INTRODUCTION

This handbook describes parts and procedures to prepare ECOtec Race Engines and Hydra-matic Race Transmissions used by GM Racing in professional sport compact drag racing. This information in this handbook is for experienced and knowledgeable race engine and transmission builders only. The procedures described require specialized tools and skills. If you do not have the appropriate training and equipment to perform these modifications safely, this work should be performed by other professionals.

This handbook pertains exclusively to engines and vehicles which are used off the public highways. Federal law restricts the removal or modification of any part of a federally required emission controls system on motor vehicles. Further, many states have enacted laws which prohibit tampering with or modifying any required emission or noise control system. Vehicles which are not operated on public highways are generally exempt from most regulations, but the reader is strongly urged to check all applicable local and state laws.

Many of the parts described or listed in this handbook are merchandised for off-highway application only, and are tagged with the following "Special Parts Notice":

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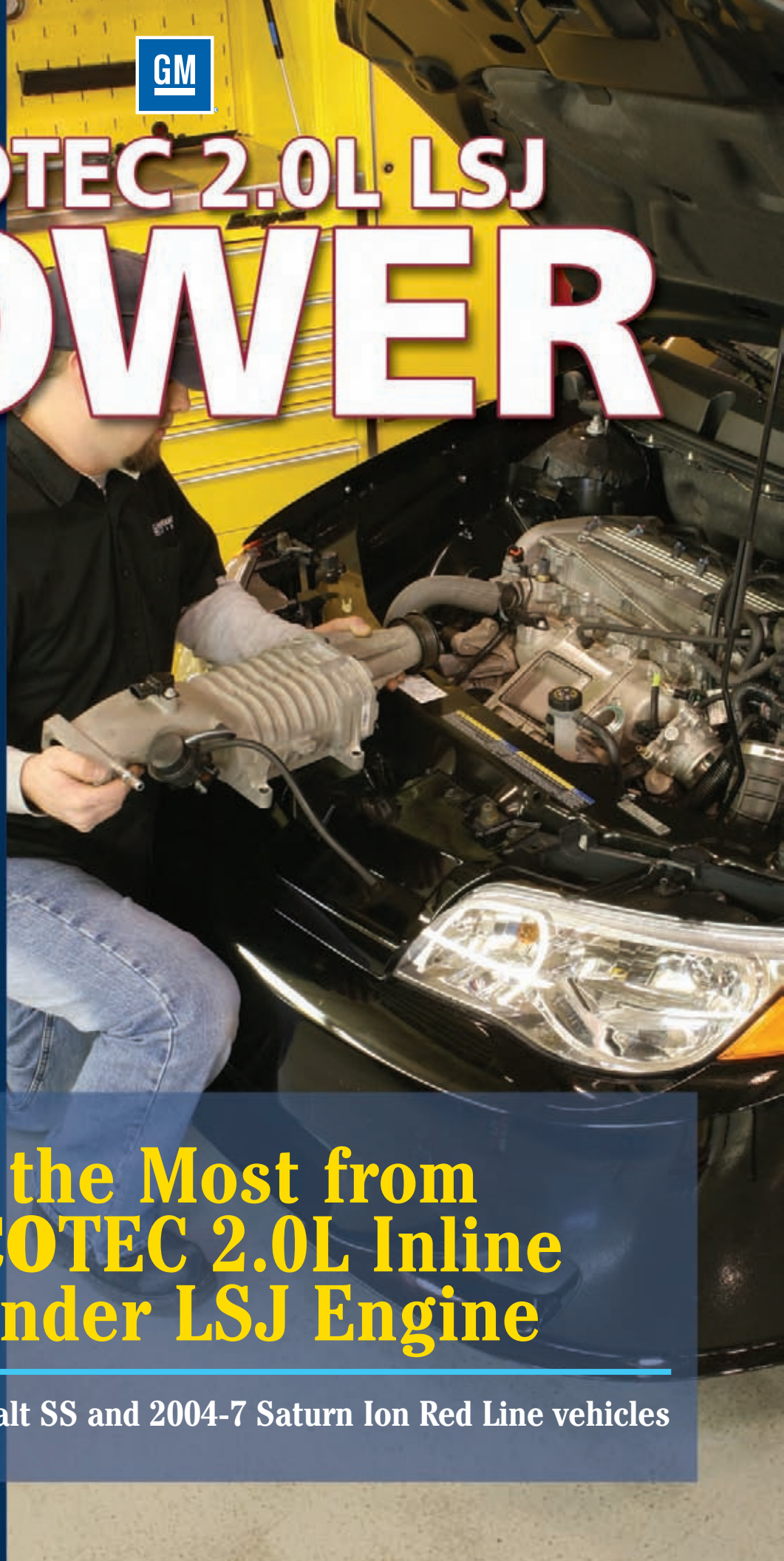
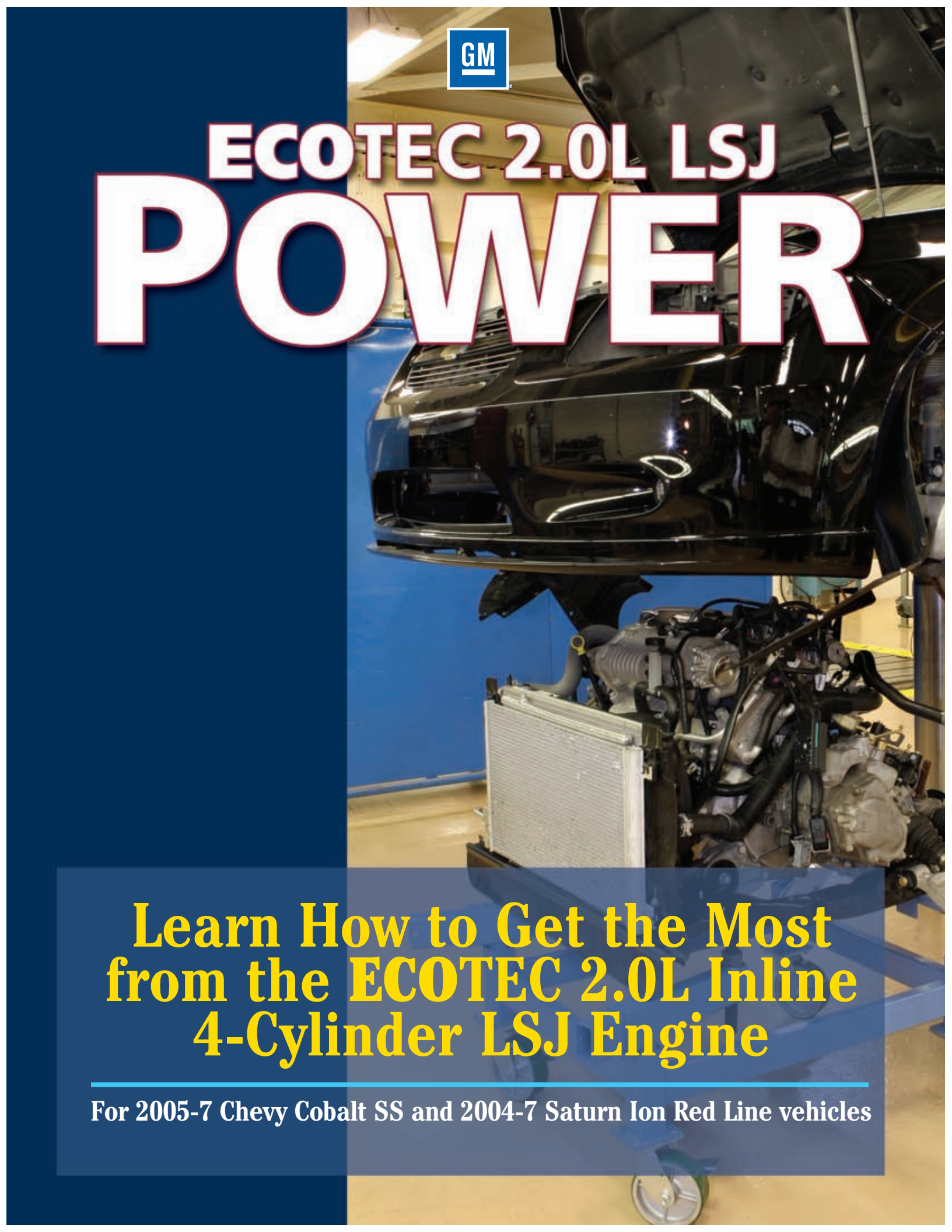


ECOTEC 2.0L LSJ POWER

- Learn Ecotec Engine History
- How to:
  Engine Removal and Installation
  Stage 1 and Stage 2 Upgrade Installation
  Performance Clutch Installation
- 300 hp LSJ Race Engine Buildup

Get the Most from the ECOTEC 2.0L Inline 4-Cylinder LSJ Engine

For 2005-7 Chevy Cobalt SS and 2004-7 Saturn Ion Red Line vehicles



ECOTEC 2.0L LSJ POWER

Learn How to Get the Most from the ECOTEC 2.0L Inline 4-Cylinder LSJ Engine

For 2005-7 Chevy Cobalt SS and 2004-7 Saturn Ion Red Line vehicles

This book describes parts and procedures to prepare Ecotec Engines in Cobalt SS Supercharged and Saturn Ion Red Lines. The information in this book is for experienced and knowledgeable technicians only. The procedures described require specialized tools and skills. If you do not have the appropriate training and equipment to perform these modifications safely, this work should be performed by other professionals.

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All ECOTEC Powered

The ECOTEC LSJ Story

Ecotec 2.0L Supercharged LSJ Engine

Welcome to the enthusiasts' technical resource for the 205 hp General Motors (GM) Ecotec 2.0L four-cylinder supercharged engine (RPO–LSJ). This engine, which powers the 2005-7 Chevrolet Cobalt SS Supercharged and 2004-7 Saturn Ion Red Line performance vehicles, and is also available as a crate engine (P/N 12499466), has a strong following on the street for its impressive power output and durability along with its ability to be easily upgraded in power output. The "LSJ" engine is so called because on the vehicle build sheet the Regular Production Option (RPO) designation (see sidebar for more on RPOs) for this engine is "LSJ"—which has led to enthusiasts referring to this engine as the "LSJ" engine.

There are many topics covered in this book to show you how to get the most from the Ecotec LSJ-powered vehicle. There are chapters that detail how to remove and reinstall the LSJ engine in the Cobalt and Ion, how to install the GM Performance Stage 1 and Stage 2 upgrades, how to install a performance clutch and how to build a 300+ hp ultimate performance LSJ.

This first chapter is loaded with information on the Ecotec engine family, some early motorsports usages of the LSJ engine and what to look for in the future.

Whether you are a four-cylinder engine performance enthusiast or not, chances are the performance, elegantly simple design and available power upgrades these engines respond to will impress as you learn more about the overall Ecotec engine family and especially the LSJ engine.

The Ecotec LSJ engine exclusively powers the Cobalt SS Supercharged production car. This vehicle was developed by the GM Performance Division for all around performance.

The Saturn Ion Red Line production vehicle was the first sport compact front wheel drive vehicle the GM Performance Division developed. It is the sleeper performance car of the entire GM fleet—this thing flies!

What's an ECOTEC?

Back in 1995, the GM Powertrain leadership team was developing an all-encompassing global four-cylinder gasoline platform plan. They looked across the entire GM global enterprise to determine what vehicles were planned for the future, what consumer desires were, and how they could meet those desires with one four-cylinder engine architecture. It's doubtful many of us could fathom the diverse demands these GM Powertrain folks encountered, but even more amazing is that the engine that came out of that planning, which by the way is the Ecotec four-cylinder engine design, meets the majority of those desires.

Requirements

Let's look at just a sample of those requirements: In the U.S., customers generally buy cars with automatic transmissions, are accustomed to using mostly low rpm torque to motivate the vehicle, and they expect maximum mileage while running primarily on low octane fuel—all while meeting the demanding U.S. emission requirements.

The European customer leans toward manual transmission vehicles and is more than happy to run an engine in the upper end of the powerband to take advantage of high rpm horsepower. In general, the European gasoline is of higher quality and emissions requirements aren't necessarily lower, but just different.

Then, there are locales like Canada and other parts of the world that are predominantly powered by four-cylinder vehicles that need a diverse lineup of engines to satisfy the many needs within a marketplace.

Whew! Now you get an idea how complex it is to build one four-cylinder gasoline engine architecture to meet the needs of the global economy.

Design Decisions

With all that said, the team narrowed in on a few constants. The block, cylinder head and accessory bracketry would be cast aluminum for weight savings. New technology, in the way of a "lost foam" casting technique (a GM patented technology) would be employed to maximize strength and casting accuracy, while minimizing the cost to manufacture these components. The engine architecture would utilize chain-driven dual overhead camshafts for durability, a four-valve-per-cylinder valvetrain for volumetric efficiency and cast iron cylinder bore liners would be pressed into the aluminum block to provide a rigid bore that could withstand higher cylinder pressures without flexing.

This proposed four-cylinder engine design would be able to power both front-, rear- and all-wheel drive vehicle designs, be configurable for variable valve timing, be able to handle forced induction and run on either traditional sequential intake runner-based fuel injection or direct fuel injection (where the fuel injector sprays gasoline inside the combustion chamber).

So, it's pretty obvious this engine design is basically protected for every variation known to the consumer and some that aren't yet known! Seriously, though, just about every situation the global GM team thought they'd encounter in the future was considered as this design was being schemed up.

The Build Team

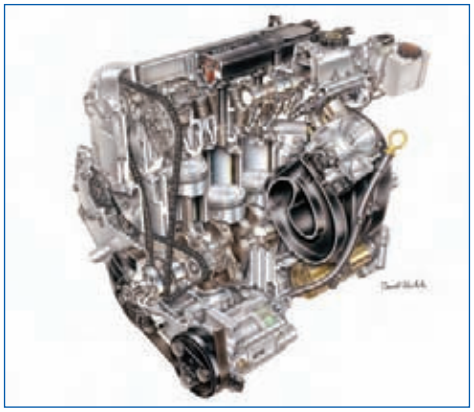
Once all the plans were laid out, finding 'neutral ground' for all the various GM entities to develop this new engine was sought. After considerable discussion, Lotus Engineering UK was engaged as the base of the engineering operations. GM leadership and engineers from GM North America and GM Europe were brought together to work as a team in developing the hardware and software for what would become the Ecotec.

They spent four years developing the basic design, testing prototype components and systems and preparing for the engine to be the global GM four cylinder architecture. Were there tough compromises? You bet, but in general, the leadership

A Sampling of the ECOTEC Family

Ecotec 2.0L Supercharged LSJ Engine

Ecotec 2.2L L61 Production Engine



Ecotec 2.2L L61 cutaway

Ecotec 2.4L Saturn Sky engine

and engineers feel the engine has been a complete success (considering the base 2.2L engine makes 140 hp and the just-released 2.0L turbo engine makes 260 hp, who would argue?).

GM has built millions of Ecotec four-cylinder engines so far to power vehicles in every corner of the world. The engine is considered a success and viewed as the next "small block" for sport compact enthusiasts to tinker with in the future. Look for more variations off this excellent four-cylinder architecture in the future, as the Ecotec family continues to expand and produce ever more horsepower!

Se Habla RPO?

In the world of the GM production cars, the Regular Production Option number, or RPO, is the alphanumeric identifier by which every option is cataloged. While most think of the RPO signaling certain suspension or appearance packages, like the Z28 Camaro or the Z71 Off Road trucks, each GM engine is also identified by an RPO.

For the Ecotec engine family, the RPOs vary from LSJ for the supercharged 2.0L engine, to the L61 base 2.2L naturally aspirated engine. For a breakdown of the many Ecotec RPOs, see the sidebar below.

A Short List on the Global Ecotec

2.2L - L61
The highest volume engine in the Ecotec family—powers vehicles across the globe.

2.4L VVT – LE5
The largest displacement and first equipped with active camshafts to enable "Variable Valve Timing."

2.0L SC – LSJ
The only supercharged Ecotec engine, and easily upgraded in power with GM Performance Stage 1, 2 and 3 upgrade kits.

2.0L Turbo – LNF
The most advanced Ecotec with a twin scroll turbocharger, intercooler, direct fuel injection.

VVT 2.2L European Z2.2xx
The European Ecotec engine family order numbers all start with a 'Z2.2' and have two more digits after the '2.2' to indicate the exact powertrain. (Example: Z2.2SE.)

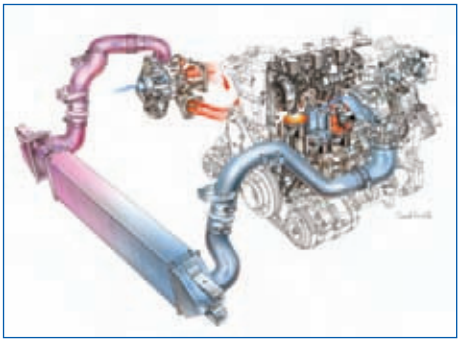
2.0L Alfa Romeo
The Ecotec also powers some non-GM vehicles, like the 2.0L Alfa Romeo.

2.0L Turbo -SAAB LK9, LQ8
The 210 hp LK9 came out in 2003 to rave reviews, the LQ8 2.0L engine makes 175 hp.

2.0L Opel Turbo – LQ8
The LQ8 powers various vehicles in Europe for Opel.

The Saturn Sky Red Line is powered by the Ecotec 2.0L (RPO:LNF) turbocharged 260 hp engine.

Ecotec 2.4L FWD engine (RPO–LE5)



Ecotec 2.0L LNF turbo system/engine cutaway drawing

How the ECOTEC 2.0L LSJ Supercharged engine was created

Back in 2001, the GM Performance Division needed a four-cylinder gasoline engine with a thick powerband to support two front wheel drive small cars they were developing. At the time, the Ecotec family consisted of some potent, naturally aspirated engines and a turbocharged engine was in the works, but nothing approached the torque and horsepower the GM Performance Division leadership felt was needed to make their sport compact cars stand out in the U.S. marketplace. To resolve the issue, the leader of the GM Performance – Powertrain department, Jim Minneker, decided to build a 200 hp version of the Ecotec with a small team of GM engineers.

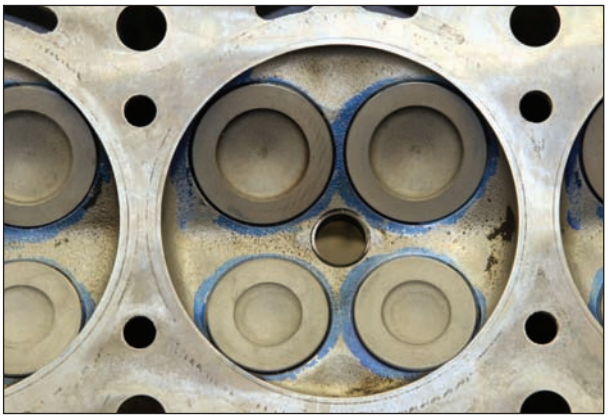
Ecotec 2.0L Supercharged LSJ

Minneker had been part of the team that built SEMA show cars in years past and had led the creation of a prototype supercharged Ecotec engine for a small car called the "Piranha". That car was fun to drive, the engine proved durable and the show car development had given him an idea of how to do a supercharged four-cylinder Ecotec.

So Minneker pulled in some of the best and brightest engineers he could to execute a tight development timeline.

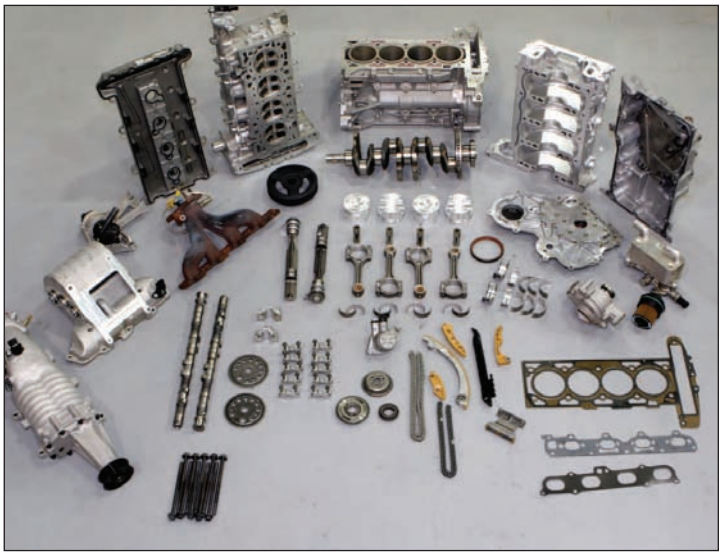
This team included Steve Felix, Grant Brady, Bill Duncan, and Matt Harlan, among others.

The team started with the 2.0L long block from the Ecotec Turbo engine that was soon to be released in the Saab front wheel drive cars. The forged crankshaft and connecting rods loaded in this engine make it a stout package that can handle the stresses created by the supercharger.



Ecotec LSJ Cylinder Head Combustion Chamber

Next, they created an integral intake manifold/intercooler that would hold the specially-designed Eaton supercharger in place on the engine. The supercharger and intake/intercooler needed to be compact enough to fit in the tight confines normally filled with a small nylon intake manifold and throttle body. The team was able to package the blower system successfully and moved on to developing the camshaft design, engine management calibration and the overall powertrain manners in the vehicles.



Ecotec LSJ Component View w/ aftermarket pistons.

As Minneker put it, "The development program was extremely aggressive, but we were testing the limits of our capability. In general, we succeeded but knew we'd left some power on the table in the end. That's why the team continued to develop some options for increased power—and from that the Stage 1, Stage 2 and Stage 3 performance upgrade kits were developed. The team that did the original engine development—namely Bill Duncan, Steve Felix, Grant Brady and Bill Owen—took those Stage kits from a rough idea to an easy-to-install, honest double-digit power enhancer with production-car manners and the Stage 1 and Stage 2 kits are 50-state emissions legal! That team amazed me with what they accomplished on those kits—and the consumers that have installed them can't believe the power increase they get for their time and money. They really exceeded anything we could have imagined."

The Ecotec 2.0L Supercharged LSJ engine is a performance car enthusiast's dream come true—great power output, efficient, easy to upgrade even further and nestled into a fully integrated performance car (either the Cobalt SS Supercharged or Ion Red Line). If you haven't driven or ridden in a Stage 2-equipped ride, make that a priority. The only problem is you'll be forced to figure out how to get your hands on one of these rockets in the future.

ECOTEC Component Comments

Engine Block

Lost foam and sand cast aluminum with pressed-in cast iron cylinder liners, four bolts per cylinder, setup up for twin balance shaft vibration cancelling system.

Main Bearing Girdle

Lost foam cast aluminum integral main caps held in place with 'torque-to-yield' fasteners.

Cylinder Head

Cast aluminum with dual overhead camshafts, design capable of supporting active camshaft phasing for variable valve timing, direct fuel injection and more...

Crankshaft

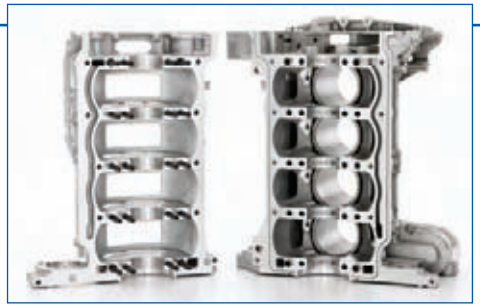
The 2.2L and 2.4L Ecotecs have a cast iron crank. The LSJ crankshaft is a forged steel design that incorporates induction heat-treated fillets for added strength, and cross-drilled, chamfered oil passages for excellent lubrication characteristics.

Connecting Rods

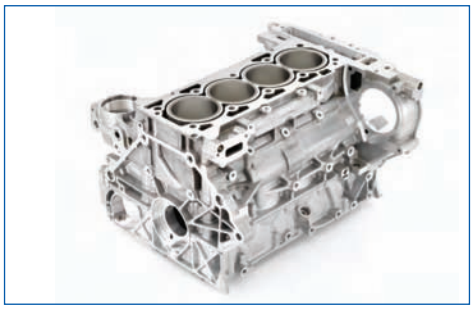
The 2.2L and 2.4L Ecotec engines come with powdered steel rods, while the 2.0L engines have forged steel, large I-beam rods.

Pistons

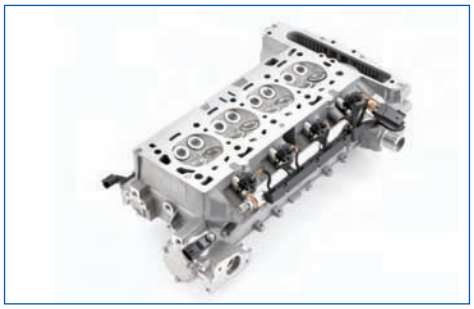
All the Ecotec engines come with eutectic cast aluminum pistons. The common pistons in the Supercharged and Turbocharged Ecotec engines have a 5.6 mm top ring land, much thicker crown & strut sections, coupled to a heavy walled 23 mm piston pin.



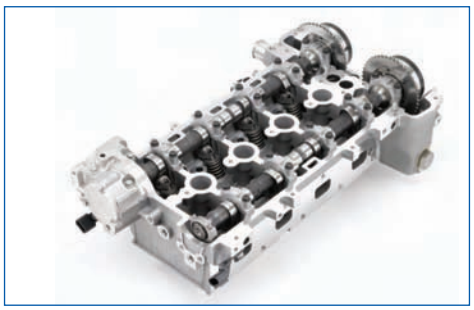
Block and Main Bearing Girdle



Engine Block



Cylinder Head Combustion Chambers



Valvetrain

Crankshaft

Piston Rings

The LSJ uses a 1.15 mm Chrom-Keramik top piston ring, a 1.45 mm napier phosphate coated second ring and a 2.5 mm dual rail with expander design oil control ring.

Valvetrain

The Ecotec cylinder head has 16 valves at 35.1 mm intake and 28 mm exhaust diameters. Valve actuation is accomplished via lightweight, direct-acting cam followers (what looks like an upside-down rocker from a pushrod engine) pivoting on stationary hydraulic lifters. The lobes of the two camshafts press on these cam followers, which in turn open and close the valves. The system is compact, durable and elegantly simple—and it works!

Crank Trigger

Early Ecotec engines used a 7x crank trigger (which means the wheel on the crank had 7 notches in it for the computer to 'read' to determine what inputs to apply to make it run), but as of 2007, all Ecotec engines have a 58x crank trigger (which is the new global standard for engine controls).

Piston and Oiler

ECOTEC 2.0L LSJ Powertrain Component Details

Displacement – 122 ci (1998 cc)
Compression Ratio – 9.5:1
Bore – 3.780 inch (96 mm)
Stroke – 3.780 inch (96 mm)
Block – 'lost foam' aluminum casting with pressed in cast iron bore liners
Head – highly accurate semi permanent mold (spm) casting process, 356 aluminum
Crank – forged steel, induction hardened counterweights, 8-bolt flywheel mount and cross drilled oil passages with inlet and outlet chamfers
Pistons/Rods – 6 mm top ring land piston, oil jet cooled, 23 mm piston pin and large I-beam rod
Valvetrain – 4-valves/cylinder, sodium filled exhaust valves, chain driven cams
Supercharger/Intercooler – helical roots blower design with integral intake manifold intercooler that uses water-to-air 'laminova' heat exchange tubes to cool intake charge
Oiling System – Large oil sump for improved oil control and engine cooling
Transmission – F35 five-speed transmission


LSJ in vehicle


Intercooler Laminovas


Supercharger


Valvetrain

The ECOTEC Turbo LNF Engine

The 2007 Solstice GXP and Saturn Sky Red Line are powered by the newest and most powerful Ecotec engine created and sold in a production vehicle. It is a 2.0L turbocharged, intercooled, direct fuel injection tour de force that makes 260 peak horsepower and 260 peak lb-ft of torque. That's about 130 hp/L!

In case that hp/L number doesn't hit you, the Ecotec LNF turbo engine puts out more horsepower per liter than any engine ever produced by GM. And to really put this in perspective, if you had a 7.0L engine with this capability, it would produce over 900 hp!

The GXP Solstice is more than a big power behemoth. The suspension is the impressive Z0K package developed by the GM Performance Division for SCCA Showroom Stock B competition. The exhaust is a true dual outlet system and the body has increased openings in the front to allow air into the air-to-air intercooler and cooling system.


Solstice GXP


The 265 hp Ecotec 2.0L LNF engine

SSB Solstice Racer

The Pontiac Solstice is the first rear wheel drive (RWD) production car using the Ecotec engine architecture. While this car has gotten rave reviews from the media and consumers for its street manners, it has shown itself to be a very capable track car. While the base 170 hp Ecotec 2.4L LE5 engine is not a firebrand power plant, it does an able job keeping the car moving on a roadcourse and is actually a great tool for teaching driver discipline—as a moment off the throttle results in a dramatic impact to tracktimes.

With this in mind, the GM Performance Division did considerable engineering to develop a road race package that can be ordered from the factory and run in the Sports Car Club of America (SCCA) Showroom Stock – B (SSB) class.

The RPO for this package is Z0K and it deletes certain heavy items like the air conditioning while adding a performance-intended suspension (that is good enough it ended up being the suspension under the higher horsepower GXP Solstice).

Racers then need to install a rollcage, safety harness, fire suppression system, higher temperature brake pads, grippy tires and a GM Performance Division-engineered hardtop (available through the SCCA). The engine remains stock, as does the suspension.

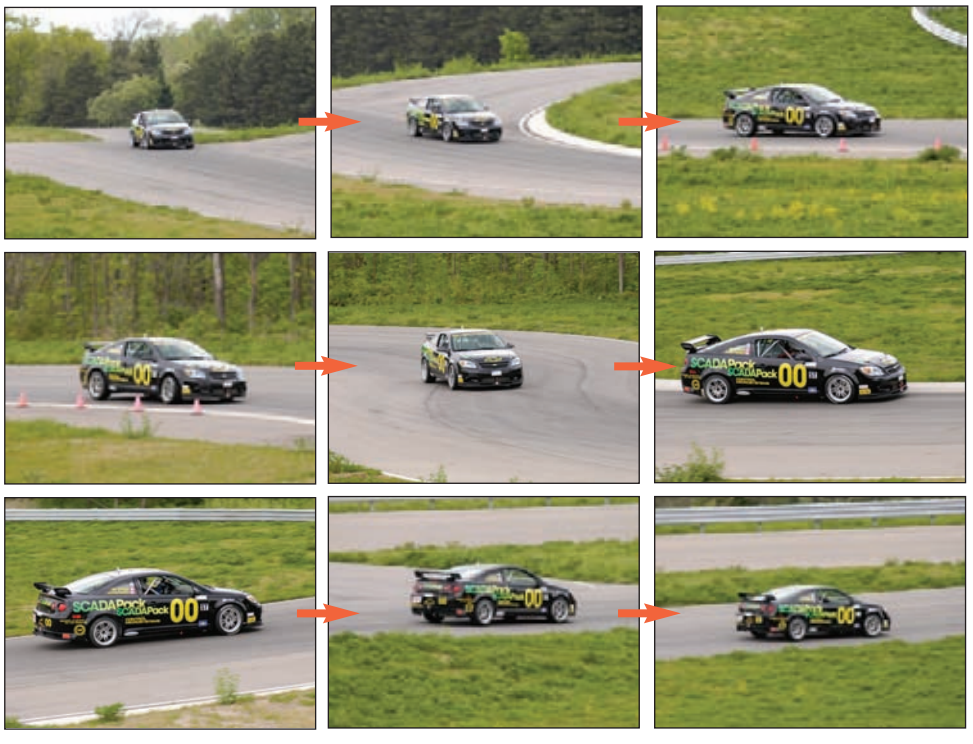
The Solstice competes with the Mazda Miata and other cars of its ilk in SSB and has shown itself to be competitive—winning some races and regional championships.

Grand Am Cup Development

Grand Am Cup races might be one of the most "real" competitive arenas in the world of motorsports for front wheel- and all-wheel-drive sedans right now. These races routinely start over 50 cars from every manufacturer you can imagine. Even better, Grand Am Cup rules are simple enough that much of the development used to go fast on the track can be translated into performance upgrades for the street.

The GM Performance Division has used their Grand Am Cup development work to help in creating the immensely popular Stage 1, Stage 2 and Stage 3 performance upgrade systems. (See Chapter 4 for more.)

These 'real' performance packages are easy to install, come complete with calibrations to take advantage of the performance parts being installed, and net honest double-digit power increases.



A Grand Am Cup Cobalt running through the low-speed Esses at the GM Milford Road Course (MRC) vehicle development track.

Time Attack Development

What you probably know is that the GM Performance Division took a heavily modified Chevy Cobalt SS Supercharged to the Super Street Magazine Time Attack event at the road race track in Buttonwillow, California, last year and netted an Overall Win the first year out. What many don't know is that this vehicle was a developmental testbed for products that would become available to the public not long afterwards. The "Time Attack Cobalt", as it became known inside GM, also assisted in the development of the GM Performance Division-supported Grand Am Cup race program.

Starting with a production Cobalt SS Supercharged, the GM Performance engineering team had the car completely gutted, a racing rollcage added along with the other required safety equipment when driving in competition (race seat, 5-point seat belts and fire suppression system). They then focused on making more power from the LSJ engine, improving the suspension, lowering the vehicle mass and improving the aerodynamics (more downforce/less drag).

The part most interesting was that the GM Performance Stage 2 (see Chapter 4 for the install on the Stage 2) and GM Performance Stage 3 (just now becoming available to the public) performance upgrade kits were refined on the Time Attack car.

Also, some wild innovations were tested on the car to determine if they would provide performance increases. One of these packages was a large tank filled with cold water to cool the inlet charge—it would heat up almost immediately and provide no substantial power increase in a short amount of track time. The other was a computer-controlled 50 hp shot of nitrous used sparingly but to excellent effect. Much of this nitrous control and calibration work made its way into the GM Performance Stage 3 performance upgrade kit that is just now becoming available.

The Time Attack Cobalt, winner of the 2006 Super Street Time Attack event.


The Attack Cobalt during testing at the GM Milford Proving Grounds Milford Road Course (MRC) development track.

The Time Attack Cobalt engine was a testbed for the Stage 1, 2 and 3 performance upgrade systems.

The Time Attack Cobalt testing also assisted the Grand Am Cup (GAC) vehicle development process—as it was much faster than the GAC cars.

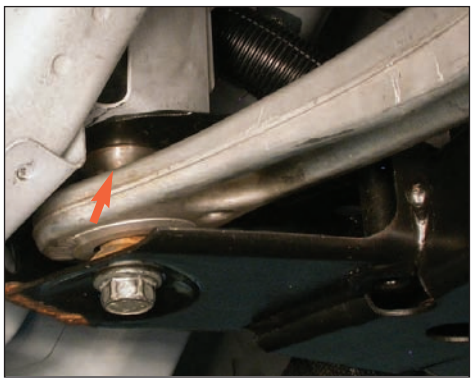

The Time Attack Cobalt Engine was handbuilt and for appearance, the block, girdle and heads were powdercoated black.

Road racing veteran and GM Performance Division Director, John Heinricy, did the development and competition driving for the Time Attack Cobalt.

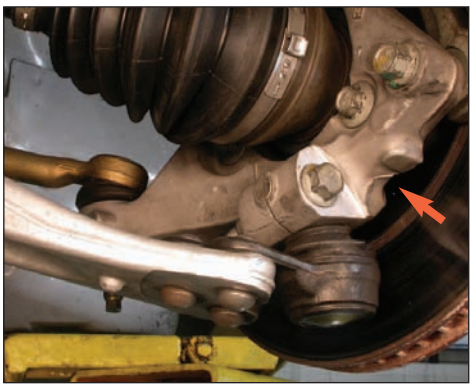
The Time Attack Cobalt Engine is more stock than many would like to believe—yet made almost 400 hp on a 140 hp shot of nitrous!

The trunk of the Time Attack Cobalt is filled with a quick-fill fuel tank, nitrous tank and battery.

The Time Attack Cobalt floorpan is as it came from the factory. The straight through exhaust has a HUGE muffler (arrow) on it near the bumper to meet the noise standards of the MRC. Notice the Ohlins shock absorber reservoirs—these shocks are awesome in their adjustability.

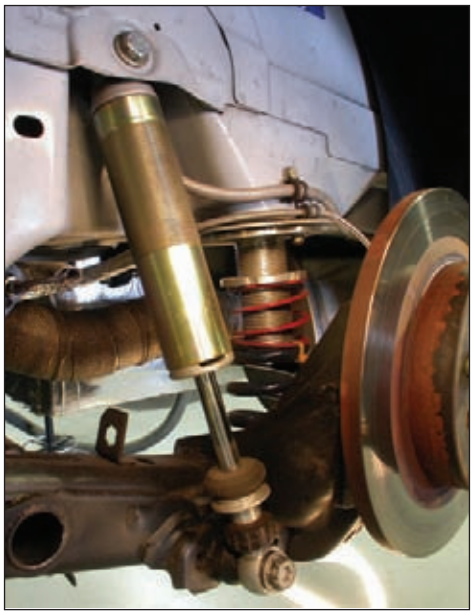


If you want your Cobalt to handle, you'll need to install these spherical rod ends (arrow) in the rear mount of the front lower A-arms.



To handle the immense power and road loads, a Pontiac Grand Am knuckle (arrow) was modified to accept the lower A-arm ball joint and installed on the Time Attack Cobalt.

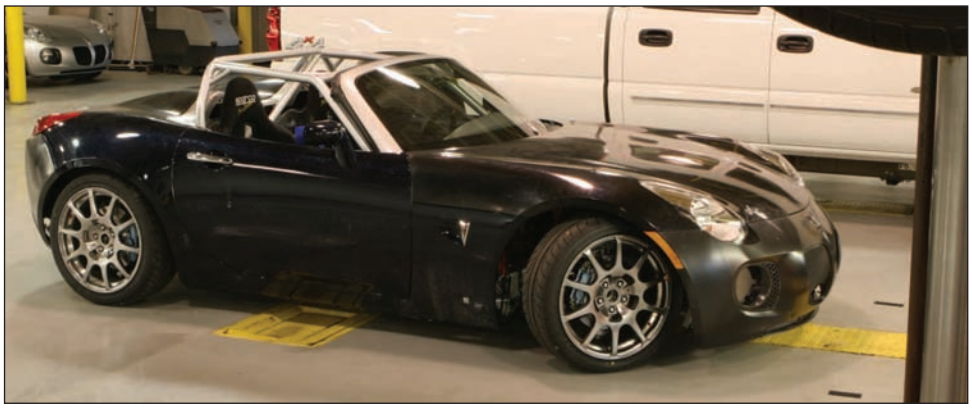
If you're building a performance Cobalt, it is a good idea to install solid engine mounts that rotate the engine forward and then shim the steering rack (shown) up to straighten the half-shafts and minimize bump steer, respectively.



The rear axle was modified by cutting off the ends and welding on Pontiac Grand Am five-lug hubs, installing a custom adjustable sway-bar and relocating the Ohlins shocks and Hyperco springs.

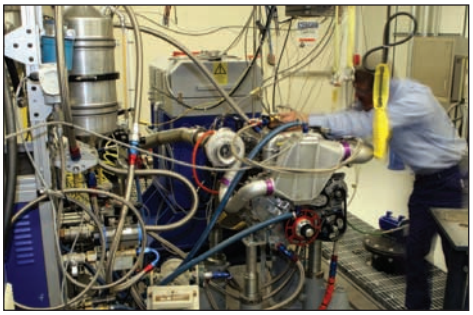
Drifting with the ECOTEC

The latest race vehicle to come out with Ecotec power is this GM Racing-supported drifting Solstice GXP being campaigned by Rhys Millen. Running an Ecotec 2.0 L turbocharged engine that makes about 600+ hp and modified to allow almost 60 degrees of turning radius (that's about double what the stock vehicle has), this drifter is loaded up and ready to run. The carbon fiber and stock sheetmetal body is shown just prior to being painted up with Red Bull livery for competition.



A stock-bodied Solstice was upgraded with a full rollcage, a fuel cell, modified steering system, permanently installed air-jacks for the rear and more.

The methanol-burning turbo Ecotec makes about 600 hp.



As with all GM Racing-developed engines, this engine package was refined on the dyno to have a wide powerband with maximum durability.

The LSJ-powered Land Speed Racer

The GM Performance Division has been running an LSJ-powered 'Lakester' land speed race vehicle at the Bonneville Salt Flats for the last few years with much success. The car has run over 200 mph with a modified Stage 3 performance upgrade on the engine.

The GM Lakester was built in partnership with SoCal Speedshop, based in Pomona, California—which would explain the SoCal red and white paint scheme.

The car features a tube chassis, all independent suspension, an innovative body design and the previously mentioned Ecotec powerplant hooked up to a transaxle transmission/differential putting the power to the rear wheels.

The engine has been breathed on with aftermarket forged aluminum pistons, more aggressive camshafts and valvesprings and a modified Stage 3 upgrade kit. Some of the pieces on this vehicle, like the multi-pass intercooler, helped to create the Stage 3 upgrade kit (See Chapter 6 for more on the Stage 3 kit) just now becoming available to the public.

The engine is controlled by the stock powertrain control module (PCM), but with a modified calibration to take advantage of the low restriction intake and exhaust and internal upgrades—and helped with the Stage 3 upgrade calibration development.

As you can see, the Ecotec LSJ engine in the Lakester looks very close to stock.

This Ecotec LSJ-powered Lakester has set multiple land speed records at Bonneville.

Crazy race turbo ECOTECs

In case you've heard about a front wheel drive (FWD) Cobalt running 250+ mph at Bonneville or a drag FWD Cobalt running over 200 mph in the quarter mile and thought, 'That can't be right…", here's your answer: Turbo. A race-intended turbo Ecotec program supported by GM Racing, GM Powertrain, GM Performance Division, and GM Performance Parts people and resources has been developing engines and vehicles for a few years now with some pretty incredible results.

Obviously, to run over two bills at a dragstrip requires serious power—and these engines deliver. In general, the turbocharged, intercooled, methanol burning 2.0L Ecotec engines started out making 600 hp in 2001 and are making over 1400 hp when in their full-competition drag race setup. The Bonneville turbo engines are detuned slightly to be able to handle wide open throttle (WOT) applications in excess of 60 seconds (that's a looonnnngggg time!) without scattering.

Ecotec turbo engine in Cobalt bodied racecar.

Cobalt bodied drag car with turbo engine.

This Cobalt has records over 200 mph at Bonneville.

This chopped, tube chassis land speed HHR has big turbo Ecotec power.

All ECOTEC Powered