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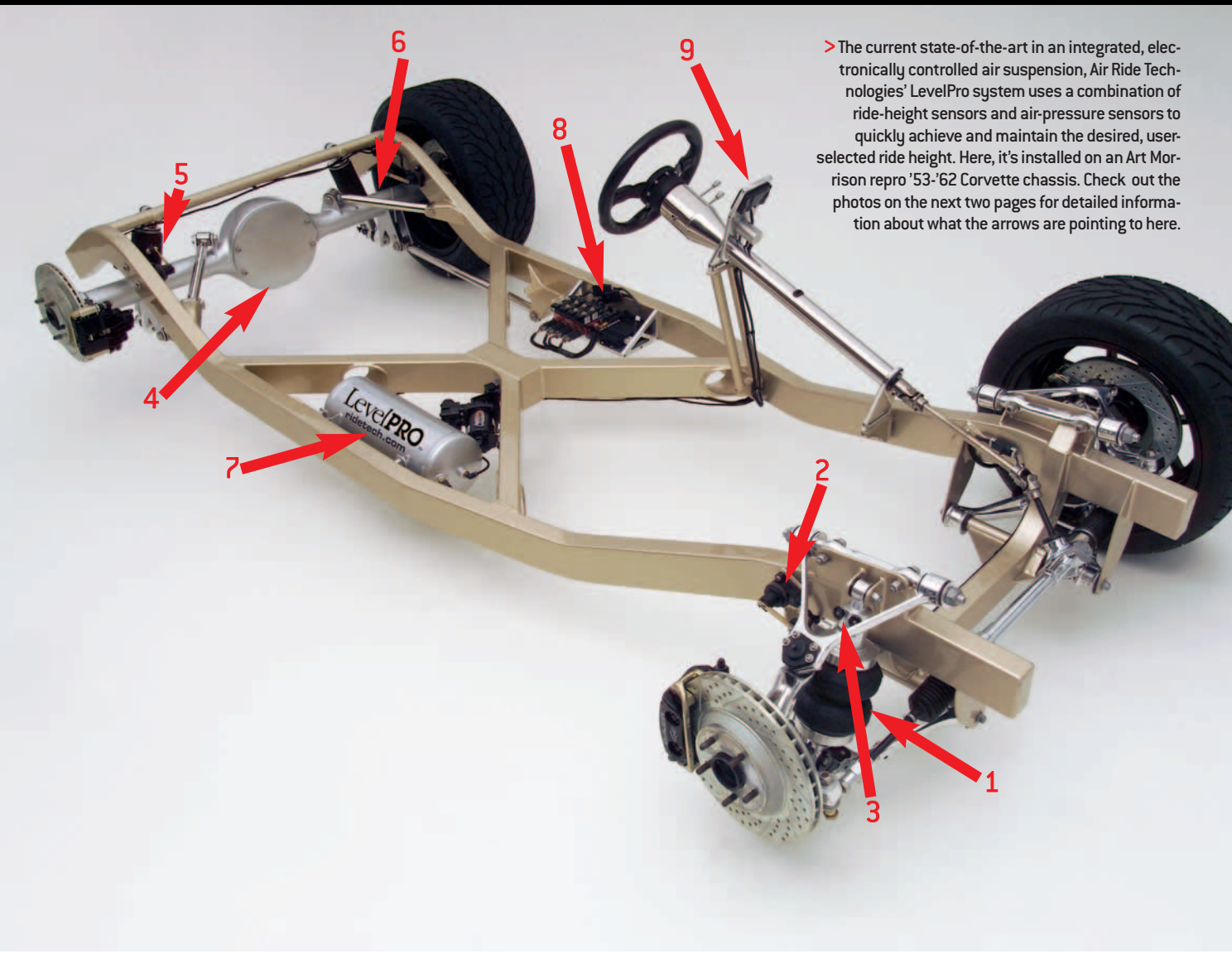
HOT ROD

Air Suspensions Have Hit Mainstream Hot Rodding. We Explain Everything You Need To Know About Them.

By Marlan Davis
Photography: Marlan Davis, Scott Killeen, and the Manufacturers

AIR TO BE DIFFERENT



> The current state-of-the-art in an integrated, electronically controlled air suspension, Air Ride Technologies' LevelPro system uses a combination of ride-height sensors and air-pressure sensors to quickly achieve and maintain the desired, user-selected ride height. Here, it's installed on an Art Morrison repro '53-'62 Corvette chassis. Check out the photos on the next two pages for detailed information about what the arrows are pointing to here.

A sea-change in hot-rod suspensions is sweeping across the scene: replacing conventional metal suspension springs with air springs, often controlled by sophisticated air compressors and self-leveling electronics. Whether it's for looks, easy ride-height alterations on the fly, handling improvements, or better load-carrying ability, air suspensions combined with huge wheels and tires are more mainstream than ever. To get the lowdown on air suspension, HOT ROD consulted leading air suspension specialists, including Air Ride Technologies' Bret Voelkel and Total Cost Involved's (TCI) Sal Solorzano. These outfits are among the leaders in bringing practical, bolt-on air-suspension technology to the hot-rodding mainstream. They shared their expertise on what it takes to install a first-rate air suspension on your hot rod.

WHAT IT IS

An air suspension replaces conventional springs with air springs similar to those on big 18-wheel semitrucks. Conventional coil-spring suspensions are the easiest to upgrade, with the airbags slipping right in place of the coil springs and often bolting to proprietary bolt-in brackets supplied by the aftermarket manufacturer. Air-spring design has progressed to the point that pioneer companies like Air Ride Technologies, TCI, Air Lift, and others have developed bolt-on kits for most popular coil-spring cars and trucks. There are even air-spring solutions for leaf-spring and torsion-bar suspensions.

WHY YOU WANT ONE

An air suspension offers at least five major benefits:

Tunability: Air suspensions have a wide tuning range for spring rate and load capacity. Weeks of conventional spring and shock tuning can be painlessly compressed into a few minutes via in-car adjustability. Getting the ride height, load, and rate on a coil spring right on the first try is a hit-and-miss affair, but an air suspension provides a much broader envelope, so precise selection isn't as critical as on a conventional spring.

Handling: Most air springs are progressive. The more they compress, the stiffer they get. Combine this inherent progressive spring rate with in-car adjustability, and the result is enormous performance potential. Tuning for conditions is quicker and faster. In a sophisticated handling application, the air spring should be coupled with shocks adjustable for both rebound and compression and carefully selected antisway bars.

Performance customiza-

> With their greater load capacity, double-convoluted air springs are usually used up front. The latest development is Air Ride Technologies' ShockWave, a patented combination of an air spring and a shock absorber that's similar to a high-tech racing coilover. It makes replacing original factory coil springs easy by eliminating the need for shock-absorber relocation.

> A ride-height sensor near each wheel provides to the computer information on the vehicle's actual ride height.

> ShockWaves are available as single-adjustable (rebound only) units or in the preferred double-adjustable style shown here with separate rebound and compression adjustments. Double-adjustable shocks are more easily re-optimized when ride height, air-spring height, and air-spring pressure changes.

tion: Everyone has his own personal idea of how his car should ride and handle. With an air suspension, these wishes can be accommodated with little or no component changes. By adjusting air pressure and shock valving, you can make the same car be soft and comfortable, firm and tight . . . or anywhere in between. You can drive the car comfortably to the track, firm up the air pressure and shock valving to go racing, then readjust the pressure and valving to return home in comfort.

Stance: Air suspensions make it easy to lower the car so you can look cool. At the far end of the coolness spectrum are spark-throwing minitrucks and lowriders, but today, they represent only a small segment of the market. Far more typical is the guy who just wants to lower his car or truck a reasonable amount for better looks without sacrificing any driveability or durability. Most kits come set up to deliver a normal ride height that's several inches lower than the stock springs. Regardless of how low the car is, air suspensions make it easy to raise the car back up for normal cruising, getting into gas stations, or even rolling onto the trailer.

Load carrying: This is the original commercial application for air suspensions: helping 18-wheelers carry heavy loads while improving driver comfort. Although probably not the main reason for switching over on a pure hot rod, it definitely is one solution for making your dualie tow truck more driveable under varying-load conditions. In fact, some new SUVs now come with air suspensions.

AIR-SPRING DESIGN

Today, most air springs are made by Firestone, which pioneered their use on big trucks. Three basic types of air springs are available: the double-convoluted, the tapered-sleeve, and the rolling-sleeve. The double-convoluted design looks like a large double cheeseburger and generally has more load capacity, a shorter stroke, and a more progressive spring rate that's best suited for use on most front suspensions where the spring sits considerably inboard of the suspension's load point, which has the effect of multiplying load-capacity requirements while dividing travel requirements. Tapered- and rolling-sleeve air springs are smaller in diameter with a longer stroke and a more linear spring rate; they're best suited for most rearend applications because there are more travel requirements and fewer load-capacity requirements.

FRONT SUSPENSION

Shock relocation was usually required with most first-generation air-spring setups because there was no hollow area in the air spring's center to accommodate the stock shock-absorber mounting location that typically ran through the center of the coil spring. Kits designed for conventional air springs come with shock-relocation mounts and new control arms as needed. This is an affordable and straightforward solution, but in some instances, relocating the shock can result in wheel/tire clearance issues, especially with today's huge wheel-and-tire packages.

As air suspensions evolved, a higher-end installation was developed based on coilover shock/spring combos but with an airbag replacing the coilover's coil spring. These setups tend to be more expensive but offer the advantage of easier installation, better looks, and more wheel-and-tire clearance.

On the other hand, depending on the chassis, a coilover-like design could yield less overall wheel travel compared with a separate air spring and shock setup. Reduced wheel travel requires a stiffer bag to avoid bottoming out the suspension at a given ride height. Under these circumstances, if

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> Air springs can be made to work in conjunction with old-school leaf springs, but most custom rods take the opportunity to upgrade to a modern four-link suspension at the same time. Virtual bolt-in conversion kits requiring only minimal axle-bracket welding are available for most popular chassis.

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> Triangulated upper four-bar links typically fit most cars better than parallel links. Laying out a ladder-bar or four-link rear suspension is similar when using an air spring, a ShockWave (air spring with integral shock), or a conventional metallic spring. Air suspensions make it easy to adjust for a large range of vehicle weight—simply vary the air pressure.

ultimate ride quality is paramount, a separate bag and shock setup might be preferable.

REAR SUSPENSION

For cars already equipped with rear coils, changing over to airbags is straightforward. They often go right where the old springs used to sit, although in some cases, different spring seats may be needed (if so, they come in the kit). Shock-within-airbag designs are available as well, but additional mods may be required to install them.

Leaf-spring cars have two options. The simplest conversion is to remove several leaves from each spring pack and install air springs between the axlehousing and the vehicle frame. Residual leaves are still needed to locate the rear axle, but airbags now perform the primary load-bearing function. On an old car with worn-out leaf springs of uncertain durability and capability, the plan (if you can afford it) is to replace them entirely by moving up to a four-link suspension. Major aftermarket outfits offer premade conversion kits that bolt right into popular leaf-spring

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> With more travel and less spring rate than the convoluted style, a tapered- or rolling-sleeve air spring is usually preferred for supporting rear suspensions. This 7000-series ShockWave replaces a conventional coilover on a four-link or ladder-bar–style rear suspension.

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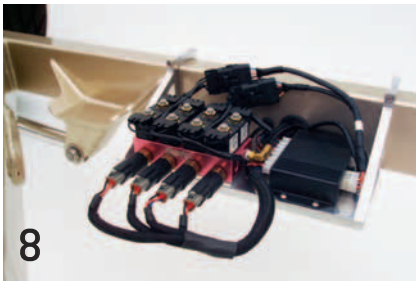
> A compressor and reservoir tank allow quick in-vehicle altitude adjustments. They can mount anywhere on the vehicle, but the most popular locations are under the car or in the trunk. Be sure to protect the compressor from direct road spray and debris damage. Run heavy-gauge wire to the compressor and use a relay to protect the low-amp pressure switch.



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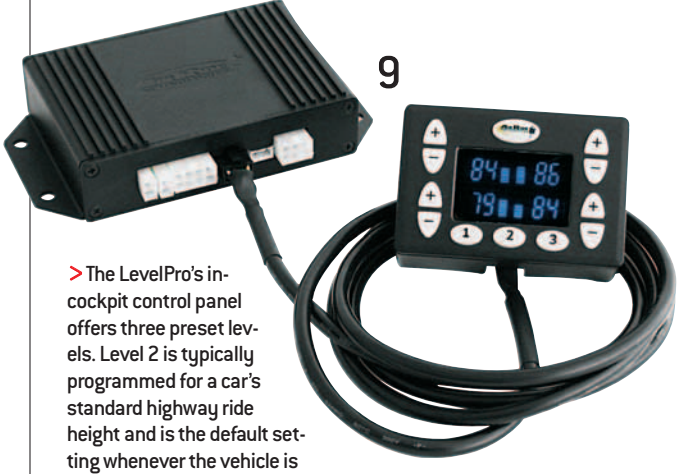
> Electric solenoids controlled by a dash-mounted switch or an ECU (on high-end setups like the LevelPro) are used to inflate or deflate the springs. Solenoids eliminate underdash air lines, plus, they can be remotely mounted in the trunk or under the car. Mount electronic components in a protected area away from moisture.



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> The LevelPro's in-cockpit control panel offers three preset levels. Level 2 is typically programmed for a car's standard highway ride height and is the default setting whenever the vehicle is started. Additionally, manual inflate and deflate controls as well as an air-pressure display are available for each corner of the vehicle.

cars with only minor welding required for new brackets on the axlehousing. Universal weld-in setups are offered for race cars and custom applications.

Depending on the physical constraints of the chassis layout and body clearance, the four-link kits' upper links may be either triangulated or parallel in relation to the lower links. Generally, parallel four-links fit better in trucks, while triangulated setups are more suitable for cars. For some chassis, both parallel and triangulated four-link configurations are available. If you have a choice, a handling or primarily street-driven vehicle usually performs better with a triangulated four-link; a parallel setup is generally the ticket for a pure drag-racer/straight-line application.

COMPRESSORS

At their most basic level, air springs can be inflated using external shop air just like an old air shock, but that obviates one of the main benefits of this type of suspension: in-use adjustability to compensate for changing road conditions, vehicle loads, or intended use. Every time you add load without on-board air—be it fuel, people, or cargo—you have to track down an air hose.

Realizing full benefits from the adjustability offered by air springs really requires an on-board air source. With air suspension, ride-quality tuning is accomplished incrementally, with very small air-pressure changes. Air springs have relatively low volume, so it is difficult to inflate or deflate them with external air in small enough increments to fine-tune ride quality.

An on-board air system consists of at least one air compressor, probably a storage tank, and some sort of control system. A cost-effective and relatively simple solution that provides reasonable ride and handling benefits would be a 2-gallon tank kept full by a single compressor. On the other hand, if you want the car to go up and down in two seconds, on a heavy car it could take as much as a pair of 150-psi compressors and two or more 5-gallon tanks, huge industrial air valves, and ¾-inch feeder lines. Yet such an extreme setup could create just as many fine-tuning hassles as a basic external-fill setup: On a fast-acting system, every push of the button may result in a 20-psi change in air pressure.

AIR LINES

Commercial, DOT-approved, plastic air lines originally developed for big trucks are standard in most kits. They provide an easy, affordable solution to connecting the compressors to the air springs. Typical operating pressures range from about 75 to 150 psi, well within the capabilities of such tubing.

For the custom look, you can fabricate stainless hard line, just as in a brake or fuel system, connecting it using typical AN flare nuts and pipe adapters. At suspension travel points, flexible hose would be needed in an otherwise hard-lined system, just as it is in a brake system. Also like in a brake system, braided stainless steel Teflon-core hose is preferred over braided synthetic rubber-core fuel/oil-line hose.

TWO-WAY VERSUS FOUR-WAY

When air suspension was first introduced to hot rodders in the mid-'90s, a two-way control system was the standard method of inflating and deflating the suspension. In other words, both air springs on each axle were hooked together. This kept things simple, requiring only one control valve per axle. However, it quickly became apparent that during cornering, the outside (or loaded) air spring tried to transfer air to the inside (unloaded) spring, magnifying body-roll issues. Sometimes the problem can be minimized on a light car by installing big antisway bars, but nowadays, nearly everyone uses a four-way system, which plumbs and controls each airbag separately. Although this requires an individual control valve and air line for each spring, it cures all air-transfer problems, plus it allows precise control over vehicle ride height to compensate for varying weight, suspension bind, or alignment changes. Think of a four-way setup as somewhat akin to weight-jacking on an oval-track car.

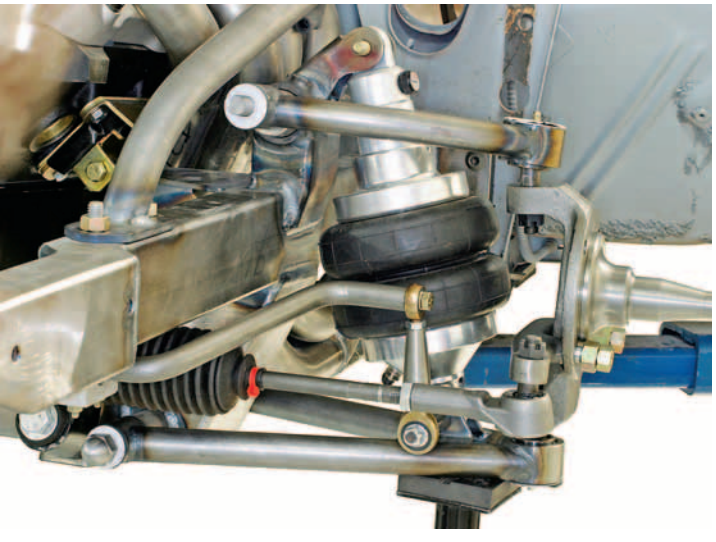
CONTROL SYSTEMS

Purely two- and four-way manual controllers are available for those on a budget. Manual setups typically use pneumatic valves mounted to a panel with

> Air suspension isn't just for profilin' or carrying loads. Compare the red '67 Chevelle with the blue '66, both with similar motors and BFGoodrich g-Force tires. The red car with its stock suspension leans like a drunken sailor. The blue car has Air Ride's full air suspension, antisway bars, and control arms, plus taller Fat Man spindles—it pulled 1.12 g on the skidpad and was 14 seconds quicker around the two-mile Putnam Park road coarse in Mount Meridian, Indiana (1:26 compared with the red car's 1:43).

> Three basic air-spring configurations are in use today. From left they are the rolling-sleeve, the tapered-sleeve, and the double-convoluted. While there are many variations for each configuration, in general, the load-bearing ability increases progressively with each basic design.

> Air suspensions can range from stock replacement bolt-ons to whole new front clips. Long known for trick street-rod chassis, TCI now offers a complete new front subframe for early '62-'67 Chevy IIs. Here it's shown with TCI's separate shock and air-spring setup. Spacers are available as shown to help develop the proper airbag installed height.



> Although pricier, the shock-within-airbag design installs easier. For TCI's '62-'67 Chevy II subframe, it fits right in place of standard coil springs. This deluxe package adds Fat Man spindles and rack-and-pinion steering. Note how at ride height the bag's end plates are parallel and in line with the shock mounts. Moving the spring toward the ball joint raises its rate.

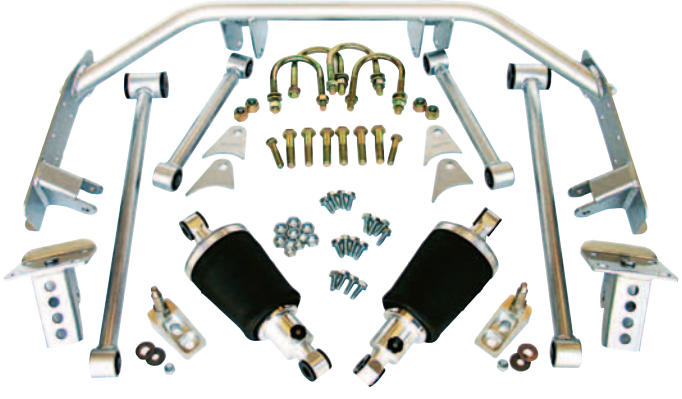
> Some cars need extra clearance to properly install air suspensions. Air Ride Technologies' tubular Strong Arms have dropped mounting points, plus they allow dialing in a little more caster. In some cases, optional matching upper arms are available that produce more negative camber while preventing ball-joint bind with today's popular taller replacement steering knuckles.

> MacPherson strut? No problem. Air Ride Technologies offers AirStruts that directly replace the stock factory struts for many popular, late-model cars. These struts have slotted spindle mounting holes and eccentric adjuster bolts that prevent the need for the special camber/caster plates usually required to restore proper wheel alignment at lower-than-stock ride heights.

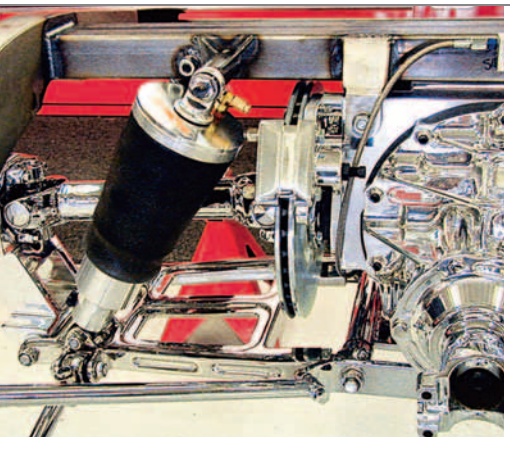
> Air springs can be used on a leaf-spring suspension. Air Ride Technologies' bolt-on AIRoverLeaf system offers great ride quality and extra load-bearing capacity without the need for re-engineering your vehicle to accept a four-link conversion. Several leaves must still remain in place as an axle-locating device.

"I can service nearly any car with four different air springs, front or rear." — Bret Voelkel, Air Ride Technologies

> TCI is developing a four-link air suspension for '67-'69 Camaros. The links are parallel, so the finished kit will include a Panhard bar to keep the rear centered in the car. The air spring is Air Ride Technologies' ShockWave 9000 with a tapered-sleeve airbag bellows. This allows a softer spring rate, longer travel, and a lower load capacity suitable for rear installation.



> Air Ride Technologies offers a plethora of bolt-in rear four-link conversion kits for a wide variety of cars and trucks. This kit (PN ABAR20400) fits the '60-'64 fullsize Ford Galaxie. Front and rear kits are even available for Chryslers.



> There is virtually no limit to retro-fitting air suspensions onto just about any vehicle. Here Air Ride Technologies' ShockWave 9000 is installed on a Kugel IRS. Typically, Kugel IRS units use two coilover shocks per side, one on each side of the drive axles—the ShockWaves fit right in place.

a pressure gauge. A more sophisticated approach with less underdash clutter is to use electric solenoids controlled by a switch or computer. The last 3-4 years have seen the introduction of various aftermarket active electronic height-control systems that attempt to maintain a set ride height as the vehicle drives down the road. An electronic height-control system adds a computer plus sensors to control the electric solenoids. Both pressure-based and ride-height–based electronic control systems are available.

PRESSURE-BASED SYSTEMS

With pressure-based electronic-control systems, the computer must rely on air pressure alone to extrapolate proper air-spring position, which should then theoretically translate into the position of the suspension, which should then (again, theoretically) translate into the ride height of the vehicle. Obviously, that's a lot of translations, interpolations, and assumptions. Although it may work fine on a vehicle that seldom sees load changes and is reasonably well balanced, for many vehicles, there's a major drawback: When any change occurs to the load an air spring sees, the assumption that any given air pressure will equate to a specific ride height may no longer be valid. Many transients can cause a load change: actual weight change via the addition or subtraction of passengers, luggage, or fuel; the vehicle sitting on an incline or pothole; or even general suspension-geometry or suspension-bind factors that end up requiring more air pressure to raise the vehicle than they do to maintain a specific ride height.

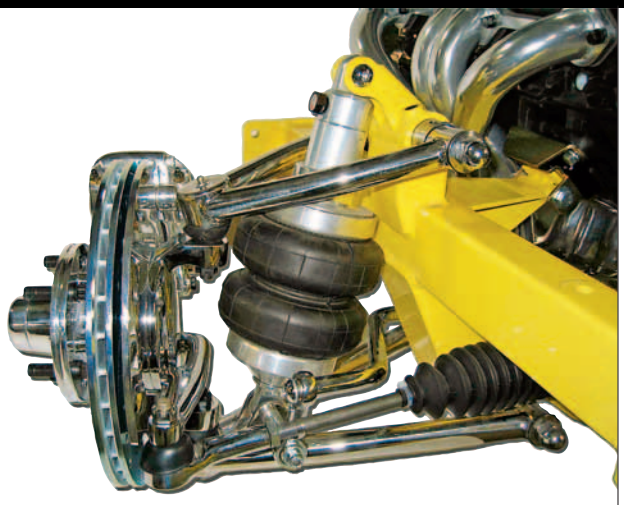
Active pressure-based systems may not react properly going through a long, sweeping turn (an interstate cloverleaf or any dynamic maneuver that increases the load on one side of the vehicle for a significant time period). Under such conditions, an active pressure-based system attempts to deflate the outside (loaded) air spring and inflate the inside (unloaded) spring, magnifying body roll and handling problems just like the old two-way system.

RIDE-HEIGHT–BASED SYSTEMS

Ride-height–based systems utilize separate sensors that directly measure the actual position of the vehicle's suspension, thereby eliminating several assumptions made on a purely pressure-based system because now precise information on the relationship between the suspension and the chassis is available to help the computer determine the vehicle's ride height. But there's still one problem known as cross-loading. This happens when the ride height is achieved with radically different air pressures on each corner. Normally, any side-to-side air-pressure variations should be held to 20 percent or less; yet it is possible to fool a pure ride-height–based system by overinflating two diagonal corners while leaving the opposing corners significantly underinflated. The computer keeps the car level, but the handling characteristics suck.

COMBO SYSTEMS

The solution is to combine pressure-based and ride-height–based leveling in the same system. Each serves as a check on the other. This is what Air Ride Technologies has done in its new LevelPro system. To save money initially, the setup can first be configured as a pressure-based system only, and the ride-height sensors can be added later, if needed. LevelPro systems also include the ability to program three different suspension heights into the computer—low (for profiling), normal (for touring and racing), and high (for clearing



> TCI offers billet air springs to replace the standard coil springs offered with its completely fabricated street-rod chassis. They're available for the rear of these chassis as well.

> Over the years, leading air-suspension manufacturers, such as Air Ride Technologies, have continued refining once-generic commercial-grade air-suspension parts specifically for hot-rod use. A typical state-of-the-art control system now includes bubble-tight solenoids, DOT-approved air lines and fittings, electronic ride-height sensors, and computerized control units.

> Air reservoir tanks come in many sizes. The main benefit of a larger tank is quicker rise time. Most hot rodders use a single 2- to 5-gallon tank. Some hard-core truckers who want a faster inflation speed may use larger or multiple tanks and compressors as well as larger-outside-diameter air lines.

obstacles like speed bumps). Simply punch a button, and the car raises or lowers to a preset level yet can still compensate at each preset for changes in fuel load, passengers, or cargo.

CUSTOM INSTALLATIONS

Complete air-suspension kits are available for mainstream classic musclecars as well as modern, high-performance factory hot rods, trucks, and SUVs. Because they are already properly engineered and sciened out, these kits are preferred over mixing and matching components from scratch. Pre-engineered air-suspension systems address all the issues of air-spring installed height, shock installed height, ball-joint travel, driveline angles, ground clearance, tire clearance, and other parameters that must be considered when building a safe, functional system.

For less popular vehicles, for which no ready-made kit is offered, it is feasible for an advanced hot rodder to custom-engineer a viable air-suspension system. Fundamentally, it's no different from engineering traditional suspension, except air springs replace metallic springs. It may actually be easier because air springs have a greater operating envelope in terms of ride height and load capability than traditional metallic springs.

Bearing in mind the different air-spring designs and system configurations in the preceding discussion, it is important to match the air spring to the vehicle's weight capacity and suspension travel. A dualie that tows a 48-foot trailer obviously needs a larger air spring than the rear of a '69 Mustang. Air-spring-suspension experts can usually provide a good ballpark air-spring recommendation given reasonable information about the vehicle's characteristics, desired maximum and minimum height, and how fast it needs to cycle up and down.

Identical springs and shocks may not always yield identical results in two different applications, even if the weight and installed height are similar. As alluded to earlier, on a front suspension, the spring-mount location on the control arm exerts a leverage effect, multiplying the theoretical spring rate as seen at the wheel. Just like an engine rocker arm, increasing the distance of the mount from the arm's pivot point (moving it closer to the ball joint) yields a higher ratio, which multiplies the spring rate. Increasing the angle of the shock also requires more spring to maintain an equivalent ride height.

Once the air spring has been selected, it must be mounted in the vehicle. Every air spring has an optimum design ride height where it delivers maximum performance. This spring-height dimension (available from the air-spring manufacturer) should be synchronized with the intended ride height to determine how to mount the air spring in the car. The mounting point must also allow for sufficient suspension travel, tire clearance, ground clearance, and appropriate driveline angles. Maintain adequate clearance between the air spring and other components—abrasion is death to these otherwise very durable units.

A variety of premade universal brackets is available from air-spring kit makers. Air-spring units, like Air Ride Technologies' ShockWaves that mount like a coilover shock, are easier to install with proper geometry than separately mounting a conventional separate air spring and shock absorber.

The vehicle should be mocked up at its intended highway ride height. At this point, you should maintain at least 4½ inches of ground clearance and have adequate suspension travel—at least 3

> Plastic air lines are standard in most kits. The end fittings simply push on with no tools required. Just be sure to cut off the lines squarely; Air Ride Technologies offers a special cutting tool to speed this up. Quarter-inch lines are the standard for most systems, but up to ¾-inch lines with multiple compressors have been used by those who want their cars to hop.

inches in compression and 2 inches in rebound. Be sure the air spring's end plates are aligned and parallel at ride height.

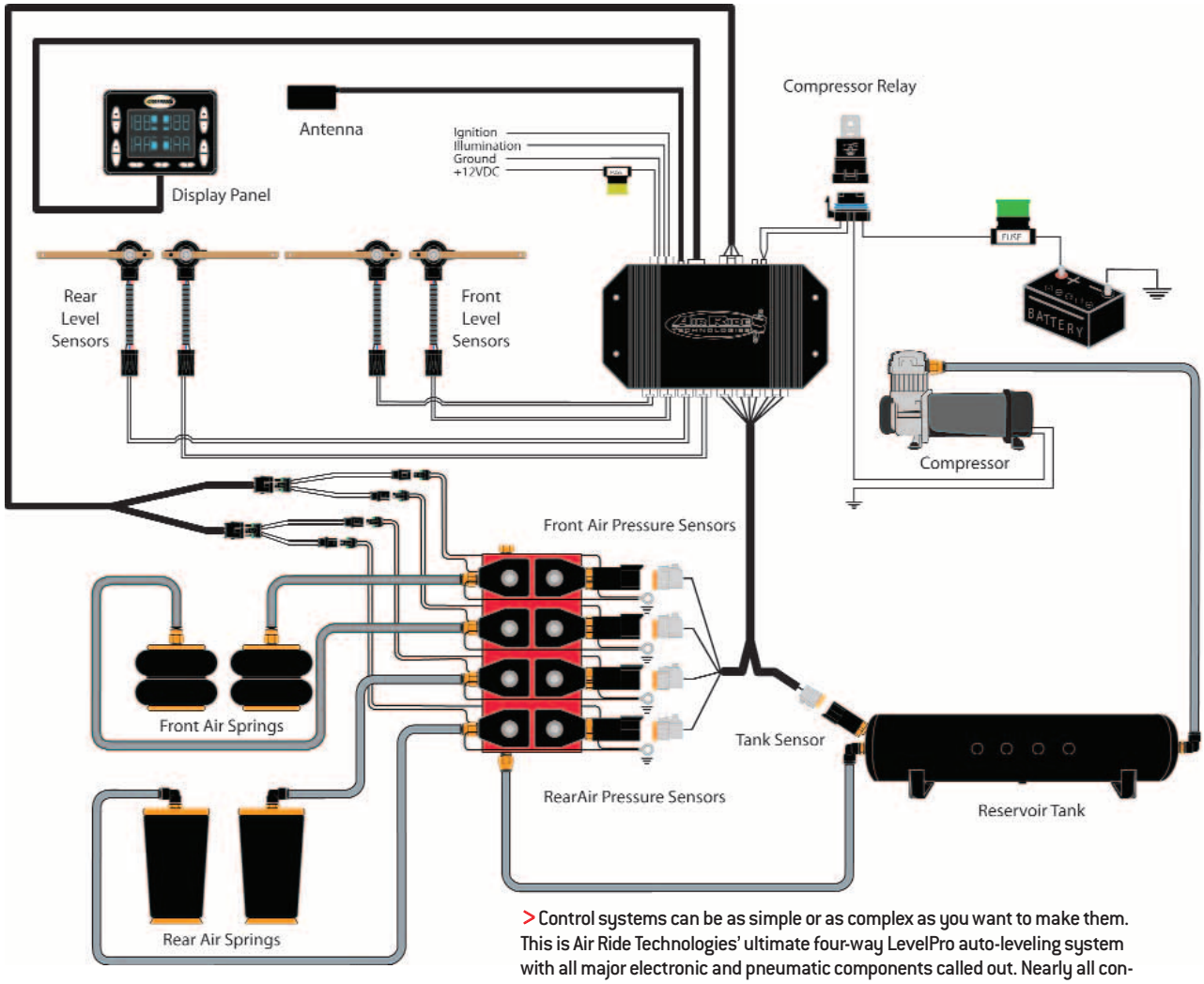
Firestone double-convoluted air springs don't require a bumpstop to avoid damage, however, your specific application may need a bumpstop to maintain safe ground clearance when deflated. For tapered- or rolling-sleeve air springs, a bumpstop and an extension strap (either a limiting strap or a shock absorber) must be used to prevent the air spring from exceeding its design compressed or extended dimensions or the spring will fail. Finally, set wheel alignment at the car's normal running ride height, understanding that it will change slightly when the suspension is in the raised or lowered position.

SUSPENSION TUNING

Shocks and antisway bars are just as important on an air suspension as they are on a conventional suspension. Whether metallic or air, a suspension spring's primary purpose is supporting the vehicle's weight at a given ride height. Shocks control suspension oscillation. Antisway bars control vehicle body roll to minimize suspension-geometry changes and weight transfer during cornering.

Air-suspension experts recommend supporting the vehicle with as soft a spring as possible, relying on proper shocks and antisway bar–tuning to control oscillation and body roll. This maintains ride quality—one of the main reasons for installing air springs—while also enhancing cornering performance.

After you select basic parts to get in the ballpark, the real advantage of an air suspension comes into play. Dialing in a traditional suspension for the exact vehicle load, road conditions, driving style, and driver preference requires time-consuming component changes. With an air suspension, fine-tuning can be accomplished with the push of a button and



> Control systems can be as simple or as complex as you want to make them. This is Air Ride Technologies' ultimate four-way LevelPro auto-leveling system with all major electronic and pneumatic components called out. Nearly all connections are direct plug-ins to simplify installation.

"An air suspension's ability to quickly change vehicle ride height is great because today's hot rods are set up low at ride height, and with an Air Ride, you can just add air to get over speed bumps, get up driveways, or put your car on the trailer." —Sal Solorzano, TCI

> Air Ride Technologies' four-way BigRed solenoid package makes short work of compressor-system installation and plumbing. Designed specifically for air suspension, its bubble-tight solenoids provide reliable, leak-free performance. The free-flowing, large-capacity valves are designed for fast ride-height adjustments.

"The ride quality of an air suspension is typically much better than conventional coil springs or coilovers because the driver is able to quickly tune the load capacity of the air spring to the exact load of the vehicle and his driving style." —Bret Voelkel, Air Ride Technologies

> An optional hand-held remote-control unit permits out-of-vehicle control over Air Ride Technologies' LevelPro system.

the twist of a knob.

DURABILITY

Quality air springs have been proven in millions of miles of heavy-duty commercial vehicle use for more than 70 years. Firestone has tested its air-spring designs for tens of millions of cycles—that translates into a 40- to 50-year life span. So long as the air spring isn't rubbing against anything and is at least 2 inches away from hot exhaust pipes, it ought to outlast the vehicle.

The most common problem is air leaks, usually caused by improper installation. Voelkel said, "The simple use of thread sealer on the fittings will prevent 97 percent of all leaks. The only other place there could possibly be a leak would be in an air valve if it gets any assembly debris or Teflon tape in the orifice. Although it is theoretically possible for an air spring or ShockWave to leak, in the 10 years we've been in business, I haven't found one yet."

Although rare, anything mechanical can break—be it metallic coils or an air spring. When engineering a custom setup, be sure there will be adequate ground and tire clearance if the air suspension fully deflates—at least enough to get you over to the side of the road without scraping the frame.

Properly engineered and designed, air springs are doing for suspensions what EFI engine-management systems and overdrive trannies have done for the drivetrain. Yes, there's a learning curve; yes, the sophisticated high-end systems are pricey—but they're yet another step forward in making it possible to truly build a car that you can race on Sunday, drive to work on Monday, and cruise the parking lot on Friday night. **HRM**

SOURCES

AIR RIDE TECHNOLOGIES; Jasper, IN; 812/481-4787; www.ridetech.com

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