liquid lubricant.

Absorption

Absorption is the process or action where one unit absorbs or is absorbed by another unit. The unit doing the absorption is called the absorbate and the unit being absorbed is called the absorbent. These units or entities can be a solution of a gas, liquid, or solid in a liquid, attachment of molecules of a gas, vapor, liquid, or dissolved substance to a solid surface by physical forces. The absorption of light at characteristic wavelengths or bands of wavelengths is used to identify the chemical nature of molecules, atoms, or ions and to measure the concentrations of these entities.

AC (Alternating Current)

The electrical potential created by an AC generator is not a steady state, it fluctuates between positive and negative. When such a potential is applied to a circuit, it causes a current that flows first in one direction and then reverses itself and flows in the other direction. In house electrical systems, this direction reversal happens 60 times a second. This current is called alternating current, or AC. Rotating a magnetic field within or around a conductor produces AC in that conductor. When a magnetic field crosses or cuts though a conductor, it induces an AC voltage in that conductor.

AC Coupling

Signal that passes the alternating current (AC) signal component to the meter but blocks the direct current (DC) component. It is an AC signal that rides on a DC signal, like an alternator charging ripple.

AC Induction Motor

This is an electric motor driven by alternating current (AC). It consists of two basic parts, an out of doors stationary stator having coils provided with AC to provide a force field and an internal rotor attached to the output shaft which is given a torque by the rotating field. Nikola Tesla invented the rotating field and pioneered the utilization of a rotary field of force to work machines and designed a two-phase induction motor in 1883. There are two forms of AC motors, depending on the sort of rotor used. The first type is the electric

motor, which rotates exactly at the provision frequency or a sub-multiple of the provision frequency. The flux on the rotor is either generated by current delivered through slip rings or by a static magnet. The second type is the asynchronous or induction motor, which is employed in battery electric vehicles. It turns slightly slower than the provision frequency or out of sync as the name suggests. The field of force on the rotor of this motor is made by an induced current.

Accelerate

Accelerate means to increase speed or the rate of change in velocity, which is a vector quantity having both direction and magnitude, where speed is a scalar quantity only having magnitude.

Acceleration

This is defined as a change in velocity (vector quantity has direction and magnitude) as it relates to time. The word comes from the Latin meaning to add speed. It can be either positive, if the vehicle is gaining speed, or negative, if the vehicle is losing speed. Equation (A.2) is used to determine acceleration:

$$a = \frac{V^2}{2 \times D} \tag{A.2}$$

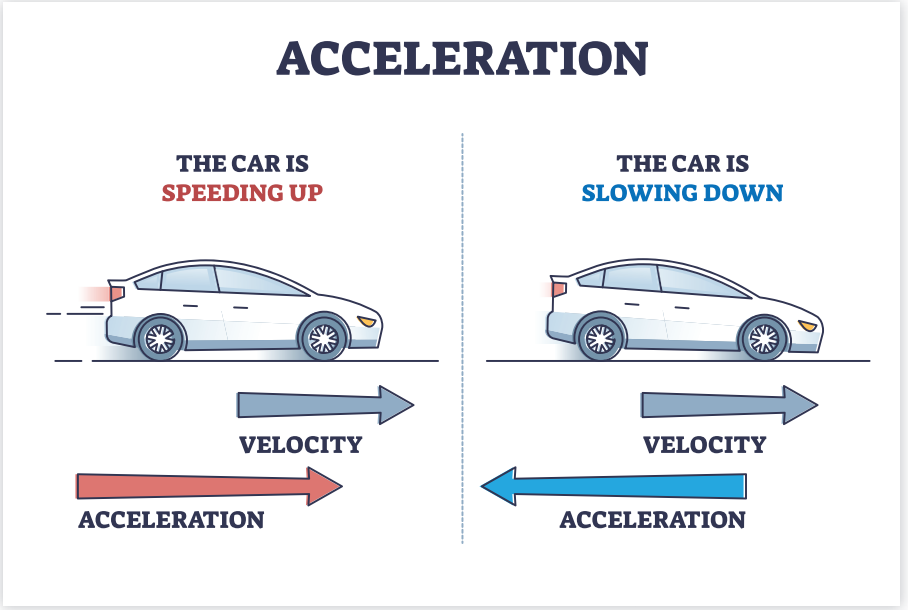
where

a is acceleration
V is velocity
D is the distance

The resultant of this equation can be converted from feet per second or meters per second into g force using Equation (A.3):

$$g = \frac{a}{32\ \text{ft/s or } 9.8\ \text{m/s}} \tag{A.3}$$

FIGURE A.4 Vehicle acceleration change in velocity.



VectorMine/Shutterstock.com.

Acceleration Test

This is an internal combustion engine (ICE) ignition system test that measures the spark plug firing voltages when the engine speed is rapidly increased. Also called a load test.

Accelerator Pump

A pumping device used in a carburetor to inject fuel into the boost venturi for additional fuel for combustion to achieve more engine speed during vehicle acceleration.

Accelerometer

A device that measures changes in motion or deceleration. It measures proper acceleration, which is the rate of change of velocity of a body in its own instantaneous rest frame, which is different from coordinate acceleration, which is acceleration in a fixed coordinate system. For example, an accelerometer on Earth's surface will measure an acceleration due to Earth's gravity, straight

upward of "g" force, which is 9.81 m/s^2 or 33 ft/s^2. Accelerometers are used in some supplemental restraint systems (SRS).

Accident Reconstruction (Automotive and Motorcycle)

Accident reconstruction is the forensic science of determining how an accident took place while supporting the determination of the accident cause or why a collision or particular event during an accident happened using all the available physical evidence. Scientific methodology is used to determine the circumstances, mechanics, and contributing factors associated with an automotive collision. It requires a working knowledge of the following: physics, vehicle dynamics, mathematics, photogrammetry, and computer applications, simulation or modeling tools, graphics and photo-management software. This would include the use of scan tools and CDR (crash data retrieval) tools and software. Questions needed to be answered, for example, what was the vehicle speed going into the collision, were the brakes applied during ABS braking, or what were the angles of a multiple vehicle collision can be answered by the forensic investigator after a review of all pertinent documents and a physical inspection [1, 2, 3].

Accumulator

A pressure absorbing unit that absorbs and reduces sudden pressure surges in a hydraulic system. Accumulators are used in automatic transmission/transaxle hydraulic systems to cushion and control range shift quality.

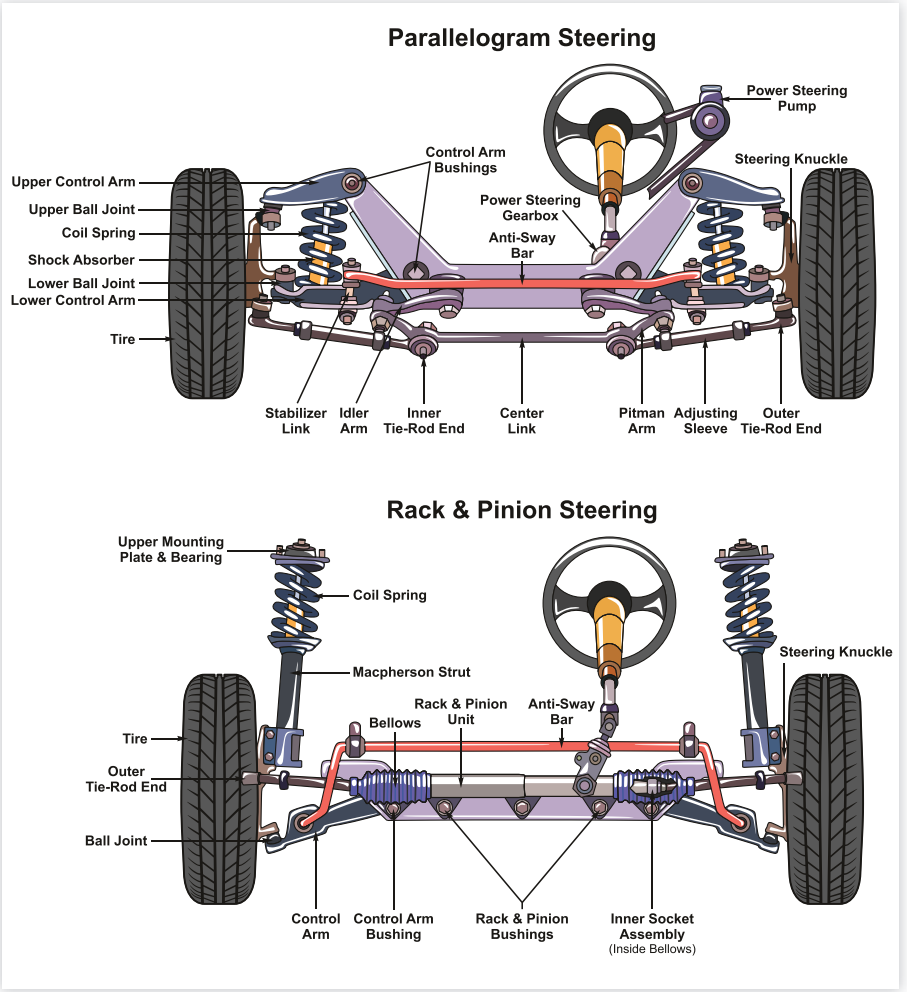
Ackermann Principle

This is the correct positioning of the wheels when steering around a corner. It is a geometric alignment of linkages in a vehicle steering such that the wheels on the inside of a turn are able to move in a different circle radius than the wheels on the outside. For more information on this, see **J670_200801** [9].

Ackermann Steering System

A steering system designed by Rudolf Ackermann that used angled steering arms and knuckles. This design allows both front wheels to turn in their own arc. The inner wheel turns at a sharper angle, allowing both wheels to turn from the same pivot point, thus reducing tire wear. This systems has been redesigned over the years. For more information on this, see **J670_200801** [9].

FIGURE A.5 Ackermann steering system that uses angled steering arms to turn a steering knuckle.



udaix/Shutterstock.com.

Acrylic Paint

Acrylic enamel paint is a fast-drying paint made of pigment suspended in acrylic polymer emulsion and plasticizers, silicone oils, defoamers, stabilizers, or metal soaps. Acrylic paints are either petrol-based or water-based, but become water-resistant when dry.

Active Restraint System

A restraint system, such as a lap/shoulder belt, that requires the occupants to ready the system through extra effort for them to activate or use. A lap seat belt must be fastened by the passenger to protect them from any crash. This is opposed to a passive restraint system like an SRS (supplemental restraint system) or air bags.

Active Sensor

A sensing device that requires an external source of power to operate; active sensors contrast with passive sensors, which simply detect and respond to some type of input from an outside source.

Actuator

An actuator is any output device like a solenoid or DC motor controlled by a management computer, where the computer operates the device by applying a ground or voltage. Devices would include solenoids or relays. They convert computer output into a mechanical action and perform the physical task dictated by a computer command. Actuators can be used to open and close switches, control the flow of fluid, and control gauges and warning lights.

AD Converter

A solid-state device that converts an analog signal to a digital signal. In electronics, a data converter called an ADC, A/D, or A-to-D converts an analog signal, such as a magnetic pickup used on a rotating shaft or a vehicle speed sensor (VSS) that generates an analog variable voltage signal into a digital signal sent to a management computer. An ADC may additionally provide an isolated measurement like a device that converts an analog input voltage or current to a digital number representing the magnitude of the voltage or current. The digital output may be a 1 and 0 complement binary number that is proportional to the input. Most ADCs are implemented as integrated circuits (ICs). These typically take the shape of metal-oxide semiconductor (MOS) mixed-signal computer circuit chips that integrate both analog and digital circuits. A digital-analog converter (DAC) performs the reverse function; it converts a digital signal into an analog signal. For more information on this, see **J1213/2_198810** [10].

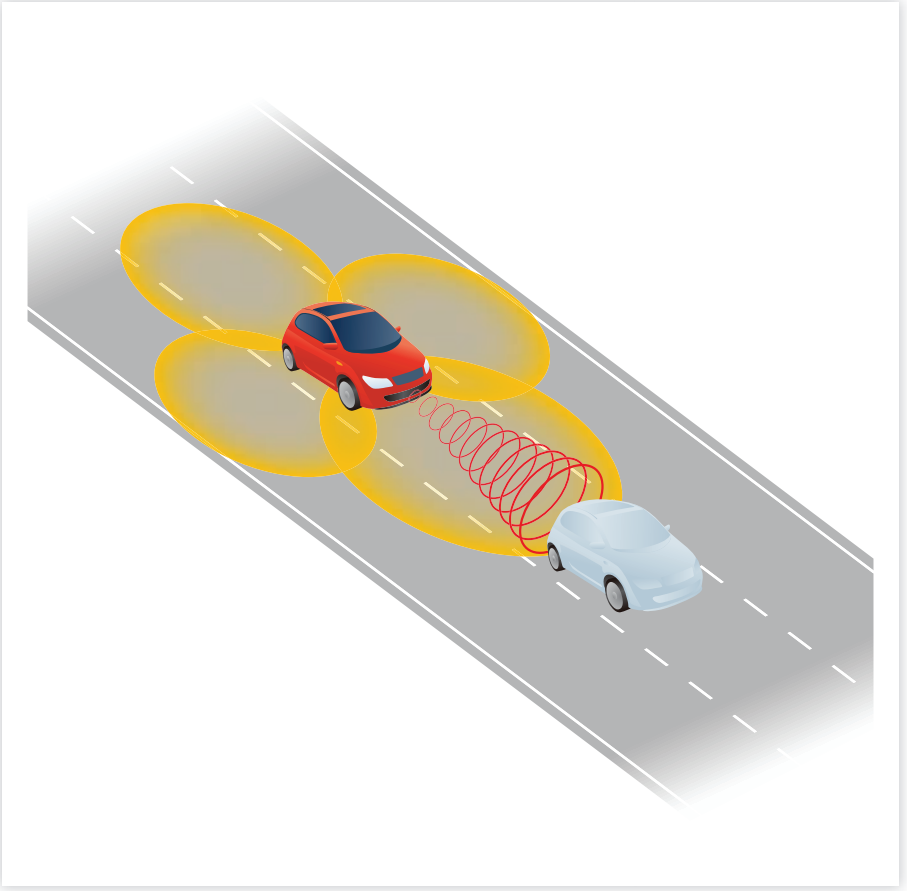
AD (Analog-to-Digital) Converter Circuit

A device circuit used by a digital computer to change continuously variable voltage or current into digital bits.

Adaptive Controller (Radar Cruise Control)

An adaptive cruise controller (ACC) is used to allow the driving force more control of the vehicle by maintaining a clear safe distance, usually 2 to 3 sec, behind the vehicle in its front. If the vehicle at the front slows down, the radar controller of the following vehicle detects the slowing vehicle and automatically reduces its speed to keep a safe distance. Then, if the vehicle at the front increases speed, the radar controller of the following vehicle also allows itself to adjust to the preset speed. For more information on this, see **J3063_202103** [11].

FIGURE A.6 Adaptive or radar controller uses long-range radar to detect faraway objects ahead of the moving vehicle. Some systems use a short-range radar and/or infrared, or optical cameras to detect distances for when the gap between the moving vehicle and another vehicle ahead is reduced.



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Adaptive Learning

The adaptive learning platform delivers learning content that is extremely relevant, adapted to each learner's needs, and is divided into micro-learning elements. To accomplish this, the learning is created through a series of questions and then followed by justifications for why each answer is either correct or incorrect.

Adaptive Memory

Adaptive memory is a feature of computer memory that allows the microprocessor to adjust its memory for computing output response based on changes in vehicle operating conditions.

Adaptive Testing

Adapting testing uses test questions that are developed from key learning points (KLP) focus on important concepts and "need to know" information required to meet the identified performance goal or behavioral change. Each KLP is a single piece of critical information that includes what the learner needs to know/do and why it is important.

ADEMS (Advanced Diesel Engine Management System)

This is a Caterpillar acronym used to describe their heavy-duty diesel engine management electronics using electronic unit injectors (EUI). The ADEMS is a full-authority control system. Every time the EUI camshaft lobe comes near the end of the intake stroke, it begins to depress the injector tappet and plunger. The EUI plunger stroke is cam actuated, so the system control is still restricted to the hard limit window created by the cam profile. In the "normal" state, the poppet valve in the electric solenoid is open. The open valve allows the injector to fill with fuel. and when the injector tappet and plunger are pushed, any pressure developed is bypassed to the fuel return system. When the engine control module (ECM) calls for injection, a 100-V electrical signal is applied to the injector solenoid, and this causes the solenoid to close the bypass poppet valve. With the bypass closed, the moving plunger rapidly develops pressure in the fuel chamber.

When the fuel pressure reaches a moderate level, the injector check valve (lower yellow portion above) opens and fuel injection commences. When the ECM stops injection, it stops sending the 100-V signal to the EUI solenoid, and the solenoid poppet valve opens. Opening the poppet valve instantly bleeds off almost all fuel pressure and fuel is again bypassed to the return system, stopping the fuel injection. With the reduction in internal fuel pressure, the fuel check valve in the lower portion of the EUI closes. The closure of the fuel check valve provides a "clean" injection stop and also prevents combustion pressure or gases from entering the injector. The EUI design permits very rapid starting and stopping of the fuel flow; ECM speed was the limiting factor at first.

In addition to the pilot injection, this high-speed cycling of the injector permits "rate-shaping" during the main-injection burn.

Additive

An additive is used to improve the performance of an engine lubricating oil. Manufacturers blend in chemical additive packages. These packages make up about 25% of the oil. A 5W-30 oil may be 75% oil base stock, 11% viscosity improver, and 14% other additives. The purpose of motor oil additive can be that an additive replaces a property of the oil that was lost during refining, strengthens a natural quality already in the oil, or adds a property that the oil did not naturally have.

Address

This is in reference to a personal computer memory; it is a specific location in the computer memory.

Adhesion

The action of adhering or sticking to a surface or object.

Adhesive

A compound that is designed to seal or stick to a surface, like gluing two items together.

Adiabatic

A thermodynamic term for a low heat rejection heat engine. The adiabatic process, which means impassable, takes place without transferring heat or weight between the thermodynamic system and its environment. In comparison an isothermal thermodynamic process transfers energy to the surroundings only as work. The adiabatic process supports the theory that explains the first law of thermodynamics that energy is neither created nor destroyed, only changed

Adjustable Brake and Accelerator Pedals

Adjustable pedals, pedal height control, or electric adjustable pedals (EAP) place the pedal and so the throttle on motor-operated movable brackets. The height of the brake pedal and the accelerator or treadle pedals are adjusted together and cannot be adjusted individually. Adjustable pedal systems include an adjustable pedal position switch, which allows an actuation to position the pedals, and thus the adjustable pedal assembly that contains the motor, threaded adjustment rods, and a pedal position sensor. The position of the pedals and power seat system are usually included as a component of the memory seat function and can be set for two or more drivers.

ADS (Automated Driving Systems)

An ADS will take over steering, acceleration, and braking in specific scenarios. The ADS must have control systems that are capable of analyzing sensory data to tell apart between different cars on the road. A three-dimensional evaluation model conforming to the functional architecture of autonomous vehicles has to be built, with each dimension representing one among three key functional layers of autonomous vehicle including sensing and perception, decision-making planning, and control and execution. Each dimension contains a set of metrics carefully defined with their weights fairly determined, supporting an entropy weights method. For more information on this, see **J3016_202104** [24].

Aerobic Sealant

A sealant that cures in the presence of air.

Aerodynamic Drag

Aerodynamic drag is the wind resistance of air moving over the size and shape of a vehicle. Air flowing over the body of a moving vehicle is very complex and will require the development of semi-empirical models to represent the resulting effect. The following equation represents aerodynamic drag:

$$D_A = \tfrac{1}{2} p V^2 C_D A \qquad \textbf{(A.4)}$$

where

C_D is the aerodynamic drag coefficient
A is the vehicle frontal area
p is air density

Aerodynamics

Aerodynamics is the study of the motion of air on a moving vehicle produced by drag and viscous friction. This is a sub-field of fluid and gas dynamics. Aerodynamics has focused on issues associated with compressible flow, turbulence, and boundary layers and is computational in nature. The gross flow of air over a vehicle body is controlled by the link between velocity and pressure found in the modified Bernoulli's equation (A.5):

$$P_{static} + P_{Dynamic} = P_{Total\ Air\ Flow} \qquad \textbf{(A.5)}$$

where

$P_t = P_s + \tfrac{1}{2} pV^2$
P_s is static air flow
P_t is the total air flow
p is the density of air
V is velocity of air relative to the vehicle

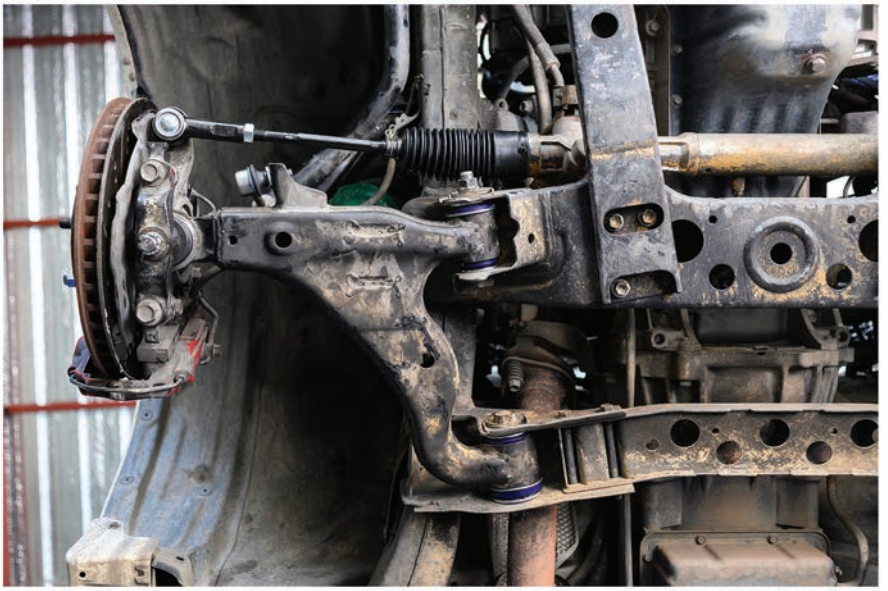
AFR (Air-to-Fuel Ratio)

This is the ratio of the amount of air to the fuel used for combustion. The chemical term stoichiometric is employed to explain the simplest AFR, which is 14.7:1. This number describes the proportions of air at 14.7% to 1 a part of fuel during a combustion reaction, required to complete the consumption of all of the fuel. It is normally expressed by mass or weight.

A-Frame Control Arm

A-frame, or A-arm, is part of the front suspension system found in short- and long-arm (SLA) suspensions and others. A-frame control arms are the primary load-bearing component of the SLA suspension system. The A-frame is also referred to as a wishbone control arm. The arm is a flat triangular component that connects to the frame or subframe at each leg of the "A" with the peak connecting to a ball joint that connects to the steering knuckle that connects to an upper ball joint that connects to the short upper control arm. The arm mounting points are spaced wide apart to prevent forward or backward movement of the steering knuckle. For more information on this, see **J670_200801** [9].

FIGURE A.7 A-frame control arm used in automotive SLA front suspension systems.



Setta Somnoi/Shutterstock.com.

Afterburner

An afterburner is used as a combustor where heat is added to the working fluid after the last expansion stage. It is a combustor used on some jet engines to increase thrust, usually for supersonic flight and takeoff. For more information on this, see **J604_201108** [23].

Aftercooler (Turbocharger)

A charge air cooler to lower the air temperature to make it cooler and, therefore, denser for more power. You either cool the air before it enters the turbo or after. The aftercooler cools the air after the turbocharger. For more information on this, see **J922_201106** [30].

AGM (Absorbed Glass Mat) Battery

This is a recombinant-type battery or valve regulated lead-acid (VRLA) design. The electrolyte is totally absorbed into the separator, making the battery leak proof and spill proof. The battery is assembled by compressing the cell about 20% and then inserting it into the container. The compressed cell reduces damage caused by vibration and helps keep the acid tightly against the plates. This design uses a pressure release valve in each cell. Most of the hydrogen and oxygen given off during charging remains in the battery. The mat is 90–95% saturated with electrolyte, allowing a portion of the mat to be filled with gas. The gas has spaces that provide channels to allow the hydrogen and oxygen gases to recombine rapidly. Due to the fact that the electrolyte is totally absorbed into the glass mat separator, an AGM battery can be mounted in any direction. For more information on battery definitions used in the automotive industry as they relate to energy storage and batteries for starting, lighting, and ignition applications, as well as for hybrid electric vehicles (HEV) and electric vehicles (EVs), see **J1715/2_202108** [8].

Air ABS (Anti-Lock Brake System)

The air anti-lock braking system (ABS) modulates the atmospheric pressure within the brake chambers to forecast wheel lockup and reduce stopping distances on slippery road surfaces by limiting wheel slip. ABS provides:

- Vehicle stability
- Steerability under emergency braking
- Stable stopping on icy or rain-slicked road surfaces and in curves
- Stopping distance
- Jackknifing or plow out (loss of steering control)
- Tire flat spotting: flat spots caused by abrasion when wheels lockup

Automatic traction control (ATC) systems use ABS components to further enhance the vehicle and trailer traction and improve control. ATC uses sensors and software to scale back wheel slippage and direct power to slipping wheels in traction loss situations like snow or ice. Also, systems used in Europe are emerging within the US market called electronic braking system (EBS) on heavy trucks that has been used on HEV and EVs. EBS is a computer-controlled air brake system where the braking negative feedback circuit is managed electronically and therefore the foot pedal is just an input to an EBS control module. Brake application at the wheels continues to be controlled using air pressure; the difference is that the control is completely electronic. One big difference between hydraulic ABS and air ABS is that, within the mechanism, pressure must be developed by a hydraulic ram, where, within the air ABS, atmospheric pressure is available from the engine-driven compressor. The ABS modulator valve either changes the atmospheric pressure to the brake chamber or holds the prevailing pressure. For more information on this, see **J2627_200908** [7].

Air ABS Blink Codes

ABS blink error codes can be retrieved either with a service tool or by initiating the ABS indicator lamp to show a blink code. Both methods return codes that indicate what system or component caused the error. Blink codes are the easiest and most common method to retrieve errors, but it is important to understand its operating parameters:

- When more than one active fault is stored in the ABS management computer memory call an electronic control unit, or ECU, the first active fault displayed must be corrected before the next fault can be displayed.
- An active fault cannot be erased from the ECU memory until it is fixed.

The blink code feature does not necessarily display the faults in the order they were recorded by the ECU. Always park the vehicle before turning on the ABS blink code lamp. To perform a blink code check, the vehicle voltage system must be between 9.5 and 14 V.

Blink code procedure:

- Turn ignition to the ON position.
- Press and hold the blink code switch for one second and then release.
- Record the number of blink code flashes.
- After recording both numbers of the fault code, turn the ignition switch to the OFF position.
- Identify the recorded blink code.

For more information on this, see **J2627_200908** [7].

Air ABS Brake Modulator

This device regulates the atmospheric pressure to the brakes during ABS action. When not receiving commands from the ABS management computer called an ECU, or electronic control unit, the modulator valve allows air to flow freely and has no effect on the brake pressure. The ECU commands the modulator valve to change the air pressure to the brake chamber or hold the present pressure. It cannot automatically apply the brakes or increase the brake application pressure above the amount applied by the motive force. The modulator valve typically contains two solenoids. The modulator valve and relay valve could also be incorporated into one unit. The modulator valve might also be separate, inserted into the baseline to the brake chamber(s) after any relay valve, or located as close as practicable to the chamber(s) itself. When the modulator valve is separate, it is to manage more air flow and, therefore, includes two larger diaphragm valves which are controlled by the solenoids. It always has three ports. For more information on this, see **J2627_200908** [7].

Air ABS Electronic Control Unit (ECU)

The truck air ABS management computer is called an ECU, or electronic control unit, that monitors the wheel speed sensors to determine the drive axle(s) wheel speed and compare these speeds to the wheels on the steering axle to determine slippage. When the speed of the drive axle(s) exceeds that of the steering wheels by a specified amount, the traction control software within the ABS ECU can command a reduction of engine speed and application of the drive axle brakes on one side of drive axle(s). Engine speed reduction is accomplished by the ABS ECU sending a signal to the engine management computer over the electronic electrical circuit between the two control modules. The communication protocol can follow SAE J1939 controller area network, or CAN. For more information on this see **J2627_200908** [7].

AIR (Air Injection Reactor)

The acronym for air injection reactor emission control systems that pumps fresh air into the exhaust system to provide further reduction in exhaust emissions. It is referred to as secondary air injection in J1930. For details on these terms, see **J3016_202104** [19].

Air Bag

The air bag, as it is called, or the supplemental inflatable restraint (SIR) system includes three important elements. The electrical system includes the impact

sensors and therefore the electronic control module. Its main functions are to conduct a system self-check to let the driving force know that it is functioning properly, to detect an effect, and to send a symbol that inflates the restraint. The constraint module is found within the steering wheel for the driving force and within the dash panel for passengers. It contains the restraint and therefore the parts that cause it to inflate. The knee diverter cushions the driving force of the knee from impact and helps prevent the driver from sliding under the bag during a collision. It is located underneath the steering column and behind the steering column trim. Air bags are located in multiple locations in a vehicle: passenger's side, roof curtains, side impact and pillars, etc. For more information on this, see **J1538_201504** [13].

FIGURE A.8 Air bag or supplemental inflation restraint.

Attapon Thana/Shutterstock.com.

Air Brake Compressor

This compressor provides the compressed air to the truck/bus/train air brake reservoirs, also referred to as air tanks. The compressor is an air pump with

pistons, rings, and an inlet and discharge valve to supply a constant pressure to apply and control the air brakes. Air is sucked into the compressor through the inlet valve from a filter, it is compressed when both valve are closed on a compression stroke. The compressor built-up air pressure goes out the discharge valve to the air tanks or reservoirs and ultimately goes to the brake pads or shoes of the foundation brake units. The air pressure is controlled by an unloader piston, which is controlled by air pressure bled off by the governor. The governor is a spring-controlled piston with an inlet and exhaust valve. System air pressure pushes against this adjustable spring, and when it gets to the adjustment valve, it sends air pressure to the bottom of the unloader piston, pushing it up, and opens the inlet valve that unloads the compressor and reduces the air pressure.

Air Brake Double Check Valve

This valve allows control of the trailer service brakes by the use of the trailer hand valve or foot valve. If both systems are applied at the same time, the trailer service brakes will have compound braking. So if the hand valve is applied at 60 psi and therefore the foot pedal at 20 psi, the trailer brakes will be applied at 60 psi. Also it allows blended supply atmospheric pressure taken from the first and secondary reservoirs. If one among the first subsystem loses gas pressure, the two-way check valve will redirect air from the upper pressured secondary system and deliver it to the rear spring brake chambers so that the spring brakes do not apply automatically. Some air brake systems have this valve integrated into the trailer control valve. For more information on this, see **J1409_201607** and **J1410_202012** [15, 16].

Air Brake Dual Air Pressure Gauge

Air pressure gauges monitor the air pressure in air reservoirs and brake lines. Dual air gauge display gas pressure for the front- and rear-service systems on dual air circuit systems using two color-coded needles. The gauge operation is verified by using a master gauge, a good quality, liquid-filled gauge that uses a Bourdon principle of operation. The gauge has two color-coded needles; the colors vary among truck original equipment manufacturers (OEMs). One needle is additionally green to point the front brake reservoir pressure, and thus the opposite could even be red to point the rear service system reservoir gas pressure. Two separate air line connections are located at the rear of the gauge to activate each gauge needle. For more information on this, see **J1409_201607** and **J1410_202012** [15, 16].

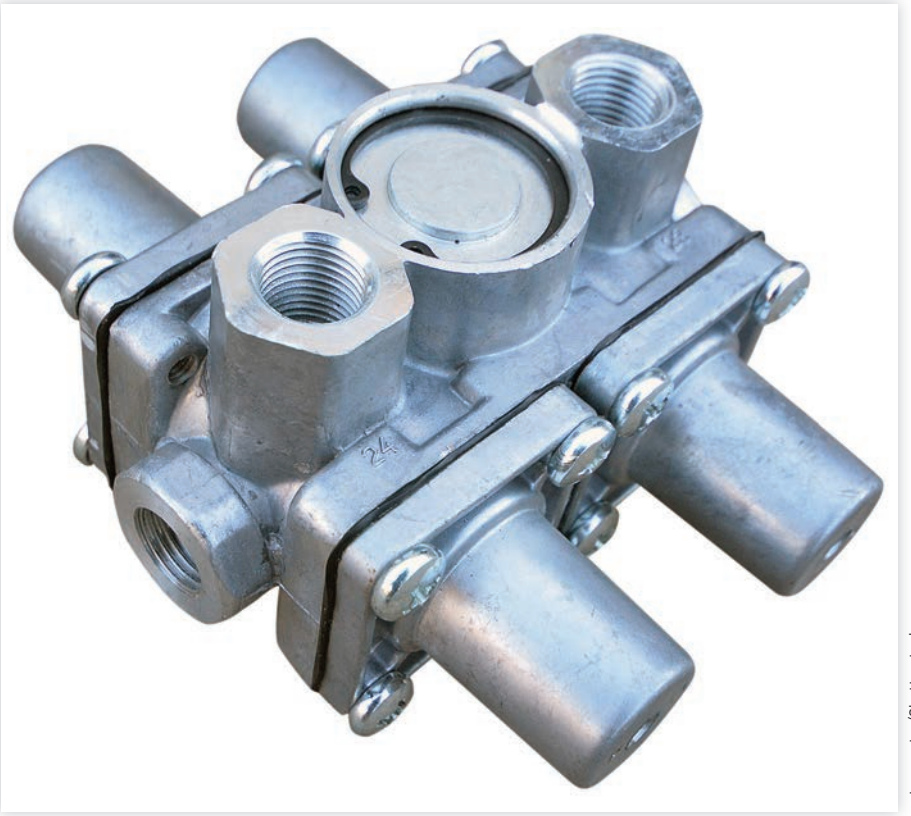
FIGURE A.9 Air brake system dash dual air pressure gauge.

Courtesy of John F. Kershaw Ed.D.

Air Brake Pressure Protection Valve

Dual-circuit air brake systems use pressure protection valves, which are normally a closed valve that is used to protect or isolate one air reservoir supply from another by closing automatically at its pressure setting in the event of a system leak. It may also be utilized in rapid buildup air systems by delaying the filling of auxiliary reservoirs until a preset pressure is achieved within the primary reservoir. Some air brake manufacturers discuss using this valve as a charging valve. Compressed gas is delivered to a second air brake reservoir only if the rated pressure for the system within the first reservoir has been reached. If the pressure within the first reservoir falls below that of the second reservoir, there is a feedback supply of air from the second reservoir. Some air brake systems use multi-circuit protection valves. For more information on this, see **J1409_201607** and **J1410_202012** [15, 16].

FIGURE A.10 Air brake pressure protection valve.

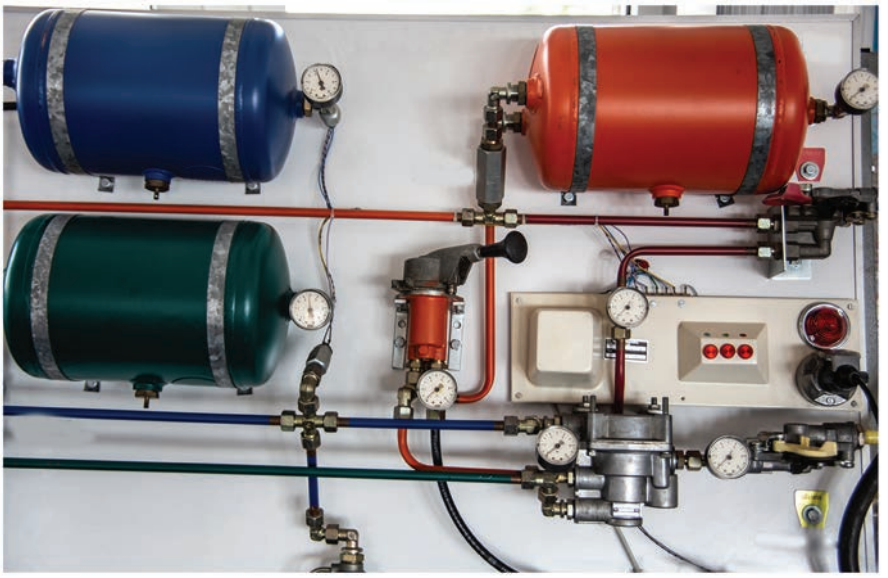


notsuperstar/Shutterstock.com.

Air Brake Reservoir (Air Tank) Drain Valves

A drain valve used to remove any water or condensation from the air brake reservoirs. There are drain valves used for both manual and automatic actuation. The automated drain valve prevents the buildup of water in pipe lines and brake chambers through automatically draining the reservoirs. Air from the auxiliary port on the governor unloader enters the control port and pushes the piston to its lowest position. Water from the reservoir enters a port and passes into a chamber via the undercut diameter on the piston. Water within the control line passes into chamber via a small hole within the piston. When the governor unloader cuts out, the pressure within the control line falls to zero, and therefore the pressure within the reservoir pushes the piston to its uppermost position, and the water is ejected via the undercut diameter. The manual drain valve has a valve on for draining; otherwise, you pass through the stem of the valve to empty out any water. For more information on this, see **J1409_201607** and **J1410_202012** [15, 16].

FIGURE A.11 Truck air brake system showing drain valves, check valves, tanks, relay valve, and trailer brake control valve.

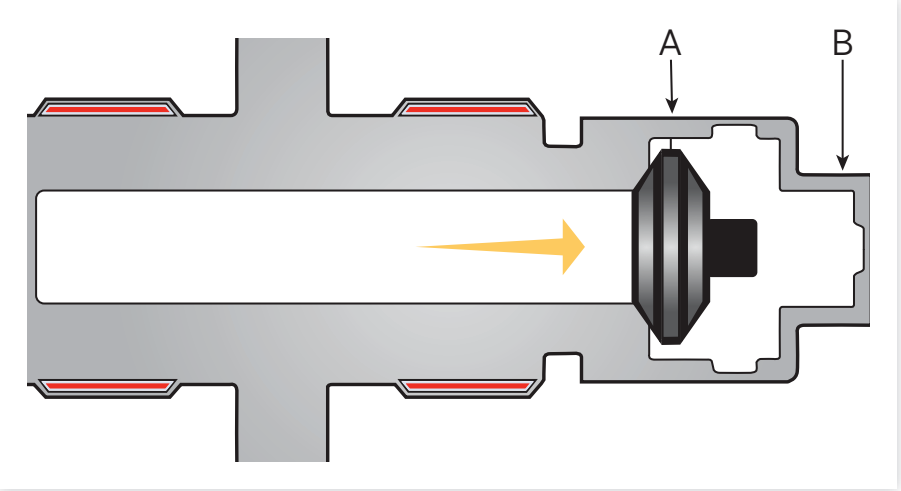


Dr. Norbert Lange/Shutterstock.com.

Air Brake Reservoir Safety Valves

A safety valve used to make sure that the pressure in air reservoirs is not decreased. The compressed air from the air feed line opens a check valve at and reaches the air reservoir, provided its pressure is higher than the pressure in the reservoir. The valve will remain open until the pressures in the feed line and the reservoir are equal. The safety valve prevents the air from returning from the reservoir as, when the pressure in the feed line is reduced, the valve is closed by a spring and the higher reservoir pressure. Air can pass through the check valve only in the direction from the feed line toward the reservoir. For more information on this, see **J1409_201607** and **J1410_202012** [15, 16].

FIGURE A.12 Air brake safety.



Courtesy of John F. Kershaw Ed.D.

Air Brakes (Truck and Bus)

A brake system used on trucks, buses, and locomotives that uses compressed air–activated service brake chambers to apply force to slack adjusters and caliper pistons to stop the moving wheels of a commercial vehicle. For more information on this, see **J257_201907** and FMVSS 121 Air Brake Systems.

The determining criteria for deciding brake rating power capability are:

- Cold brake stopping ability
- Fade as a result of brake power absorption
- Hot brake stopping ability following brake power absorption
- Brake system stability following brake power absorption
- Functional and structural integrity of brake system [14]

Air Cleaner

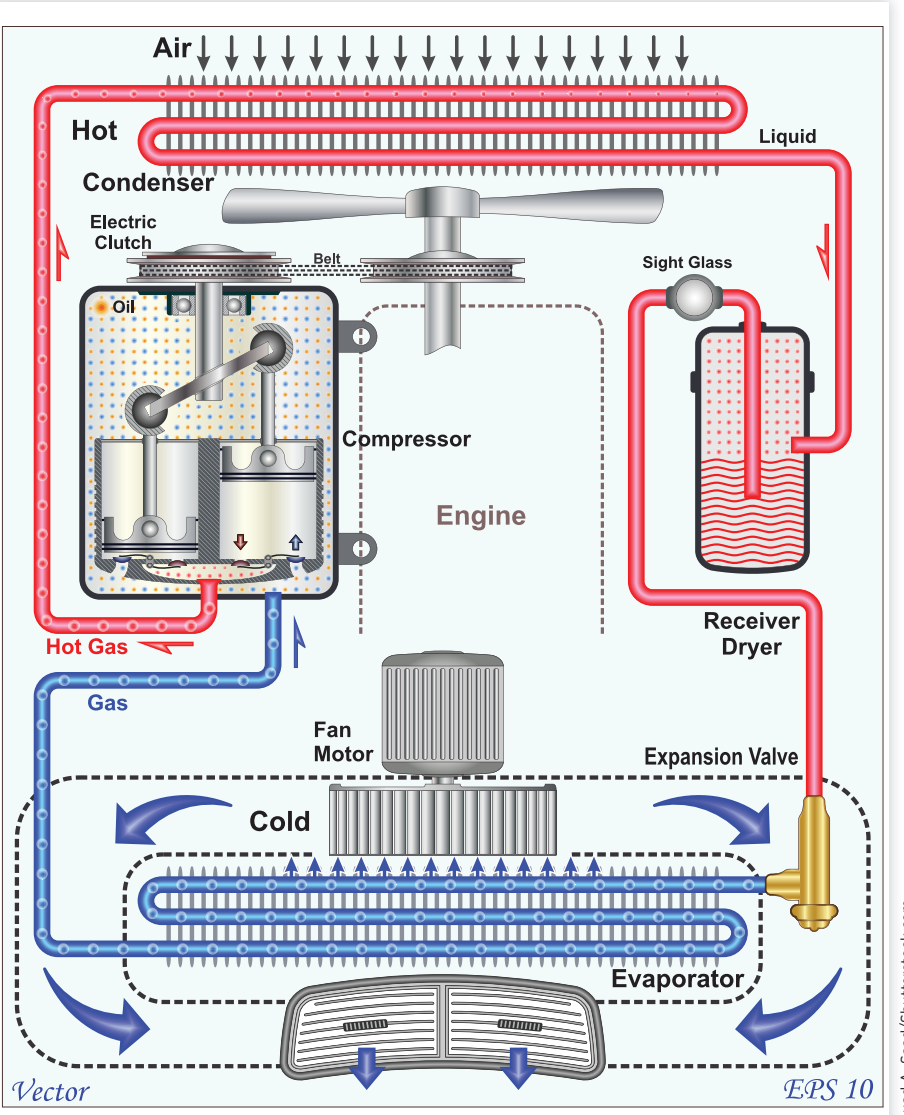
This is a paper or oil bath filter that removes dust from the air that passes through it on its way to the throttle valve of a carburetor or throttle body in a fuel injection or diesel system.

Air Conditioning

A finned radiator core is the cooling unit called the evaporator. The air to be cooled passes through the evaporator. The refrigerant boils in the evaporator in boiling the refrigerant absorbs heat and changes into vapor. The vapor is pumped out of the vehicle, and the heat that caused the vapor creation is carried outside the vehicle. Once the vapor is out of the evaporator, the heat it contains must be removed. Since heat expanded the refrigerant from liquid to vapor in the first place, removal of that same heat will let the vapor condense into liquid again. Then the liquid refrigerant can be returned to the evaporator to be used over again. Vapor coming out of the evaporator is very cold and boils at –21.7°F. Heat cannot be removed from subfreezing vapors by "cooling" them in air temperatures, which usually range between 60 and 100°. This is because heat refuses to flow from a cold object toward a warmer object.

The compressor exerts pressure for two reasons: pressure makes the vapor hot enough to cool off in warm air. The compressor raises the refrigerant pressure above the condensation point at the temperature of the surrounding air so it will condense. As the refrigerant leaves the compressor, it is still a vapor and hot. It is ready to give up the heat that was absorbed in the evaporator. In the condenser, refrigerant vapor gives up its heat. This is radiated into the surrounding air through the finned surfaces of the condenser. The vapor in the condenser condenses back into a liquid which collects at the bottom of the condenser. When the refrigerant condenses into liquid refrigerant, it is ready for boiling in the evaporator to remove the heat. The heat-laden vapor is squeezed in a small space. When the vapor is compressed, the heat it contains is concentrated. The pressure and temperature increase. In this way, the vapor gets hotter without adding any heat. So the vapor can cool the warm air through convection. Heat flows from the warm air to the cold evaporator to cool the air.

FIGURE A.13 When the vapor is compressed, the heat it contains is concentrated. The pressure and temperature increase. In this way, the vapor gets hotter without adding any heat. So the vapor in the evaporator can cool the warm air through convection. Heat flows from the warm air to the cold evaporator to cool the air.



Fouad A. Saad/Shutterstock.com.

Air-Cooled Engine

Automotive air-cooled engines require an auxiliary fan to furnish an adequate supply of air for cooling the engine. Forced air engine cooling systems use sheet-metal shrouding to direct air over the heads, cylinders, and oil cooler. They are thermostat-controlled cooling using a bellows-type air flap under each side of the engine. These thermostat flaps open when the temperature of the air under the cylinders reaches 205°F.

FIGURE A.14 Air-cooled boxer engine that is a horizontally opposed engine with finned aluminum cylinder heads and cylinders that are cooled by air flow. It is commonly used in motorcycles, industrial engines, Volkswagens, and Porsche vehicles.

spr/Shutterstock.com.

Air Core Gauge

A measuring gauge that does not operate using a magnetic metal core surrounded by a coil. It is an analog display gauge that enables an indicator to rotate a full 360°. The air core gauge is an air core motor where the sector is made by moving a pivoting static magnet.

Air Dam

Air dams improve air flow at highway speeds because they direct airflow and create a low-pressure area that directs the air through the radiator at highway speeds. Airflow created by vehicle movement is considered ram air because it is forced through the radiator through vehicle movement. Air dams can be attached to the underside of the front of a vehicle or, in the case of a truck, over the cab to improve air flow over the vehicle. They act to improve stability, aerodynamic performance, and engine cooling by redirecting the flow of air. For more information on this, see **J2971_201908** [17] and **J1594_201007** [26].

FIGURE A.15 Air dam on the front of a Dodge Barracuda.

Tony Savino/Shutterstock.com.

FIGURE A.16 Truck air dam.

FotograFFF/Shutterstock.com.

Air Density

A variable used in aerodynamic calculations that depends on temperature, pressure, and humidity conditions. At a standard temperature of 59°F and 29.92 in. of Hg, air density is 0.076 lb/ft^3. In Equation (A.6), the air density is expressed as mass density and is obtained by dividing the acceleration of gravity. The air density equation (A.6) is as follows:

$$p = 0.00236 \frac{P_r}{29.92} \frac{519}{460 + T_r} \quad \textbf{(A.6)}$$

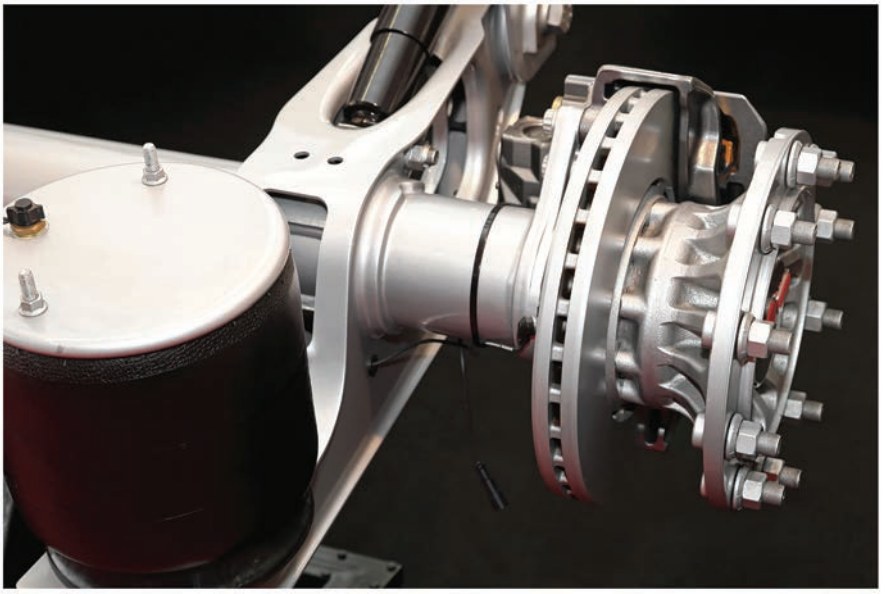
where

P_r is the atmospheric pressure, in in. of Hg
T_r is air temperature, in °F

Air Disc Brakes (Truck and Bus)

This pneumatic single piston brake is actuated mechanically via a diaphragm brake cylinder or a spring brake actuator, which is fitted directly onto the brake caliper. When the brake diaphragm pushes inward, it moves a crank arm that pushes against the inboard pads that, in turn, pulls in the outward pad, applying equal force on both pads. It is an action-reaction operation. A short outboard friction pad service life is usually an indication of caliper assembly seizure, that is, the sliding action of the brake caliper stops. The caliper slide pins are usually at fault. The rotors used on truck air disc brakes are usually vented to aid in the dissipation of brake heat. In vocational applications which require constant use of the brakes, air disc brake rotors have been vulnerable to heat-related failures such as warpage, which meant that they are not commonly used. For more information on this, see **J2627_200908** [7].

FIGURE A.17 Air screw disc brakes.



Baloncici/Shutterstock.com.

Air Flow

Air flow or airflow is the movement of air from one area to a different area. The first explanation for airflow is the presence of pressure inclines. Air behaves in a fluid manner, meaning particles naturally ensue areas of upper pressure to a lower pressure. Air pressure (14.7 psi) is directly associated with altitude, temperature, and composition. In engineering, airflow may be a measurement of the quantity of air per unit of time that flows through a specific device. The flow of air will be induced through mechanical means (such as by operating an electrical or manual fan) or can occur passively as a function of pressure differentials present within the engine compartment.

Air Flow Meter

An automotive electronic fuel injection air flow meter that is found in air induction system inlet pipe between the air filter and also the throttle body. This device used a measuring plate, compensation plate, return spring, potentiometer, and a bypass passage. The flow meter incorporates the idle mixture adjusting screw, fuel pump switch, and intake air temperature sensor. The intake air volume is a direct measure of the load placed on an engine, and the vane-type air flow meter provides the input to the engine management computer for fuel and spark calculations.

Air Flow Types

Air is a fluid that may exhibit both laminar and flow patterns. Laminar air flow takes place when each air particle follows smooth paths and also the paths never interfere with one another. The air velocity of the fluid is constant at any point within the airflow. The flow is an irregular flow, which is characterized by tiny whirlpool regions. The rate of this fluid is certainly not constant at every point. The flow occurs when there is an irregularity such as a pause in the surface across which the air is flowing that alters the direction of movement. Streamline flow occurs when air can flow smoothly, and exhibits a parabolic velocity profile which may be a velocity profile accustomed to model or measure laminar or smooth airflow. The resistance to flow in air is characterized in terms of the viscosity of the air, if the flow is smooth. In the case of a moving plate in the air, it is found that there is a layer or lamina which moves with the plate and a layer which is actually stationary.

Air-Fuel Charge

The air-fuel charge in the most appropriate proportion of air to fuel that will be induced into the combustion chamber of an ICE. This is typically a stoichiometric measure of 14.7 parts air to 1 part of gasoline in a gasoline-fueled engine. A diesel engine uses a stratified charge that can be 100 parts air to 1 part fuel at idle or 20 parts air to 1 part fuel at full load.

Air-Fuel Ratio

The air-fuel ratio is the amount of air by weight mixed with 1 lb of gasoline, as in 14.7 lb of air to 1 lb of gasoline, or a 14.7 to 1 air-fuel ratio.

Air-Fuel Ratio Sensor

A sensor that monitors air-fuel ratio over a broader range above and below stoichiometric than a conventional oxygen sensor. It can sense air-fuel mixture ratios from 0.9 to 2.2. Also called a wideband oxygen sensor.

Air Gap

Anti-lock brake systems (ABS) that use adjustable wheel speed sensors may require an air gap setting. ABS wheel speed sensors are adjusted by loosening a holding screw and then inserting a nonmagnetic brass or plastic feeler gauge between the tip of the sensor and a high point on the tone ring. The sensor position is adjusted so there is a slight drag on the feeler gauge, and then the screw is tightened.

Air-Over-Hydraulic Brake System

A medium-duty truck brake system where air pressure from the foot brake treadle is used to apply hydraulic pressure to operate wheel cylinders or calipers to apply brakes. The foot brake application valve supplies control line pressure directly to the master cylinder.

Air Spring (Bag) Suspension

Air-ride suspension systems provide enhanced ride characteristics—when ride quality is equally important whether loaded or unloaded. On buses and over the road coaches, the air-ride system provides ride quality and comfort. All the major suspension OEMs offer air suspensions, each using a series of air springs or air bags. These suspensions make it more important to inspect and maintain U-joint angles since air suspensions can actually change their ride height and driveline angles just by adjusting their level using a height control valve. The suspension air control system uses compressed air from the reservoirs to pressurize the air springs. Some tractors are equipped with a dash-mounted control valve, allowing the driver to raise or lower the rear axle suspension when connecting or disconnecting the trailer. For more information on this, see **SAE J511_201604** [18].

FIGURE A.18 Air spring assembly.

ilmarinfoto/Shutterstock.com.

Air Standard Dual Cycle

This is the air cycle used in diesel engines. Heat energy is added at constant volume and constant pressure. The constant-volume burning process is carried out until a predetermined pressure is reached, after which any additional burring is carried out at constant pressure.

Air Turbulence

Air turbulence is the extreme disturbance of the compressed air in the combustion chamber. It causes the air molecules to move in all directions. They collide with each other and cause friction and heat. A twisting force like small tornadoes changes the smooth laminar airflow into turbulent flow. This increases the transfer of heat between the cool liquid-fuel droplets and this hotter air.

ALCL (Assembly Line Communications Link)

ALCL was an early acronym for the device now known as a DLC, or data link connector. This is a 6-, 9-, 12-, or 16-pin connector that a diagnostic scan tool or interface with laptop computer is plugged into to extract diagnostic trouble codes (DTC) from the vehicle computer. For more information on this, see **J1930DA_202105** [19].

ALDL (Assembly Line Diagnostic Link)

ALDL is another name for the ALCL (assembly line computer link) and DLC (data link connector), which was defined in SAE J1930 and the most current term. For more information on this, see **J1930DA_202105** [19].

Align

Align means to bring parts of a component into the correct position.

ALLDATA

This is a company that provides an online source for service information that is licensed by the Original Equipment Manufacturers (OEM) to offer this information to the aftermarket.

All-Electric Drive Mode

An all-electric drive mode is a hybrid drive mode in which the hybrid operates like an all-electric vehicle, or EV. In this mode, the high-voltage battery pack provides all of the energy needed to propel the vehicle. This mode is used in reverse on most HEVs. For more information on this, see **J1715/2_202108** [21].

Alloy

A metal that contains one or more elements usually added to change the structure of the metal for increased strength or give the base metal needed properties for the design.

Alphanumeric Code

A code that uses a combination of alphabetical (letters) and numerical characters. They are a group of Latin letters and Arabic digits. It is an identifier composed of alphanumeric characters. An engine RPO (regular production option) code like LT1 is an alphanumeric code.

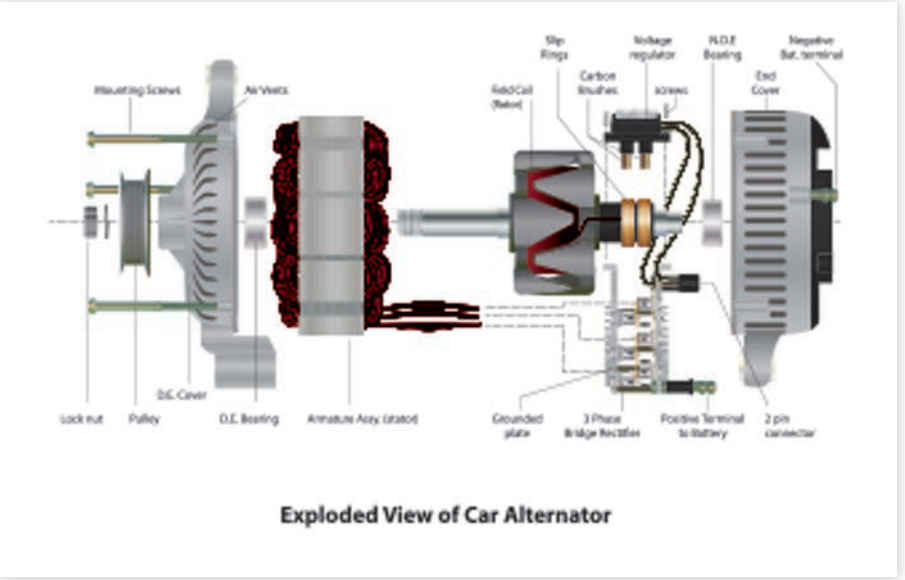
Alternative Fuels

Alternative fuels are ICE fuels, apart from gasoline, used to fuel an ICE, to scale back exhaust emissions and lessen the dependence on fossil fuels. A number of these fuels are derived from petroleum while others are from non-petroleum sources. Fuels like ethanol or ethyl alcohol or plant product, which are made of grain and located in alcoholic drinks, consists of two carbon atoms and six hydrogen atoms with one added oxygen atom. Propane or LPG and methanol are also used as alternative fuels. For more information on this, see **J1297_201710** [20].

Alternator

An alternator is an AC generator that produces DC voltage and current using electromagnetic induction. The rotor winding generates the magnetic field. The rotor poles may retain some magnetism when not used. Yet residual magnetism is not strong enough to induce voltage across conductors. So excitation winding, or field winding, varies the field current through rotor winding to manage the strength of the magnetic field, and this field current is regulated by a voltage regulator which adds resistance in series to control the field current. The field current is about 1.5–3.0 A. The stator is the conductor in the alternator. The stator windings are laminated to prevent unwanted eddy currents from forming in the iron core. There are three alternator conductors wound onto the cylindrical, laminated core and assembled as a one-piece called the stator. It does not rotate. Each stator winding is molded into a number of coils spaced evenly around the core and there are as many coil conductors as pairs in each of N-S (north-south) poles in the rotor. The brush-type alternator uses carbon brushes that ride on two slip rings. The brushes are connected to a battery suppled current and the circuit carries current to and from the stator. A holder is used to house the brushes.

FIGURE A.19 Automotive alternator or AC generator that is engine driven to provide electrical output to a vehicle that operates on the principle of electromagnetic induction.



Exploded View of Car Alternator

ilmarinfoto/Shutterstock.com.

Aluminum Bearing Material

This material uses small quantities of tin and silicone alloyed with it. This makes a stronger but more expensive bearing than either Babbitt or copper-lead alloy. Most of its bearing characteristics are equal to or better than Babbitt and copper lead. These bearings are used for high-speed and load conditions and do not contain lead.

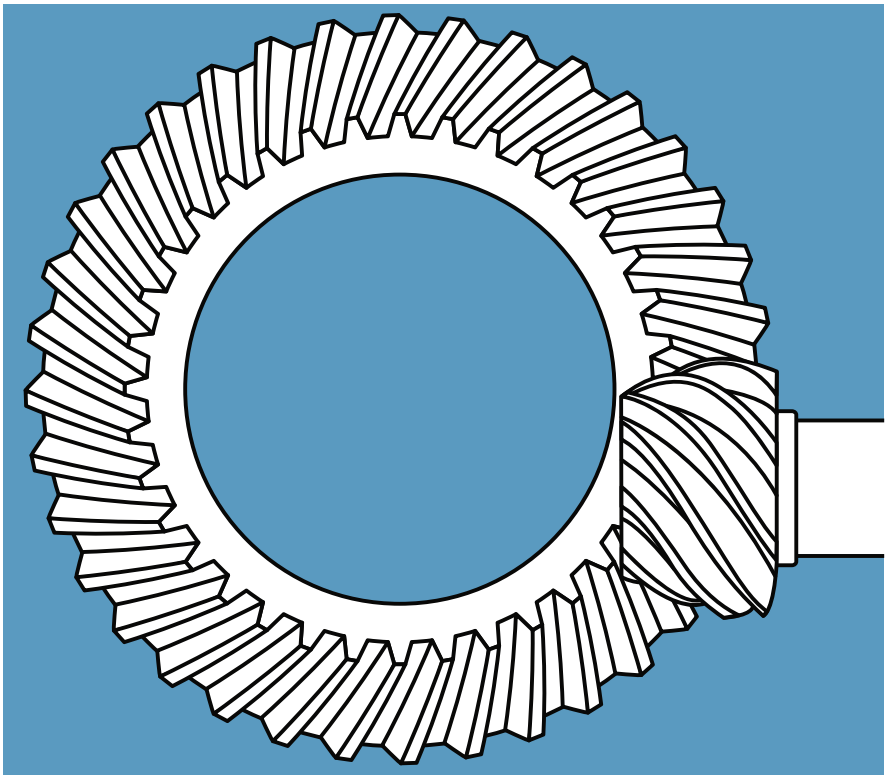
Ambient Air Temperature

Ambient air temperature is the temperature of the air surrounding an object.

Amboid Gearset

The amboid gearset is the opposite of the hypoid gearsets. They have the drive pinion axis plane above ring gear axis plane. They exert thrust on the drive pinion in the direction of power flow.

FIGURE A.20 Hypoid final drive gearset is the opposite of the amboid gearset (see Figure A.21).



AlexanderZam/Shutterstock.com.

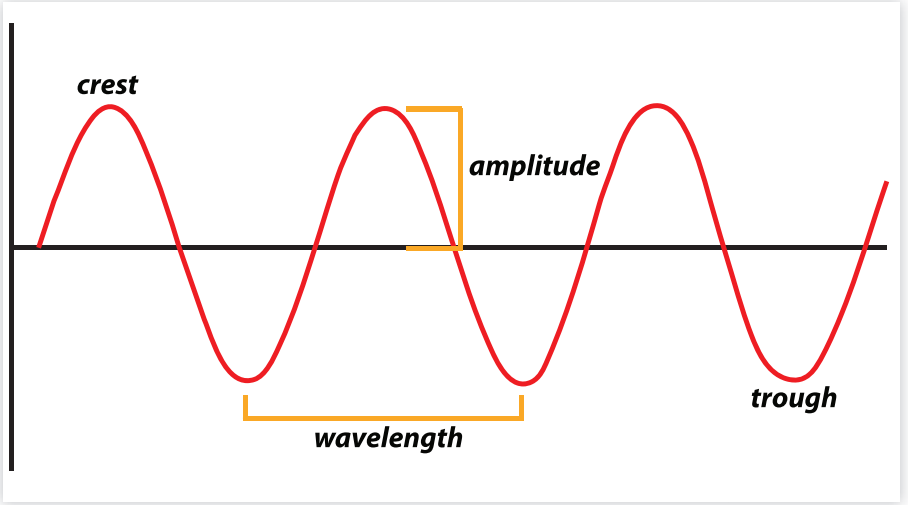
FIGURE A.21 Amboid gearset is the opposite of the hypoid gearset.

Ake Apichai Chumsri/Shutterstock.com.

Amplitude

Amplitude is the maximum value of a periodically varying quantity or waveform. It is the top or apex of the waveform and is used for vehicle vibration diagnostics. It denotes the magnitude of the disturbance. A severe vibration or disturbance would have a high amplitude; a minor disturbance would have a low amplitude. Amplitude is measured by the number of actual movement, or displacement. A radial vibration caused by an out-of-balance wheel moving up and down at 50 mph (80 km/h) would be more severe than a vibration occurring at 25 mph (40 km/h). This takes place because, as the speed increases, the amplitude also increases. For more information on this, see **J3152_202005** [22].

FIGURE A.22 The amplitude waveform.



gstraub/Shutterstock.com.

Ammeter

An ammeter measures either direct or alternating electrical current (I) depending on the circuit construction. It is an abbreviation of ampere meter. Electric current is measured in amperes, or amps where you connect the ammeter series with the circuit. Ammeters are no longer stand-alone measuring devices; they are part of a digital multimeter (DMM). The ammeter has low resistance so that it does not result in a significant voltage drop in the circuit being measured.

Ammeter Shunt

An ammeter shunt is a low-resistance conductor like a diode or resistor placed in parallel with the ammeter movement, so most of the current passes through

this conductor (shunt) with only a small amount going to the meter. This design extends the usable range of the meter.

Amperage

Amperage is the amount of amperes, or amps, flowing in an electrical circuit or conductor.

Ampere-Hour

This is a current of 1 A flowing for 1 h. If you multiply the current in amperes by the flow time in hours, you will arrive at the total number of ampere-hours.

Ampere-Turn

The measure of the magnetomotive force developed by an electric current in one turn of a coil of wire through which a current of one ampere is flowing.

Amperes

Amperes is the electrical unit for current, which has been shortened to amps. It is also called the rate of flow of electrons. One volt pushed across 1 ohm of resistance causes a current flow of 1 A. A current flow of 1 C/s equals 1 A.

Ampere's Rule

Ampere's rule states that a current flowing in a certain direction is equal to the motion of the positive charges in that specific direction. The magnetic lines of force or flux generated from the current appears as wire circles around a current in a counterclockwise direction when it is approaching the observer.

Amplifier Piston

The amplifier piston is the hydraulically actuated piston that pumps fuel to injection pressure to very high values in the Caterpillar and Navistar HEUI (hydraulically actuated electronic unit injection). It can also be called an intensifier piston.

Anaerobic Sealant

A sealant that will not cure without the presence of a metal along with the lack of oxygen. An anaerobic sealant is used between two closely fitted metal parts or on a nut and bolt to seal in the absence of air. Sometimes called a Superglue.

Analog

Generally referred to as the class of devices or circuits where the output is a continuous function of the input. An analog electrical signal is continuous and variable. A type of dash instrument that indicates values by use of the movement of a needle or similar device.

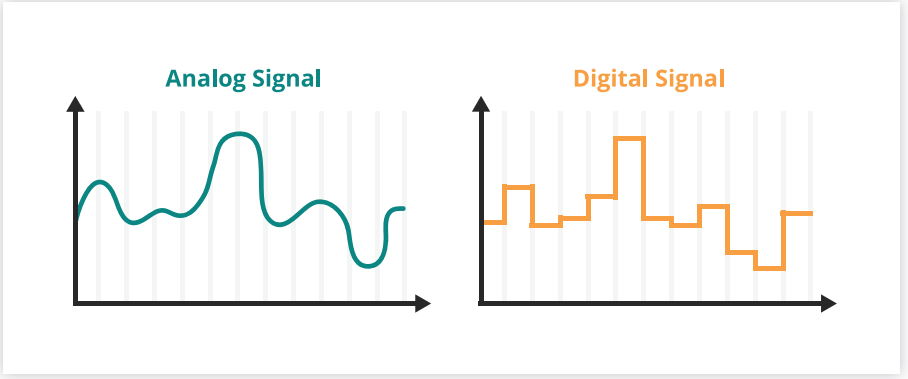
Analog Multimeter

A meter that uses a needle or pointer to show electrical readings at a constant value that can measure voltage, current, or resistance. The needle moves up and down to show temporary or rapid changes in electrical values.

Analog Signal

A signal that progressively changes in strength which is continuous and variable.

FIGURE A.23 Analog signal waveform on left.



petrroudny43/Shutterstock.com.

Anemometer

An anemometer measures airflow and is sometimes called an airflow meter. This tool may use ultrasound or resistive wire to measure the energy transfer between the measurement device and the passing particles. A hot-wire anemometer, for example, registers decreases in wire temperature, which can be translated into airflow velocity by analyzing the rate of change.

Aneroid

A sealed bellows or capsule that contains a partial vacuum and changes its length or size in response to a change in atmospheric pressure.

Annealing

Annealing is a heat treatment process that changes the physical and chemical properties of a metal to increase its ductility to make it more workable. The metal is heated to above its transition temperature, maintaining a suitable temperature, and then cooled. Annealing can induce ductility, soften material, relieve internal stresses, making it homogeneous, and improve cold-working properties.

Annulus

An annulus is a circular or ring-shaped device that are commonly used in automatic transmissions and transaxles.

Anode

Anode is the positive electrode; the electrode toward which electrons flow.

Anti-dive

A term used to describe the geometry of an automotive suspension that controls the movement of the vehicle during braking. It is normal for a vehicle to dive slightly during braking, and this is designed into most vehicles.

Antifreeze

Antifreeze is a chemical that lowers the freezing point of a water-based liquid and also increases its boiling point. An antifreeze mixture is used to achieve freezing-point depression for cold weather and also achieves boiling-point elevation to allow higher engine temperatures. Freezing and boiling points are properties of a solution, which depend on the concentration of the dissolved substance. Water has good properties as a coolant, water plus antifreeze are used in internal combustion engines. The purpose of antifreeze is to prevent the engine block from bursting due to expansion when water freezes. Commercially, both the additive (pure concentrate) and the mixture (diluted solution) are called antifreeze, depending on the context. Careful selection of an antifreeze can enable a wide temperature range in which the mixture remains in the liquid phase, which is critical to efficient heat transfer and the proper functioning of heat exchangers.

Antioxidants

Antioxidants are additives used to reduce engine varnish by preventing the buildup of acids, destroying chemicals that produce undesirable oxidation by-products, and interrupting the oxidation chain reaction.

Anti-rattle Clips

Anti-rattle clips are one or more metal components designed to keep brake pads from vibrating and rattling.

Anti-roll Bar

See **Stabilizer Bar**.

Anti-squat

A vehicle suspension geometry term that describes the movement of the vehicle body during acceleration. When the body of the vehicle stays level during acceleration, it displays 100% anti-squat. If the level of the vehicle body is less than 100%, this indicates that the body squats down in the rear during acceleration. Anti-squat acts as a lever between the tire and the body, trying to force up the back of the car as acceleration pushes it downward. At 100% anti-squat, the rear of the car will stay level on a launch instead of squatting down (RWD) or raising up (FWD). Anything over 100% anti-squat will raise the body over the tires; any less than 100% will permit the body to lower itself over the tire.

A properly set up suspension will use the axle torque and weight transfer to actually plant the tires and gain traction. This is indicated by the rear body staying level or raising slightly under acceleration, an indication that the tires are being forced downward. When the vehicle body "squats," this is a sign that the axle housing is moving upward. Since it cannot lift off of the ground, the body drops or squats. Rear body squat does not mean that weight is applied to the suspension for better traction, but rather that the suspension is moving up and unloading the tires, therefore minimizing traction. "The anti-squat equation e/d = h/L (e = elevation, L = wheelbase, d = distance from the wheel center to the trailing arm, h = height from the CG to the ground) defines the locus of points extending from the tire contact point on the ground to the height of the center of gravity (CG) over the front axle" [12].

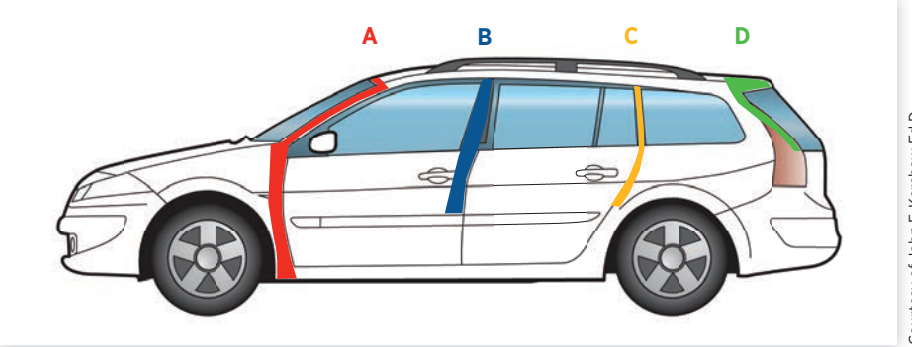
Anti-sway Bar (Sway Bar)

See **Stabilizer Bar**.

A-Pillar

The A-pillar is part of an automotive body that supports the hinges for the front doors and support the windshield. The body B-pillar supports a pin that fortifies the front door locks and the hinges for the rear doors. The C-pillar supports the pin that secures the rear door locks and rear window. The D-pillar supports the rear doors or tailgate of an SUV. Pillars are identified by the side on which they are found (driver side/passenger side) and the pillar location, for example, driver's A-pillar or passenger B-pillar.

FIGURE A.24 Body sections are A-Pillar, B-Pillar, etc.



Courtesy of John F. Kershaw Ed.D.

Apex

Apex is the highest point on an object, illustration, or component.

API (American Petroleum Institute) Oil Service Classification

The API classification is a standard that rates engine oils on their ability to lubricate, resist oxidation, prevent high- and low-temperature engine deposits, and protect the engine from rust and corrosion. API has organized a system of letter classifications with two categories, the S category and the C category. API's S (service) category emphasizes oil properties critical to gasoline engines, and the C (commercial) category emphasizes oil properties for diesel engines. To give an oil formulation a particular classification, the oil is run through a series of tests in specific engines.

API Donut

The donut symbol appears as a label printed on the container of oil. The upper half of the symbol displays the API service classifications of the oil, the center of the donut displays the SAE viscosity grade of the oil, and the lower half of the symbol contains the words "Energy Conserving," if the oil is formulated to meet those requirements. When selecting an oil, always make sure the oil quality information on the API donut conforms with the vehicle manufacturer's specifications.

API Service Classification

The API service classification rates engine oils on their ability to lubricate, resist oxidation, prevent high- and low-temperature engine deposits, and protect the engine from rust and corrosion.

API Starburst

The American Petroleum Institute (API) starburst symbol indicates the oil has been certified by the International Lubricant Standardization and Approval Committee (ILSAC) as the correct type for gasoline engines in passenger cars and light trucks. To qualify for the starburst symbol, oils must meet the Energy Conserving II requirements. Only multi-viscosity oils with SAE 0W, 5W, and 10W, such as 5W-30 and 10W-30, will qualify.

FIGURE A.25 ILSAC starburst symbol as an approved engine oil.

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A-Post

See **A-Pillar** (same definition as A-pillar).

APP (Accelerator Pedal Position) Sensor

Mounted on the accelerator pedal assembly, this sensor is two or three individual accelerator pedal position sensors with one housing. Two to three

separate circuits for signal, ground, and 5-V reference connect the APP assembly with the engine management computer. It works to provide input to the engine management computer regarding driver requested accelerator pedal position and throttle angle at the throttle body. The APP 1 signal increases as the accelerator pedal is depressed, from 0.67 V at 0% pedal travel (pedal at rest) to 2.51 V at 100% pedal travel (pedal fully depressed). The APP 2 signal decreases from 4.33 V at 0% pedal travel to 2.49 V at 100% pedal travel. The APP 3 signal decreases from 4.0 V at 0% pedal travel to 2.88 V at 100% pedal travel.

Application Valve

The dual air brakes service application valve may be a floor-mounted foot valve, also referred to as a treadle valve. It is two valves in one. The upper portion of the valve is the primary section and the lower portion is the secondary or relay section. Each section features a dedicated feed and its own exhaust port. The upper or primary section of the treadle valve is supplied directly from the first reservoir. The secondary reservoir sends air to the lower or relay section of the valve. The valve is mechanical, that is, it is operated by foot pressure from the driving force. When the driver's foot presses on the applying valve, the first piston is forced downward. This movement first closes the first exhaust port and thus modulates air in proportion to the piston travel to Actuate whatever brakes are connected into the first circuit: this is often usually, but not exclusively, the rear drive axles on a typical tandem drive tractor unit. Actuate the relay or secondary piston, located below the first section in a very dual circuit application valve. Act against the mechanical pressure (foot pressure) to produce brake feel. The secondary or relay section of the twin circuit application valve is actuated pneumatically by the primary circuit air. This section operates similarly to a relay valve, therein an indication pressure value (air from primary section) is employed to displace a relay piston, which then modulates the secondary circuit air to whatever brakes/valves are located within the secondary circuit. In a very typical tractor air brakes, this might normally be the front axle brakes.

Aramid

Aramid is a generic name for aromatic polyamide fibers developed in 1972. Kevlar is the DuPont brand name for aramid.

Armature

The armature is the rotating part of an electric motor that consists of electromagnets, known as field coils, and the segmented contacts, known as the commutator. The armature commutator is an electromagnet created in a loop of wire that is place between two electromagnetic poles. Motors work on

principle of magnetic repulsion. This magnetic repulsion takes place when a straight-loop wire conductor made up of an armature, commutator, and brushes is located within a magnetic field and current flows through that wire loop. This situation creates two separate magnetic fields. One produced by the magnet (poles of the magnetic field winding) and another produced by the current flowing through the conductor (armature/commutator/brushes).

Articulated

Articulated means that a vehicle may have one or two sections connected by a flexible joint or connection.

Articulated Bus

A transit bus that has two sections using a flexible joint or fifth wheel so that it can turn corners in the inner city.

Articulation Test

A test specified by some OEMs that tests the amount of force necessary to move the inner tie-rod end in the ball socket assembly. The specification is greater than 1 lb (0.5 kg) and less than 6 lb (2.7 kg) of force.

Asbestosis

Asbestosis is a health condition where asbestos causes scar tissue to form in the lungs causing shortness of breath.

ASD (Automatic Shutdown)

This is the automatic shutdown relay on a Fiat Chrysler system used to power the ignition coil. The ASD relay will not supply voltage to the coil unless the engine is cranking and the computer senses a crankshaft sensor signal. This little fact has fooled many technicians.

ASE (Automotive Service Excellence)

This is the abbreviation for the National Institute for Automotive Service Excellence, a nonprofit organization for the testing and certification of vehicle service technicians. It was originally called NIASE before it was shortened to ASE.

Ash Content

Ash is soot or suspended solids that contain metallic compounds such as sodium. Contained within the fuel oil are ash-forming materials in the form

of abrasive solids or soluble metallic soaps. The solids will cause wear of injection components, increase engine deposits, and contribute to engine wear. As content is determined by burning, a given weight of fuel oil in an open container until all the carbon deposits are consumed. The weight of the remaining ash is then expressed as a weight percentage of the original test sample of fuel oil.

ASME (American Society of Mechanical Engineers)

American Society of Mechanical Engineers. ASME is an American association, which promotes the science, and practice of multidisciplinary engineering and allied sciences through: education, training, professional development, standards, research, conferences and publications, and government relations. It is altogether an engineering society, a standards organization, enquiry and development organization, advocacy group, education provider, and a nonprofit organization.

Aspect Ratio (Tire)

Aspect ratio is a comparison of the tires cross-sectional height to cross-sectional width. These two dimensions are found by measuring the widest point and the tallest point of a fully inflated tire. Aspect ratio is determined by the following equation:

$$\text{Aspect ratio} = \left(\text{Section height} / \text{section width}\right) \cdot 100 \qquad \textbf{(A.7)}$$

- Section height of 130 mm and a section width of 185 mm is described as a 70-series tire.

Assist Hybrid

Assist hybrid is a type of hybrid vehicle that can only move from a standstill when the internal combustion engine is running. A small motor generator assists the gas engine in accelerating and propelling the vehicle from a standstill to about 10 to 20 mph.

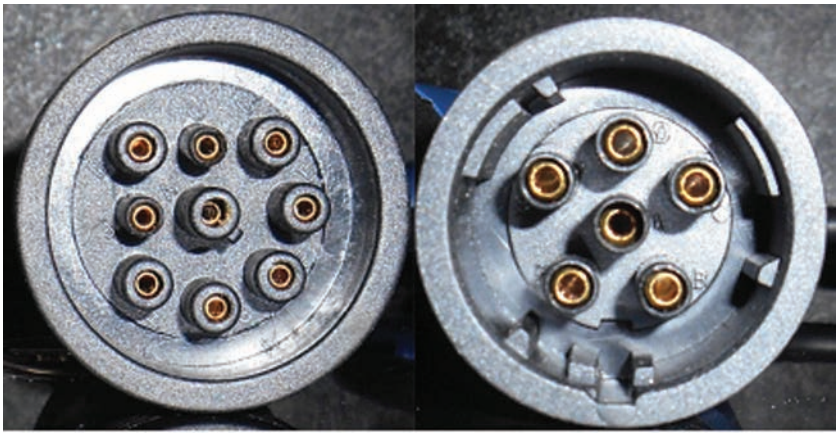
Asymmetrical

Asymmetrical means to be different on both sides of center. In an asymmetrical low beam headlamp, the light beam is spread farther to one side of center than to the other.

ATA (American Trucking Associations) Connector

Heavy-duty truck electronic service tools capable of reading data are connected to the on-board electronics by means of a SAE/ATA J1584/J1708 "6" PIN or J1939 "9" PIN Deutsch connector in all current systems. Before heavy-duty on-board diagnostics (HD-OBD), the connector was used by all the truck OEMs and referred to as the ATA connector. All current systems uses the 16-pin HD-OBD DLC, or data link connector. This common connector and the adherence to SAE standards allows the software of one manufacturer to, at least, read the parameters and conditions of their competitors.

FIGURE A.26 6 & 9 pin truck DLC.



Courtesy of John F. Kershaw Ed.D.

ATC (Automatic Traction Control) Heavy Truck

The ATC is a system used on heavy commercial trucks. These systems are integrated with ABS which is now mandatory for all air-braked vehicles and vehicles with hydraulic brakes having a GVWR (gross vehicle weight rating) in excess of 10,000 lb. These systems utilize components of the ABS as well as additional components specific to the ATC. It applies a preset amount of torque to both rear wheels even if one starts slipping. A transmission without ACT will lose traction completely if one rear wheel starts slipping. For more information on this, see **J2627_200908** [7].

ATC (Automatic Transfer Case)

The automatic transfer case can automatically select 2WD and 4WD modes depending on driving conditions. It also uses a driver-controlled shift select

switch that allows the driver to manually select 2HI, 4HI, 4LO, AUTO-4WD, and neutral. For more information on this, see **J646_201807** [29].

ATCM (Automatic Transfer Case Control Module)

The ATCM uses speed sensors located in the transfer case to continually monitor front and rear propshaft speeds. If the ATCM detects a difference in propshaft speeds, it reacts to apply the clutch pack. When the clutch pack is applied, torque is directed to the front and rear wheels.

ATDC (After Top Dead Center)

ATDC, or after top center, is an ICE piston position where the piston has moved after it has been at the top of the cylinder.

ATF (Automatic Transmission Fluid)

The ATF is a hydraulic fluid oil employed in vehicles with automatic transmissions that provide automatic up and down gear shifts or changes. It is typically dyed red or green to tell it apart from ICE oil and other vehicle fluids. There are different formulations for this ATF. An ATF was first introduced for Genreal Motors (GM) during the fifties under the brand Dexron and used for all automatic transmissions. The 1940–1949 GM Hydra-Matic Drive used a specialized lubricant called GM Transmission Fluid No. 1.

By using the term "fluid" instead of "oil," this fluid was composed of a base oil and additives to limit oxidation, foaming, rust, corrosion, varnish, and sludge buildup. Dexron is the name used for the technical specifications for the ATF created by GM and a GM registered trademark that licenses the name and specifications to companies which manufacture the fluid. All licensed Dexron fluids have a number that begins with the letters B through J. The first Dexron (B) transmission fluid was introduced on April 1, 1967. Over the years, the first Dexron (B) was supplanted by Dexron-II (C), Dexron-II (D), Dexron-II (E), Dexron-III (F), Dexron-III (G), Dexron-III (H), Dexron-VI (J), Dexron HP, Dexron LV ATF HP, and Dexron ULV, which is the latest fluid used in multiple speed transmissions, HEVs and EVs.

Ford Motor Company created the Mercon ATF technical specification, which is a Ford registered trademark. The first Mercon (M2C185-A) ATF, also called Mercon-type CJ, was introduced in January 1987 and was developed for Ford C-6 transmissions. It was developed to compete with Dexron 2, which had similar specifications. It has been replaced by Mercon "V", Mercon "SP", Mercon LV, and Mercon ULV, which is the latest fluid used in multiple speed and HEV/EV transmissions. Ford has upgraded the Mercon specifications over the years; the newer fluids are not always backward compatible with previous fluids.

Atmospheric Pressure
Atmospheric pressure is the pressure exerted by the atmosphere on all things based on the weight of the air.

Atom
The atom is the smallest particle into which an element can be divided and still have all the characteristics of that element.

Atomization
Atomization is the action of breaking liquid fuel particles into small droplets by pumping it at a high pressure through a miniscule flow area

Atomize
Atomize means to reduce or separate gasoline or diesel fuel into fine or minute particles.

AUTO-4WD (Automatic Four Wheel Drive)
This system uses an automatic transfer case (ATC), which operates like an automatic transmission selecting between two-wheel drive (2WD) and four-wheel drive (4WD). These ATCs come in both single- and two-speed models. The system selects between 2WD, 4WD, and AUTO-4WD, depending on the driving conditions using input sensors and control modules or computers. They use an automatic transfer case control module, which is a computer. For more information on this, see **J646_201807** [29].

Auto Ranging
Auto ranging is an automatic scale used on digital multimeter (DMM) that automatically changes to the correct scale. You would set the rotary switch on the DMM for volts, amps, or ohms.

Automatic Locking Differential
Automatic locking differential has the ability to positively lock the axles to the differential carrier.

Automatic Locking Hubs
Automatic locking hubs connect the wheels to the front axle when 4WD is selected. They connect the wheels to the front axle when 4WD is selected. Torque applied to the front wheels engage a clutch mechanism in the wheel hubs that effectively locks the hub to the axle. The hubs automatically unlock

when the vehicle is placed into 2WD. Sometimes it is necessary to drive the vehicle a few feet in reverse to unlock the hubs.

Automatic Transaxle

The automatic transaxle is a transmission that automatically changes forward gear speeds and also contains the final drive unit ring and pinion or another planetary gearset. They use a fluid clutch assembly called a torque converter rather than a mechanical clutch assembly. The torque converter uses ATF (automatic transmission fluid) to provide a fluid link between the engine and transmission. This results in a smooth, cushioned connection between the engine and transmission, and it permits them to remain engaged whether the vehicle is moving or at a standstill. Contained within the torque converter is a lock-up clutch that is also called a torque converter clutch. This clutch directly connects the ICE output to the transmission, bypassing the fluid coupling. These transmissions use 4 to 10 forward speeds, neutral, and reverse. The higher gear ratios are overdrive gear ratio. For more information on this, see **J648_201106**, **J649_198807**, and **J646_201807** [27, 28, 29].

FIGURE A.27 Automatic transaxle combines transmission with final drive rear axle.

Setta Sornnoi/Shutterstock.com.

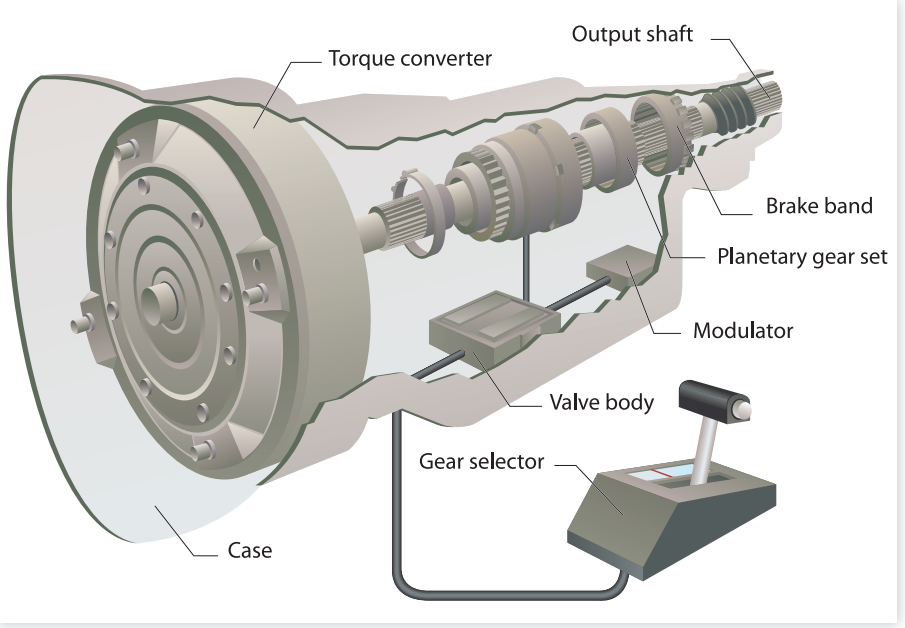
Automatic Transmission

An automatic transmission is a transmission that automatically changes forward speed gears and uses a torque convertor, which is a fluid clutch that provides

additional torque through three elements: turbine, stator, and pump. This converter uses automatic transmission fluid (ATF) to produce a fluid link between the engine and transmission. This provides a smooth, cushioned connection between the engine and transmission and permits the powertrain to stay engaged whether the vehicle is moving or stationary. The fluid coupling or torque converter enables the vehicle to stop without stalling. Automatic transmissions have four to ten forward speeds, neutral, and reverse. The upper ratios are overdrive gear ratios.

The first automatic transmission was called the automated safety transmission (AST), and it was a four-speed transmission providing power shifting and no clutch. It was called the AST because clutch operation was reduced to one-third to that required by a traditional transmission. The clutch was only used when starting or stopping the vehicle. It was first used by Oldsmobile in 1937. This transmission did not use ATF, but instead used the identical grade of ICE oil for lubrication and hydraulic controls. The AST had two driving ranges: low and high. In the low range, the transmission would shift from first to second gear and hold in second. In the high range, the transmission would start in first gear, go to third gear, and shift to fourth gear. Heavy truck applications now used automatic shifting manual twin-shaft transmissions, which will be stated as automatic transmissions. For more information on this, see **J648_201106**, **J646_201807**, and **J649_198807** [27, 28, 29].

FIGURE A.28 Automatic transmission.



Colin Hayes/Shutterstock.com.

Automotive A/C Servicing—Refrigerant Flushing of a Failed A/C System

"The failure of an A/C system often results in the introduction of contaminants to the A/C system. The sources of the contaminants include debris from damaged components and debris from the surrounding environment. Returning the A/C system to service requires the removal of these contaminants from any reused components. The recommended approach to cleaning contaminated components and systems is to flush with a solvent flushing machine. Previous internal studies have concluded that solvent flushing will remove all contaminants, restoring component and system performance. Many commercial refrigerant recovery and recharge machines include a refrigerant 'flush' feature which can flush oil from the system and components with the systems refrigerant. The effectiveness of using the 'flush' feature of a refrigerant recovery and recharge machine with an added in-line filter to remove contaminants is investigated. One gram of Arizona Test Dust is introduced to the suction line of an automotive A/C system, and the system is run to compressor failure. This introduces debris from the damaged compressor into the condenser and the rest of the system. The condenser is removed, and the refrigerant recovery and recharge machine with the added in-line filter is used in 'flush' mode in an effort to remove the debris from the condenser. The condenser is sectioned and inspected to evaluate the effectiveness of the debris removal. Two machines, made by different manufacturers, were selected to represent machines typically used in A/C service operations. Several compressors were failed in order to create contaminated condenser samples. The condensers were then flushed for varying lengths of time, filled with epoxy, sectioned and photographed under microscope for cleanliness evaluation" [25].

Autonomous Vehicle Levels

The terms related to On-Road Motor Vehicle Automated Driving Systems are listed below; for more information on this, see **J3016_202104**:

- Level 0: No Driving Automation
- Level 1: Driver Assistance
- Level 2: Partial Driving Automation
- Level 3: Conditional Driving Automation
- Level 4: High Driving Automation
- Level 5: Full Driving Automation [24]

AutoShift and AutoShift Generation II Manual Automatic Transmissions

Transmissions that are classified as being semi-automated shift-by-wire models because they automatically select and engage the transmission gears. The driver

must, however, use the clutch pedal for both starting and stopping. These transmission are also called three-pedal units because it has an accelerator, brake, and clutch pedal. They require a power-assisted clutch release system on all rear engine coach applications; all other vehicle applications require adjustment-free clutches for all 6-, 7-, 10-, and 18-speed applications. It is a 10-speed base transmission (RTO-XX9 I O-B/C-AS2) with a 5-speed front box and a 2-speed rear box. The 18-speed AutoShift (RTLO-XX918A-AS2) requires a 4-speed rear or back box.

AutoShift Truck Transmissions

Generation II Eaton Fuller Roadranger truck transmissions are classified as being semi-automated shift-by-wire models because they automatically select and engage the transmission gears. The driver must, however, use the clutch pedal for both starting and stopping. So these transmission are also called three-pedal units because it has an accelerator, brake, and clutch pedal. They require a power-assisted clutch release system on all rear engine coach applications; all other vehicle applications require adjustment-free clutches for all 6-, 7-, 10-, and 18-speed applications.

AV (Autonomous Vehicle)

The AV or driverless car, self-driving car, or automated car is an unmanned or occupied ground vehicle that is capable of driving itself by sensing its environment and navigating without human input. Autonomous means self-governing or self-driving. They are possible thanks to the integration of numerous current automotive technologies, such as adaptive cruise control, forward collision warning, lane departure warning, and V2V (vehicle to vehicle) communication being merged into one complex system. These self-driving vehicles generate and maintain an internal map of their surroundings based on a number of input sensors like radar or lidar (light detection and ranging). For example, Uber's self-driving prototypes use 64 different lidar laser beams, along with other sensors, to construct their internal map, and Google's prototypes have used lidar, radar, high-powered cameras, and sonar. For more information on this, see **SAE J3016_201401** [24].

Available Voltage in a Circuit

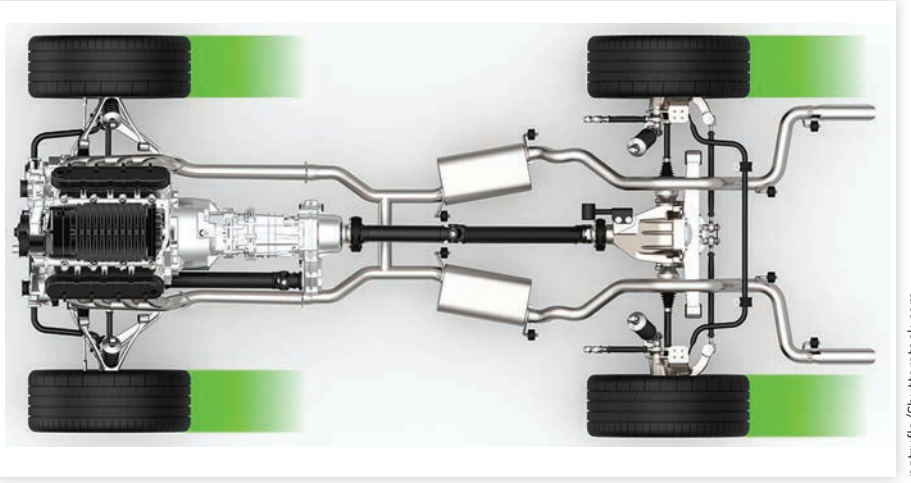
Sources of low-voltage problems and high-resistance faults are isolated by systematically taking available voltage readings along a circuit while it is carrying current. These available voltage tests provide a quick way to determine overall circuit condition. For example, if an accessory motor is not turning fast enough, available voltage testing can pinpoint the problem area of the circuit. Begin testing at the point of highest potential voltage, or closest to the power

source. Then work down the circuit and take readings at each load. The DMM readings can show that there is not enough available voltage to correctly operate the motor. So the problem is either in the switch or the circuit between the switch and the motor.

AWD (All-Wheel Drive)

AWD is a drive system that can drive both the front and rear wheels through all phases of operation. Also called full-time four-wheel drive (4WD). AWD vehicles can be set up on a traditional 4WD vehicle using an inner axle differential to prevent axle windup or with a front-wheel-drive (FWD) vehicle using a transaxle, power transfer unit (PTU), and propeller shaft (driveshaft) sending power to a rear drive unit (RDU). These are FWD-based systems. A single speed PTU can have a differential, a viscous coupling, a center differential, or multi-plate clutch directing power to the rear axles (RDU) so both axles may rotate at the same or different speeds.

FIGURE A.29 A general AWD drivetrain layout for a FWD-based vehicle that would use a front transaxle-based PTU that could connect to differential, viscous coupling or multi-plate clutch to drive the rear wheels.



patruflo/Shutterstock.com.

AWG (American Wire Gauge) System

A system designed for solid wire used to indicate the diameter of conductors. A smaller wire gauge number represents a larger conductor diameter, and a larger wire gauge number represents a smaller conductor diameter.

Axial

Axial means to be situated in the line along with the axis or centerline of a part or component. Axial play in a ball joint means looseness in the same axis as the ball joint stud.

Axial Load

Axial load is any line of force applied parallel to the axis.

Axial Motion

Axial motion is the movement along, or parallel to, the centerline or axis of a shaft. When a shaft has revolution, a dynamic seal is required to contain fluids.

Axial Play

Axial play is the movement along, or parallel to, the centerline (axis) of a shaft. It is also called end thrust or endplay. It may also be defined because the gap between the flanks of the threaded spindle and also the threaded nut. The movement of the threaded nut within the axial direction without moving the spindle.

Axis

The axis is the centerline of a rotating part.

Axis System

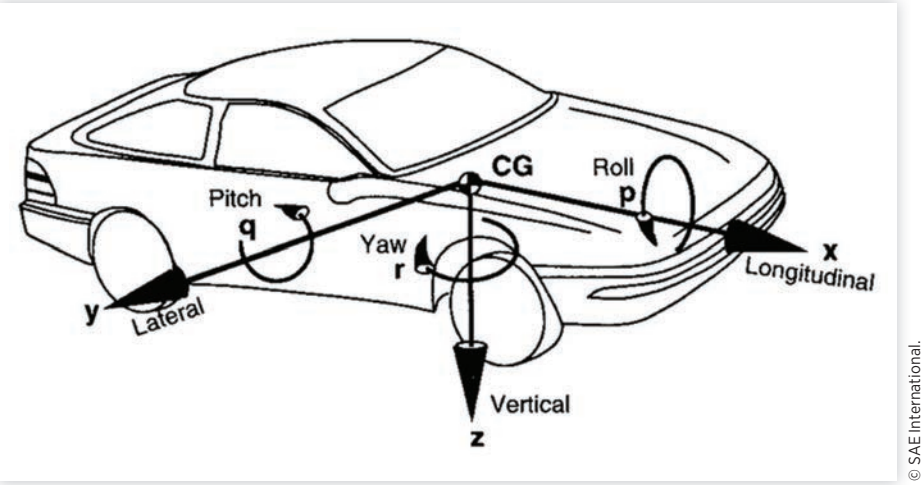
The axis system is employed to set up a fixed coordinate system within the environment relative to the vehicle because it moves through the air. The axis system is fixed within the body specified, in nominal resting condition on horizontal ground. The X-axis is an imaginary line drawn down the middle of the vehicle from front to back. It is horizontal, parallel to the longitudinal plane of symmetry of the vehicle, and pointing forward. The Y-axis is that the imaginary line across the vehicle from left to right. It is horizontal, perpendicular to the X-axis, and pointing to the left. The Z-axis is that the vertical line that runs through the middle of the vehicle from top to bottom.

Roll is vehicular movement along its X-axis. It is the rolling motion you are feeling when making a pointy corner and is usually what causes rollovers. The Z-axis is vertical, perpendicular to both X and Y axes, and pointing upward. The origin is fixed within the body and chosen because the midpoint of a virtual rear-axle is projected onto the ground. The terms yaw, pitch, and roll describe the movement of a vehicle around the three axes. Pitch is movement round the vehicle Y-axis, which is commonly felt during hard braking or fast acceleration when the front of the vehicle noses down or rises up slightly. Yaw is movement

round the Z-axis, which is felt when the vehicle deviates from its straight path, such as when the rear wheels slide out during drifting.

Movement around each of those axes must be controlled during all of the maneuvers of the vehicle for it to be safe. Many safety systems, like electronic stability control, are designed to keep vehicles within the safe limits of those axes. For more information on this, see **J1594_201007** covering axes system, resolving center, forces and moments, attitude angles, force and moment coefficients, vehicle parameters, flow parameters, and yaw-weighted drag coefficient along with **J670_200801** covering axis systems, vehicle bodies, suspension and steering systems, brakes, tires and wheels, operating states and modes, control and disturbance inputs, vehicle responses, and vehicle characterizing descriptors [6, 26].

FIGURE A.30 SAE vehicle axis system coordinates system and sign conventions.



Axle

The axle is a fixed or rotating steel rod or spindle passing through the center of a wheel or group of wheels.

Axle Bearing

The axle bearing is a ball or roller bearing that supports an axle.

Axle Windup

The axle windup is a condition found in solid, driven rear axle configuration commonly found in medium- and heavy-duty trucks. Leaf springs, control arms, pinion snubbers, and torque arms are all means of controlling axle

windup. Newton's third law of motion clearly states that for each action there is an equal and opposite reaction. The concept of axle windup is an example of that law. This is because the axle shaft rotates forward to drive the rear wheels, and the motion of the axle shaft rotating forward causes the axle housing to rotate the wrong way causing the axle to twist or lift during hard acceleration.

Axle Yaw

Axle yaw is the feature that uses an open differential to transfer torque to the wheels that have the best grip on the road.

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