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CAMARO PERFORMERS

THE ULTIMATE GUIDE

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ENGINE SWAPS
MADE EASY
+ INSIDER TIPS FROM GM



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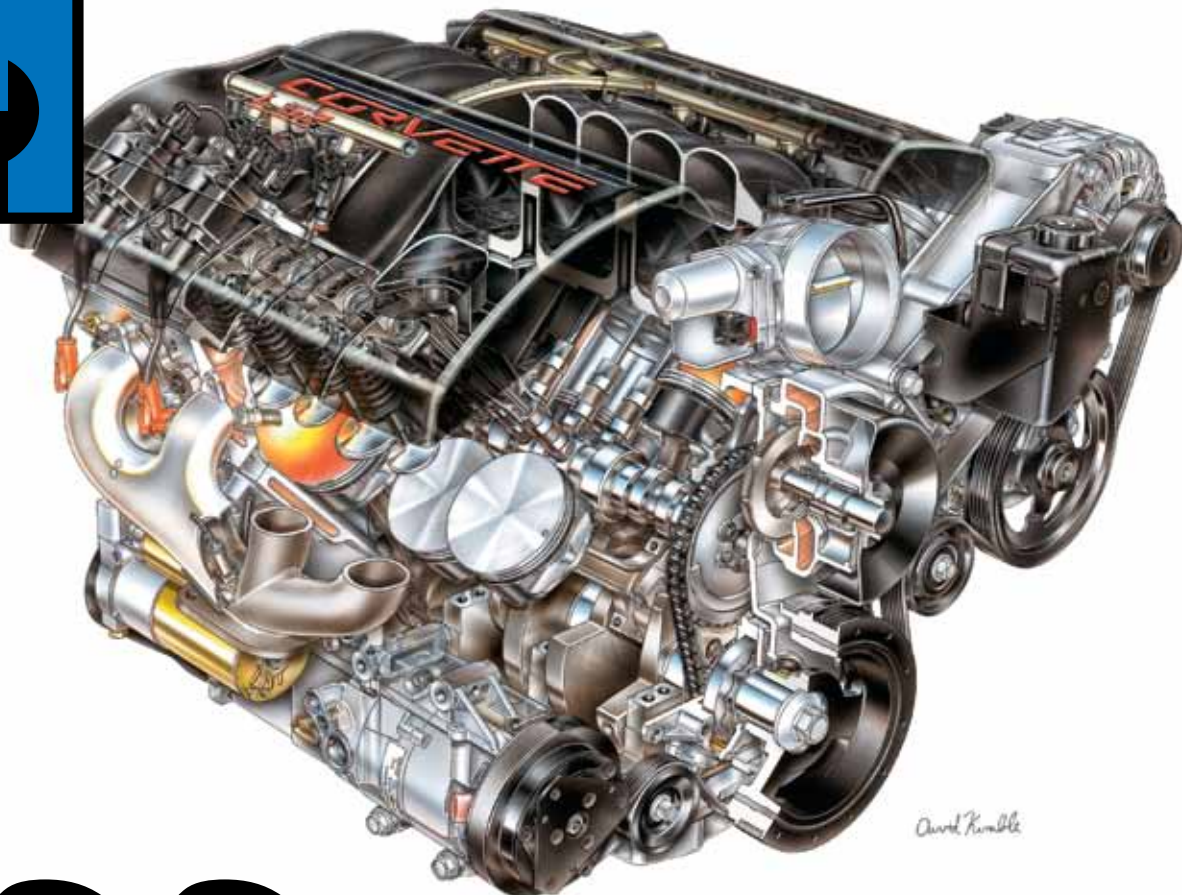
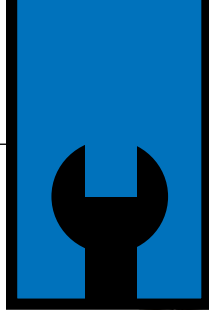
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LS Swap Secrets

Dropping an LS engine into your Camaro can be a painless process if you're in the know.

by **Michael Copeland** photographs by Steven Rupp and the manufacturers
captions and Introduction by Steven Rupp

•**Since it first hit the** automotive scene back in 1997, the venerable LS1 and its various incarnations has quickly become the go-to engine for EFI swap projects. While the LS platform hasn't surpassed the good old Gen-I small-block in terms of how many old Chevs it's powering, it's becoming more prevalent each year. Part of this growth is because the aftermarket industry is making it easier than ever to stuff this aluminum powerplant into any Chevy, or anything else for that matter.

Even as recently as five years ago it was a challenge to get an LS engine into old Detroit iron. Engine mounts had to be fabricated and, in some cases, headers had to be custom-bent to accommodate the engine's unique architecture. Guys had been retrofitting LT1s into cars for some time, so grafting in an EFI-capable fuel system wasn't so bad, but it still required fabrication and creativity. Then there was getting the electronics in order. Programming software for the computers needed to run the LS1 were scarce and hard to use by today's standards, and finding people that knew their way around the code was tougher than finding out where all the stimulus money went.

But, as they say, "That was then, and this is now." It's 2010, and getting LS power under the hood of your classic Camaro is nearly painless. Where once parts needed to

be whittled out of alloys using a dull knife, those parts are now just a phone call or mouse click away. Is it as easy as dropping in a carb'd small-block? Not yet, but the benefits of all that EFI-fired goodness are worth the small amount of extra work and cash required to make it happen.

With the aftermarket making the swap easier there remains the other common complaint about LS swaps: cost. Can you empty your wallet and max your credit by dropping in an LS engine? Hell, yeah! But like most things in life, how expensive it ultimately turns out to be is completely up to the guy holding the wrench. More people making more parts equates to more com-

"EVEN MORE IMPORTANT THAN PARTS OR CASH IS KNOWLEDGE."

petition. And that ultimately drives down the cost. It also helps that creative folks out there have had years to figure out how to do it cheaper. If you want that sweet drive system from March Performance, Vintage Air, Billet Specialties, or Concept One, but are short on funds, then, thanks to GM, you still have a plethora of LS drive systems lurking in scrap yards. Not as fancy as the billet baubles, but dirt cheap and quite capable of getting the job done. Can't afford coated long tube headers yet? Easy: make do with some free-flowing factory exhaust manifolds. A fuel system can be constructed of top-shelf Aeromotive parts or pieced together using ingenuity and OEM pieces. Whether you have enough cash to buy the best of the best or you're on a restrictive budget, dropping an LS engine into your ride is an easily obtainable goal.

Even more important than parts or cash is knowledge. Since 1997 GM has released quite a few versions of the original LS1 and instituted a host of changes—some subtle, others not so much. Since LS-based mills now reside under the hoods of so many different GM vehicles, it's imperative to know "what's what" in terms of items like oil pans, computer systems, and other differences. Being well versed in all things LS will keep you from making costly mistakes like trying to run an engine with a 58x reluctor wheel with a computer looking for the 24x version.

To get the 411 on LS swaps we went straight to Michael Copeland of General Motors. Michael was the Project Manager for the Performance Vehicles division at GM, so he knows a few things about the LS platform. So read up on what's become the most successful engine ever put out by GM. After all, knowledge is power.



▲ GM's line of Vortech truck engines like this 6L version can be found at bargain basement prices for the smaller 5.3L and 4.8L models. Just keep in mind that the truck intake may not clear your hood and swapping to the lower car version causes clearance issues between the idler pulley and the throttle body. Still, it's a lot of LS bang for very little buck.

From The Desk Of Michael Copeland:

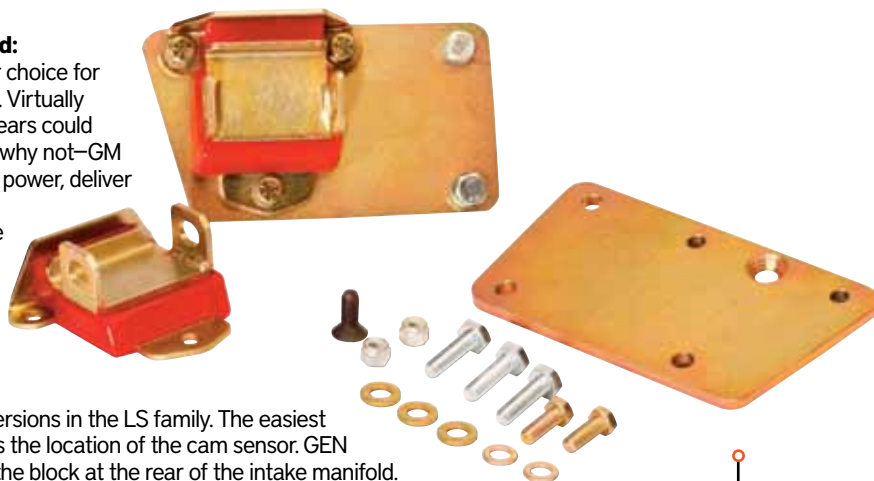
The GM LS Series of engines is a popular choice for use in almost any vehicle not built with one. Virtually every vehicle GM has built in the last 100 years could benefit from swapping in a LS engine. And why not—GM has built millions of them. They make great power, deliver amazing fuel economy, and are compact and lightweight. Not to mention, with all the factory and aftermarket support, these engines can be built to meet almost any requirement. Here are some of the "most common" topics that come up when discussing LS swaps.

● Generation Identification

Currently, there are GEN III and GEN IV versions in the LS family. The easiest way to determine which version you have is the location of the cam sensor. GEN III engines have the cam sensor located in the block at the rear of the intake manifold. GEN IV engines have the cam sensor located in the front cover. GEN III engines have 24x crank sensors and GEN IV have 58x. The 24x sensor has a black connector and the 58x has a gray connector. Engine controllers must be matched to this sensor or the engine will not run. Both cam sensors will work with either crank sensor, but the connector has to be repined to match the engine controller.

● Engine Size

All LS engines, from 4.8-liter through the 7.0-liter, are the same external size. This is true for even the maximum horsepower versions from GM, including the Supercharged LS9 and the LSX 454 Crate engine. All production LS engines have the engine size cast into the block. There are different power levels available in LS engine sizes, and the only way to identify which version you are looking at is to check the VIN number stamped in the block.



▲ The most basic items that need to be addressed when dropping an LS engine into any Chevy, where it wasn't originally designed to go, are the engine mounts. It used to be that the choices were few, but today there's a host of options out there. From the Energy Suspension pieces shown to versions offered by Holley, Edelbrock, Autokraft, and Speed Tech, there's sure to be a mount for your particular build.

There are aftermarket blocks available (Dart, RHS, World Products), both in short and tall deck versions. GM Performance Parts has both a standard and tall deck LSX iron block. These blocks allow you to build LS-based engines all the way to past 500 ci. With some of these aftermarket race blocks the deck is higher, but the rest of the block shares common dimensions with the production LS engine.

•Engine Mounts

All LS series engines have the exact same mounting bosses for the engine mounts. This makes swapping any LS for another LS a bolt in. There are many aftermarket companies making adapter mounts to install a LS into almost any vehicle made. While most share the same basic design, there are some differences. Make sure you use the mount the adapter manufacturer recommends, and install it per the instructions. Not following their directions can make the engine sit in a different location, and this can make other components like headers or oil pans difficult to install. Before purchasing additional components, you should contact the mount manufacturer to determine which components were used in the design of their mounts. Many of these mounts place the engine in slightly different locations and, unless you verify which parts work with their mount, they might not fit without modification. Also note that some iron LS blocks have undrilled bosses and need to be drilled to mount some accessories.

•Oil Pans

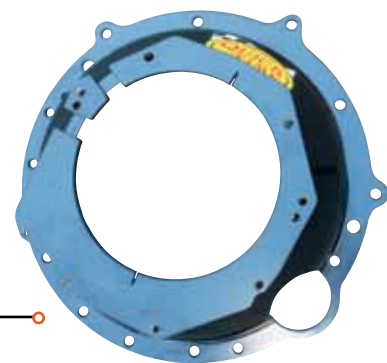
There are numerous versions of oil pans available, both from GM and the aftermarket. Most are rear sump designs, except the GTO and Holden, which use a front sump. Almost every vehicle uses a different design pan, so selecting one for your specific application is difficult. Early Corvettes use a "wing" pan. It is difficult to install in most vehicles, but is a good

▶ It's time for a quick note on reluctor wheels. All engines shipped from GM since January 2006 carry the newer 58x reluctor wheel. If you have an early LS2 (PN 12499750), then it's considered an '05 engine and will carry the 24x reluctor wheel like the LS1 and LS6 variants. This is important to know when you start shopping around for a computer to run your engine. Any LS engine can be converted either way by swapping out the reluctor wheel, but it's a bit of a pain since it has to be pressed onto the crank using a special jig. The easiest way to tell from the outside is by looking at the crank trigger (located near the starter): grey for 58x and black for 24x.

choice if your vehicle will be used for road racing. The "F" car and CTS-V oil pans both work well for engine swaps. The "F" car pan has a shorter sump, front to back, and is the most popular. The aftermarket offers a number of different style oil pans for various applications. Companies that can get you set up include Autokraft, Moroso, and Canton just to name a few. They all offer oil pans for engine swap applications, but remember to match the oil pick-up and dip stick to the pan. When you install the oil pick-up, make sure the tube and O-ring seal are straight in the oil pump. If not, you can have low oil pressure and damage your new engine. All LS-based engines use an O-ring style oil pan gasket. As long as it is not damaged, it can be reused. Even some aftermarket pans, like the one from Canton, use the GM O-ring gasket.

•Transmission Bolt Patterns

All LS Series engines share a common transmission bolt pattern. It is the same as the traditional Chevy pattern, with one missing bolt. The center bolthole on the passenger side is not drilled or tapped in



▲ No matter what transmission you want to put behind your LS engine, chances are someone sells a bellhousing to make it happen. Quick Time offers an SFI-certified bellhousing to bolt to just about any trans behind your LS engine including Tremecs, Richmonds, and all the popular GM automatics. Other companies offering transmission solutions are McLeod and Lakewood. If you're stuffing a T56 six-speed behind your LS mill, then the low-buck route is to run an aluminum GM housing and, of course, newer GM automatics have the bell integrated into the transmission case.

▼ Oil pans are another area that used to be problematic. When working with a stock subframe, swappers were forced to notch and modify factory LS F-body pans.

Today there are quite a few options from companies like Speed Tech, Canton, Autokraft, Moroso, Holley, and others. There's also a chance that there's a GM pan that will work in your particular application. A great resource to reference is the website www.LS1tech.com where they have a "conversions and hybrids" section just for swappers.



production blocks because the hole would protrude into the water jacket. This bolt can be left out if you are using a traditional transmission or bell housing. If you have a LS-based transmission bellhousing, it will not have a hole for a bolt. Some aftermarket blocks and GMPP LSX blocks have this bolthole and, if possible, it should be utilized. Some companies making bell housings include Quicktime, Lakewood, and McLeod.

•Flexplates and Flywheels

The rear snout on the crankshaft on all LS-series engines is 400 thousandths short compared to traditional small or big-block Chevy engines. If you are using a LS engine/transmission package, there is no issue. If you are installing a traditional GM transmission on LS engines, changes must be made

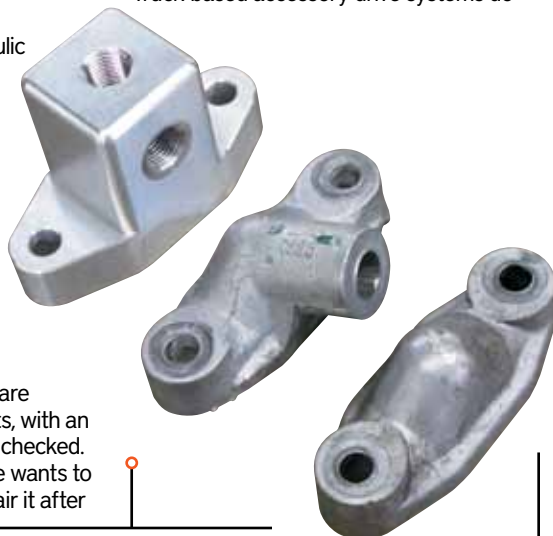


▲ Getting the fly-by-wire electronic 90mm throttle body that comes with the newer LS engines to function in your hot rod is not as tough as you may think. However, if you're old school and like the idea of running a cable, you're in luck since many companies are now making 90mm throttle bodies. In addition to Holley, FAST and several other companies offer high-flowing throttle bodies. Best of all, they bolt right up to your factory intake just like the factory ones, and if you need to suck in more atmosphere, they even come in larger sizes. Just make sure to try and size the throttle body to the intake as best you can.

to locate the flywheel or flexplate in the correct location. Spacers are available that relocate the flywheel to the traditional location. If you use the spacer, make sure you install a long roll pin into the alignment hole where the flywheel bolts on. This will help prevent the flywheel from coming loose. Also, always use new bolts or Loctite on used bolts. The better option for high-power applications is to use a flywheel or flexplate designed for this application. They are designed to locate components in the correct location. If you use one of these flexplates, a spacer must be installed on the snout of the converter to extend it. This allows the converter to retain the pilot in the end of the crankshaft. Not using this can cause transmission failure.

If you are installing a stick-shift transmission, there are two locations in the rear of the crankshaft for pilot bearings. One takes a small bearing, designed to sit deeper in the crank. The other bearing is larger, and sits closer to the transmission. Make sure you measure the input of your transmission and install the correct bearing. Another area of concern is the throwout

bearing. Most people use hydraulic throwout bearings but, regardless of which style you use, measure the travel to make sure you have enough to fully release the clutch. If you do not have enough travel, the clutch will drag and you will not be able to shift when the engine is running. Also make sure the throwout bearing is not too close to the clutch. If this happens, the clutch cannot fully engage and will slip. Even if you are using production LS components, with an aftermarket clutch this must be checked. This is a critical area, and no one wants to remove the transmission to repair it after



▲ There are two main spots on an LS engine to mount an oil pressure sender. The first one is a port at the rear of the intake manifold, which is where the factory sender would mount, and the other is down near the oil filter. To mount your sender down by the oil filter you will either need an early piece like this one from a C5 Corvette, which is perfect for drilling and tapping. You could also use an aftermarket one like those sold by Turn Key Engine Supply. If you have the lower block-off plate, don't even bother trying to make it work, just find the right one. Auto Meter makes an adaptor for the oil port at the back of the intake manifold (PN 6541) so you can mount a gauge there.



◀ The cooling system design on an LS engine seems to work best with a radiator that has both the inlet and outlet on the passenger side. Many companies like BeCool, Flex-A-Lite, AutoRad, and the AFCO radiator shown here offer these cross-flow units just for LS swap applications. In addition to the packaging benefits, there are also cooling benefits to the cross-flow design. Guys with more determination than cash can source a good candidate from a salvage yard. It won't be pretty, but it will work.

installing a new engine. Clutch companies like Centerforce, McLeod, and ACT can help you choose the right components.

• Accessory Drive Systems

Almost every vehicle GM builds with an LS engine has a different accessory drive. Most of the car-based systems interchange. Because of availability, the most popular systems used in engine swaps are the Corvette and the "F" car. Another popular system is the CTS-V. It tucks in closer to the engine and works well in limited space applications like a LS7 Solstice.

There are a number of aftermarket kits available to fit many applications. If you prefer factory components, GM Performance Parts offer a complete CTS-V (PN 19155066) and Corvette (PN 19155067) accessory drive kits. They come with every component required, including the bolts. Truck-based accessory drive systems do

not work well with car intake manifolds since the throttle body interferes with the alternator bracket. Remember, the crank pulley must match the accessory drive system you are using. All production A/C compressors are located low on the passenger side. In many applications it will hit the frame in this location. There are a number of aftermarket companies that make brackets to relocate the A/C compressor to a location above the thermostat housing. This can eliminate the requirement to modify the frame.

• Cooling Systems

All LS water pumps share a common bolt pattern, and will interchange between engines. This allows you to use an LS3 water pump in space-confined applications. It



◀ There are two points on an LS engine to pick up water temp information, one located on each head. Chances are that your computer will be using the factory sensor on the front of the driver-side head, so that leaves the port on the rear of the passenger-side head open for an aftermarket sender. Remember that it's metric and requires a special fitting available from most major aftermarket gauge companies like Auto Meter (PN 6234).

works with most accessory drive systems and is much shorter (over one inch) on the front compared to a LS1 pump.

Both radiator hoses come out on the right side of the engine. This makes it difficult to install the upper radiator hose in some applications. Using a dual pass crossflow radiator allows both hoses to hook up on the passenger side. An additional benefit to dual pass radiators is they keep the coolant in the radiator longer. This allows the fan to remove more heat, and it increases the ability of the radiator to cool more efficiently. All LS-based engines have a small hose connected to the front of the cylinder heads. In some applications, it is hooked to the lower left side of the throttle body, then to the radiator. Either way, this tube must be hooked to the radiator in the area of the upper radiator hose. It vents air from the top of the cylinder heads, and not hooking it up can cause engine damage.

Closed cooling systems with a pressurized overflow bottle cool better than a standard system with an open overflow bottle. The additional coolant in the bottle, plus the higher pressure, allows the system to cool more efficiently. This type of system is used in the Cadillac CTS-V, Pontiac Solstice, as well as other GM vehicles. They make good candidates to salvage used parts from. If you choose to install one of these systems, the lower line from the bottle should be tied into the return heater hose (the most forward 3/4-inch nipple on the water pump

housing) on a LS engine. The vent hose from the cylinder head should be hooked to the small upper nipple on the bottle.

All production LS engines are built with a 195-degree thermostat. Never remove the thermostat from an LS-based engine since it's designed to direct flow through the engine, and removing it can cause engine damage. You can run a lower temp thermostat, but remember the engine controller uses engine temperature to determine fuel and timing curves.

•Fuel Systems

All production LS engines are fuel injected. The engines are available with both "return" and "returnless" fuel rails. Early ('97, '98, and some '99) LS engines were equipped with return-style systems. These have two nipples on the fuel rail, the supply is 3/8-inch and the return is 5/16-inch. There's a regulator on the fuel rail that maintains fuel pressure. This regulator uses an internal spring and manifold vacuum to adjust fuel pressure based on engine load. Later LS engines ('99 and up) have a returnless style fuel system. These engines have one 3/8-inch supply line to the rail. A regulator must be installed before the fuel rail to maintain 56 psi of

pressure. The engine controller is responsible for all engine performance functions, with standard calibrations based on 56 psi. Pressures above or below this number can cause engine performance issues.

•Intake Manifolds

There are a number of production-based intake manifolds, as well as a number of aftermarket units available. LS1, LS6, and truck manifolds (excluding the 6.2L) interchange. These engines share a common intake gasket design. The LS6 intake is a popular upgrade for LS1 engines and adds 10 to 15 horsepower. The truck intakes makes more torque at low rpm, but in modified applications they don't make as much horsepower at high rpm. They can be an advantage on a heavy vehicle, but hood clearance can be an issue. The LS2 intake can be used as well, but the MAP



▲ The aftermarket has really responded to the need for wiring solutions. Sparteck Fuel Injection Systems can either modify your factory harness or build you a custom harness to your specifications. Sparteck also offers ECU programming, and if you want to run the fly-by-wire throttle body, they can hook you up there as well. FAST offers their top-of-the-line XFI computer and can provide you with the wiring to make it work. Other companies like Mast Motorsports, Holley, and Turn Key Engine offer their own systems with simplified harness that make installation a snap. GM Performance Parts also has a wiring kit (shown) complete with computer and all the widgets to fire up their crate engines. It's sure a lot easier than it used to be.



▲ In a stroke of genius, GM decided that all LS variants would be externally identical. That means that whether you're dropping in a 4.6L truck engine, a newer LS3, or anything in between, all the external brackets and mounts are the same. So the factory pulley system on this fourth-gen Camaro LS1 will bolt right to any other LS variant. One exception is that some iron blocks need a hole or two drilled.

sensor was moved from the back to the front of the intake, so an adaptor harness is required.

The 6.2 L76 intake manifold can be used if you are running L92 cylinder heads. These are the same heads and intake used on GM's LS3 variant. This intake was designed for use on Holden vehicles equipped with the L76 engine, which is common with the L92 truck engine.

The LS7 intake is a stand-alone component, and should only be used with LS7 heads due to the unique intake port configuration.

As a side note, all LS-based intake manifolds can be installed in either direc-



▲▶ The fuel system for your LS swap can be as pricey or low-buck as you want it to be. If you're at 500 or less horsepower, then this is the hot ticket for feeding your newly installed LS engine. The tank is from Rock Auto (PN GM32AFI) and has been retrofitted for EFI duty complete with the sender and GM pump. At well under \$500, it's a "no brainer" if you need a direct fit, baffled tank. The other wallet-friendly part of our duo is this combination fuel filter and regulator from a C5 Corvette (GM PN 10299146). It's not adjustable, but it's inexpensive and is perfect if you're pinching pennies. If you want something that can handle more power, is a custom size, or just looks a whole lot nicer, then a company like Detroit Speed Inc. can sell you a sweet stainless tank ready to rock the EFI.



tion. The bolt pattern and port design allows the intake be rotated. This can be important for some kit cars or front-wheel drive swaps.

In addition to the wide array of GM intakes, there are also a few aftermarket



▲ We remember having to custom bend tubes for headers in the early swap projects, but those days are long gone. Today there are many options for exhausting your newly installed LS engine. These headers are from AFCO/Dynatech, but companies like Stainless Works, Hooker, Doug's, Edelbrock, Detroit Speed, Lemons, and others also offer header solutions for your Camaro swap.

intakes from companies like FAST and Weiand that have been shown to add extra power to any LS engine.

● **Electronics**

We could write an entire story on all the differences with electronics used to

make an LS-based engine run, and if there is enough interest we will. For now, there are multiple sources for wiring harnesses and engine controllers. Everything exists, from a kit to install a traditional distributor and carburetor to full racing electronic control

systems. You can use modified factory components or purchase one of the many kits designed for your specific engine. For the best all-around performance and ease of installation, purchasing a complete kit is a good choice. These kits come with all the components required to make your LS engine run, and can be hooked up with as few as four wires. Many of the advertisers in this magazine offer simple to install systems that will get your LS-powered vehicle on the road. The old days of an LS swap being rocket science are long gone, and today it's easier than ever.

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