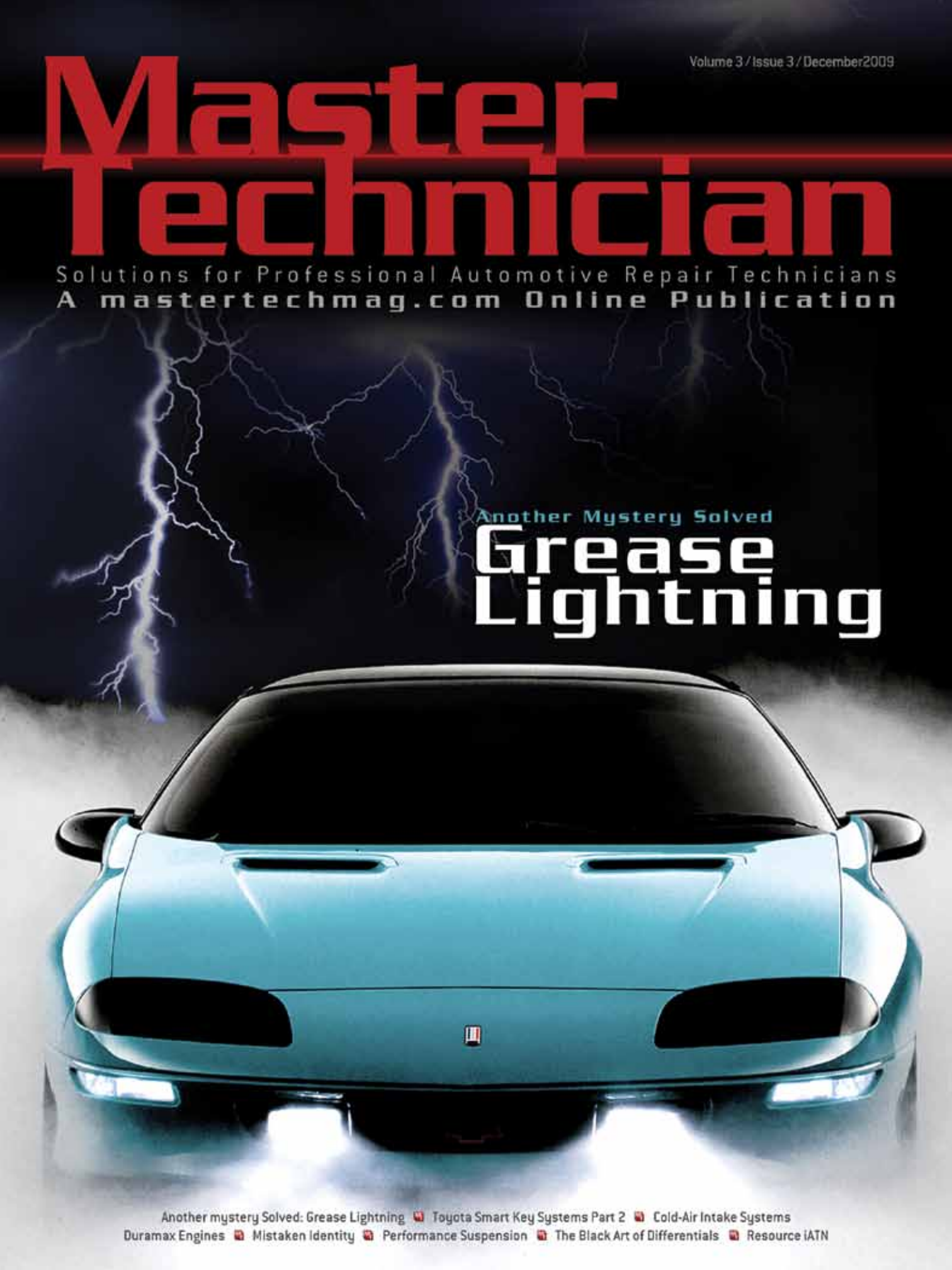
Volume 3 / Issue 3 / December2009

# Master Technician

Solutions for Professional Automotive Repair Technicians

A mastertechmag.com Online Publication



## Another Mystery Solved
## Grease Lightning

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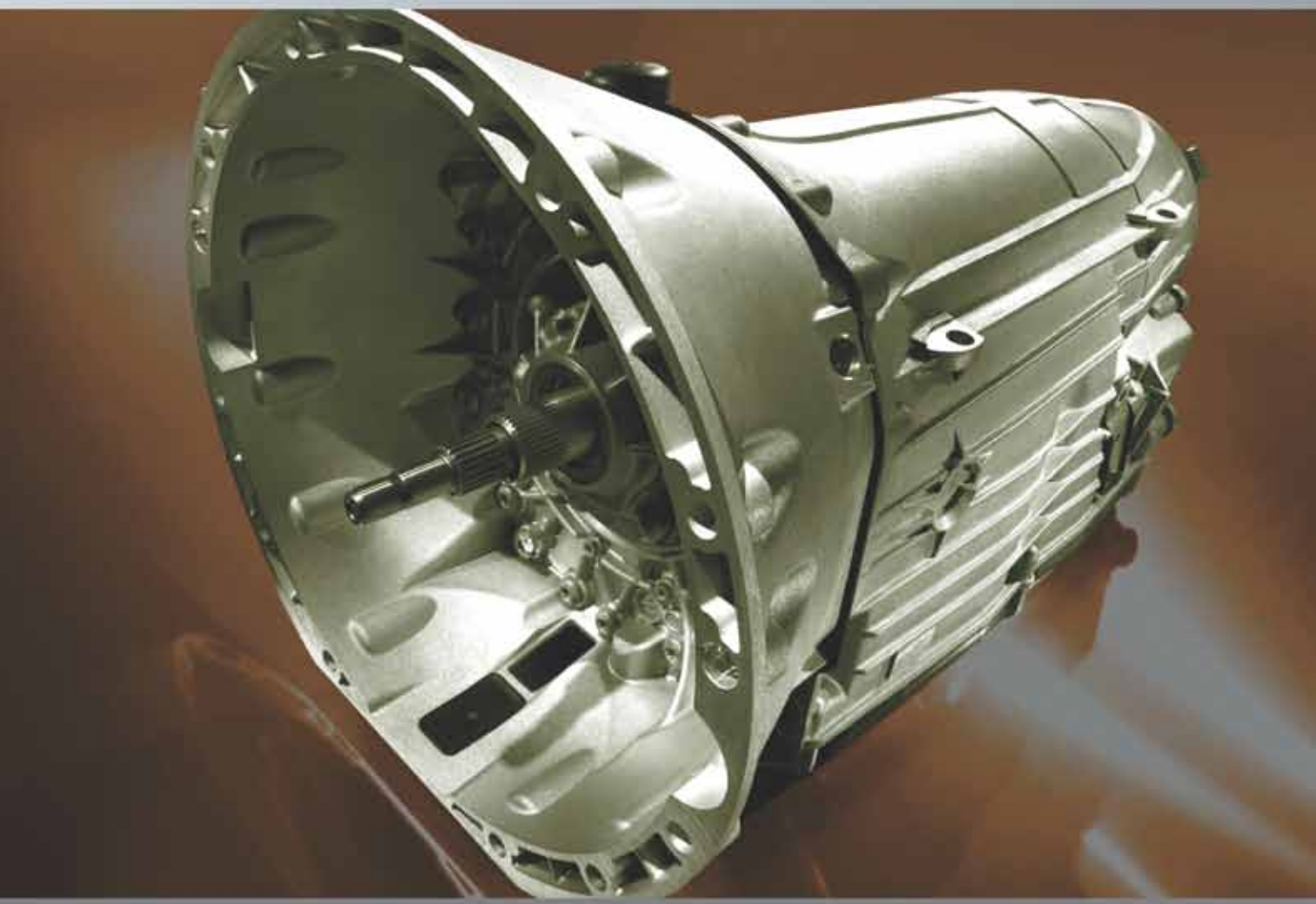

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## Feature Stories



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## December 2009

# Human Potential

by Greg McConiga

## Somebody Here is in Charge

> "This is the beginning of a new day. God has given me this day to use as I will. I can waste it, or use it for good. What I do today is important, because I am exchanging a day of my life for it. When tomorrow comes, this day will be gone forever, leaving in its place something I have traded it for. I want it to be gain, not loss, good, not evil, success, not failure, in order that I shall not regret the price I paid for it."
>
> -Author unknown

You have a choice to make today and every day. You must decide if you are going to make the most of this day, or if you are just going to survive it. Most people don't have the guts to live each day to its full potential. Most people are tickled silly just to survive.

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If you are to be successful, it will have to be your decision to do everything and anything necessary to assure success every hour of every day. You must persist in the face of criticism, long odds, and well-meaning friends and relative who will gladly take time from their busy schedules to explain why you can't do it. You will not succeed because of, or in spite of, anyone other than yourself; you have total control of your destiny. This is not to say you won't experience difficulties and setbacks. You will. But if all your energy is focused on the goal in the distance, you will forge through adversity.

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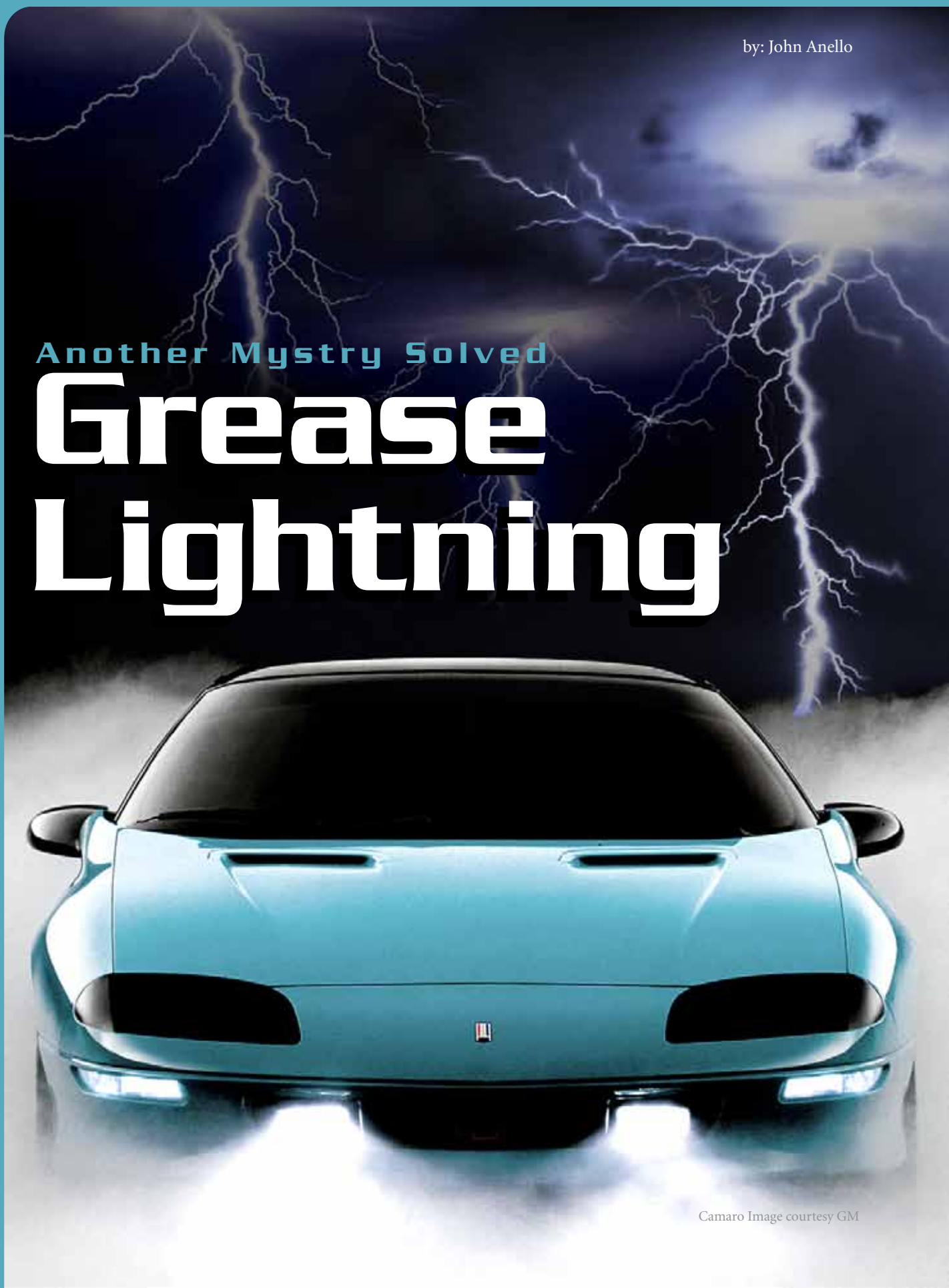
by: John Anello

## Another Mystry Solved

# Grease Lightning

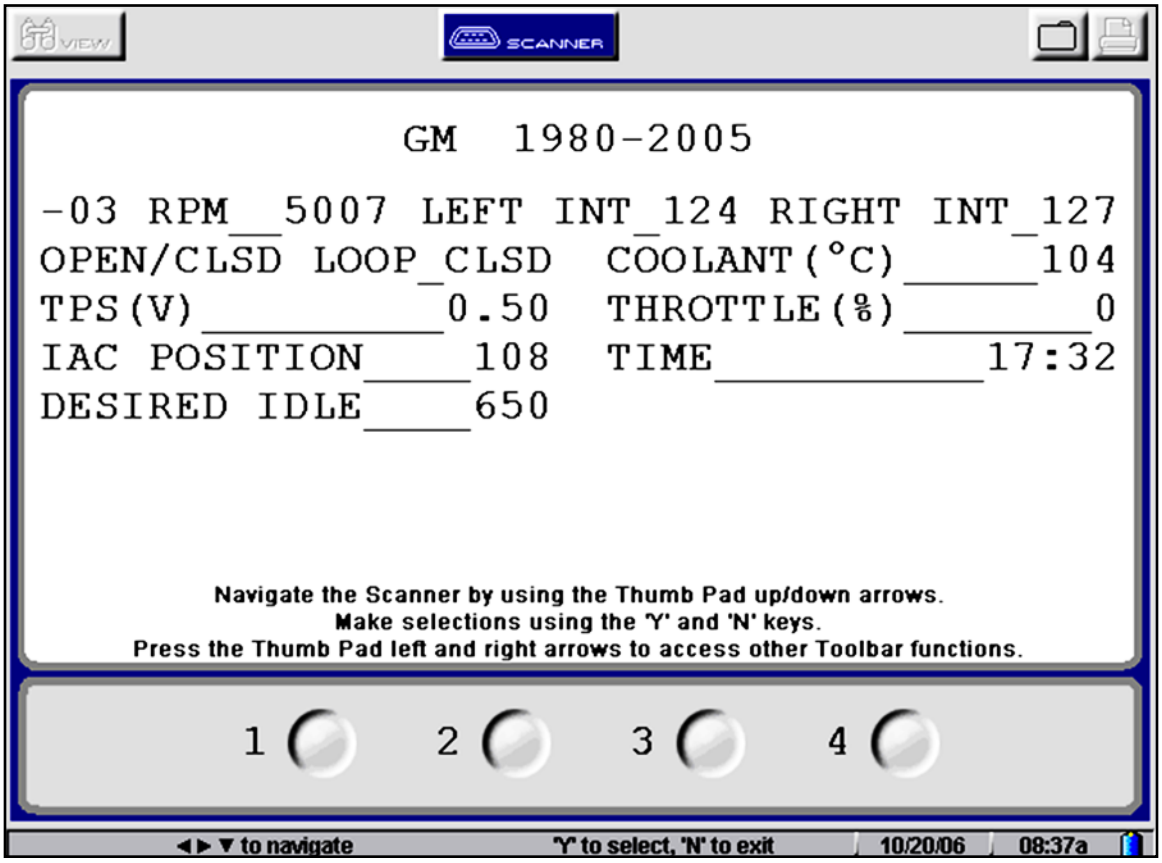


Camaro Image courtesy GM

I was called to a shop for a surging idle problem on a 1994 Chevy Camaro with a 5.7L Engine (Figure1). The shop had scanned the ECM for codes and found no codes in memory but noticed that the ECM was not controlling the idle properly. The IAC counts were very erratic and the engine would race up and slow down for no reason at all. When the vehicle was cold there were no problems but as soon as the engine got hot that was when all the fun started. The shop had recently tuned up the engine about 2 months earlier replacing spark plugs, spark plug wires, PCV valve and filters. This problem just started within the past week.

Figure 1: 1994 Chevy Camaro with a 5.7L Engine.

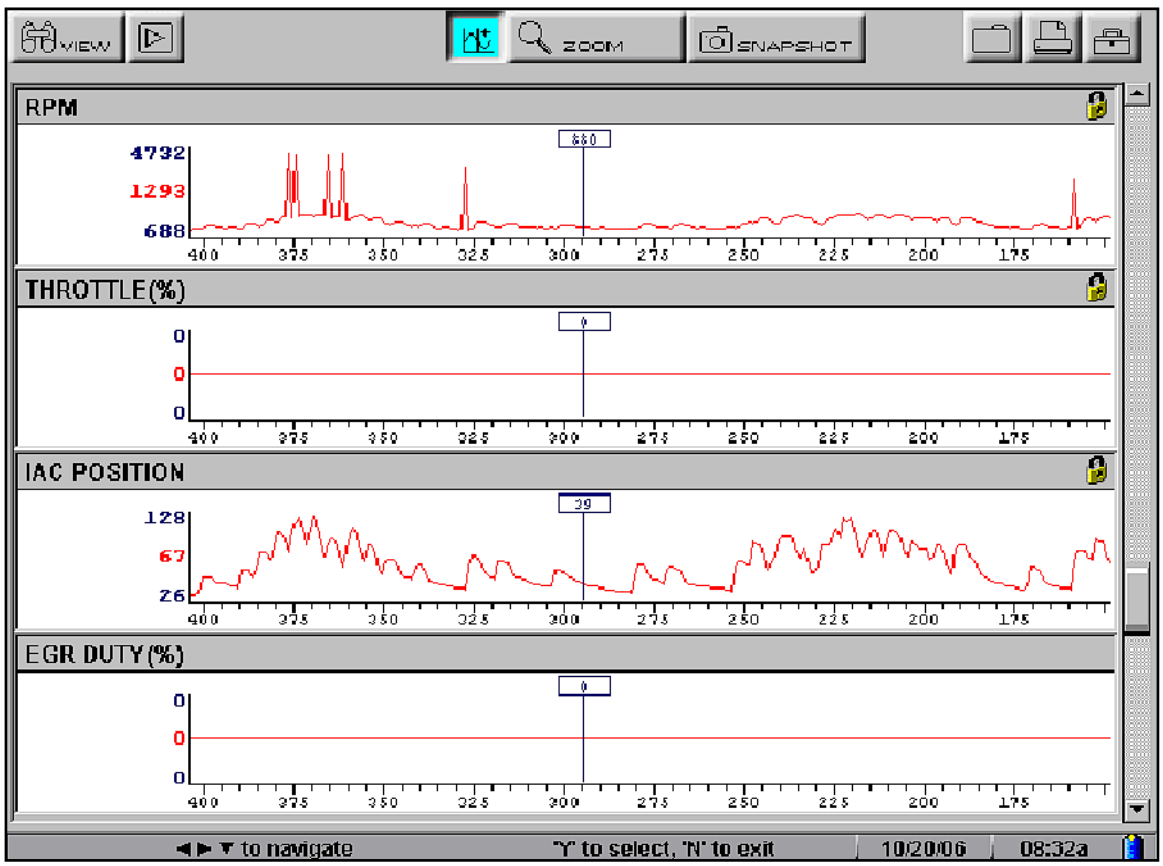
Figure 2: one frame of data showing a 5000 RPM increase.



I arrived at the shop and started the engine and it ran like a champ. I could feel nothing wrong with the engine at all. It accelerated fine and had plenty of power with no apparent misfire. I raced the engine to get the engine fully warmed up so I could experience the problem but it still seemed to run fine. I looked at the shop tech and asked him if he was crying wolf or not. This car must have known that I was coming and decided not to act up. These intermittent problems can be a real thorn in the side and in my line of business I usually give the garage a half hour to get the problem to act up or I have no choice but to go to my next stop only to revisit this problem again when the shop can duplicate it.

I had just turned my back on the car to boot up my computer on my truck when suddenly the engine

Figure 3: ECM was seeing false high RPM inputs and was only doing its job to counteract the high RPM's by moving the IAC motor accordingly.



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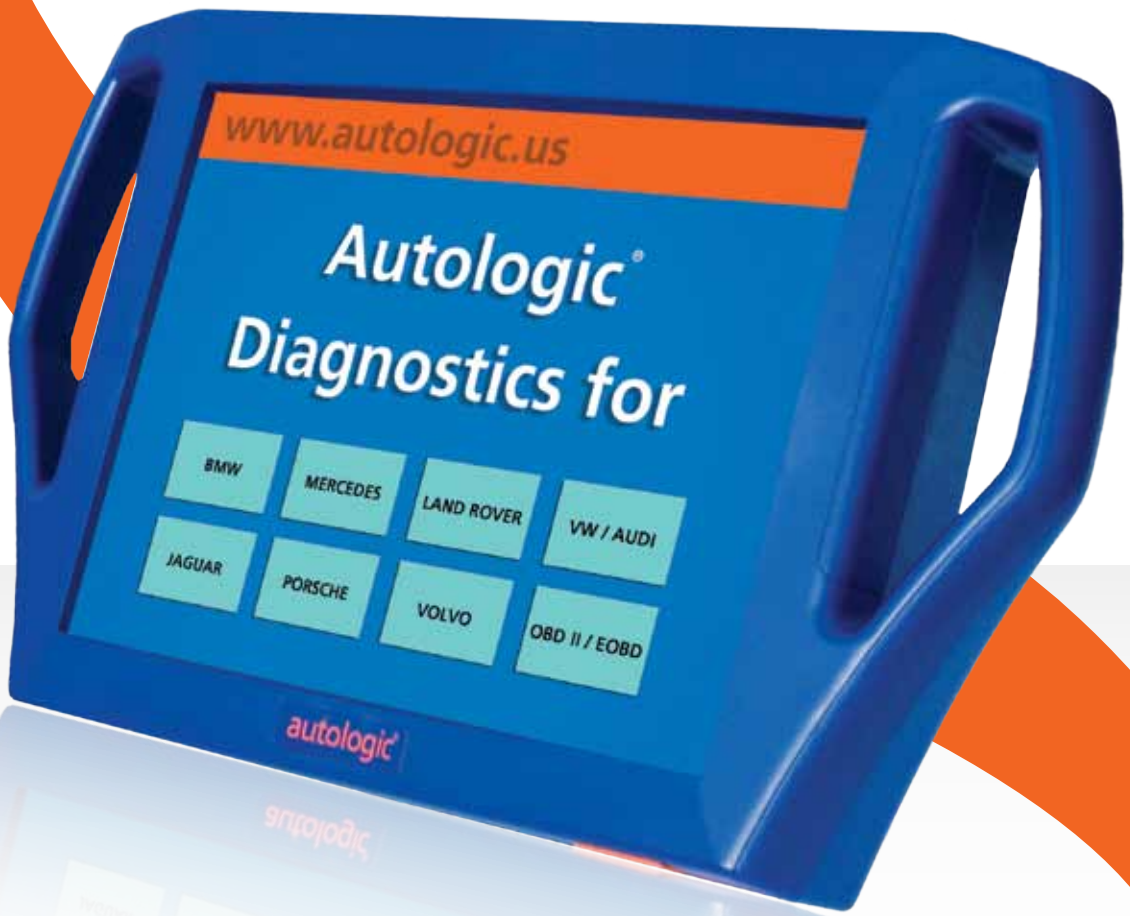


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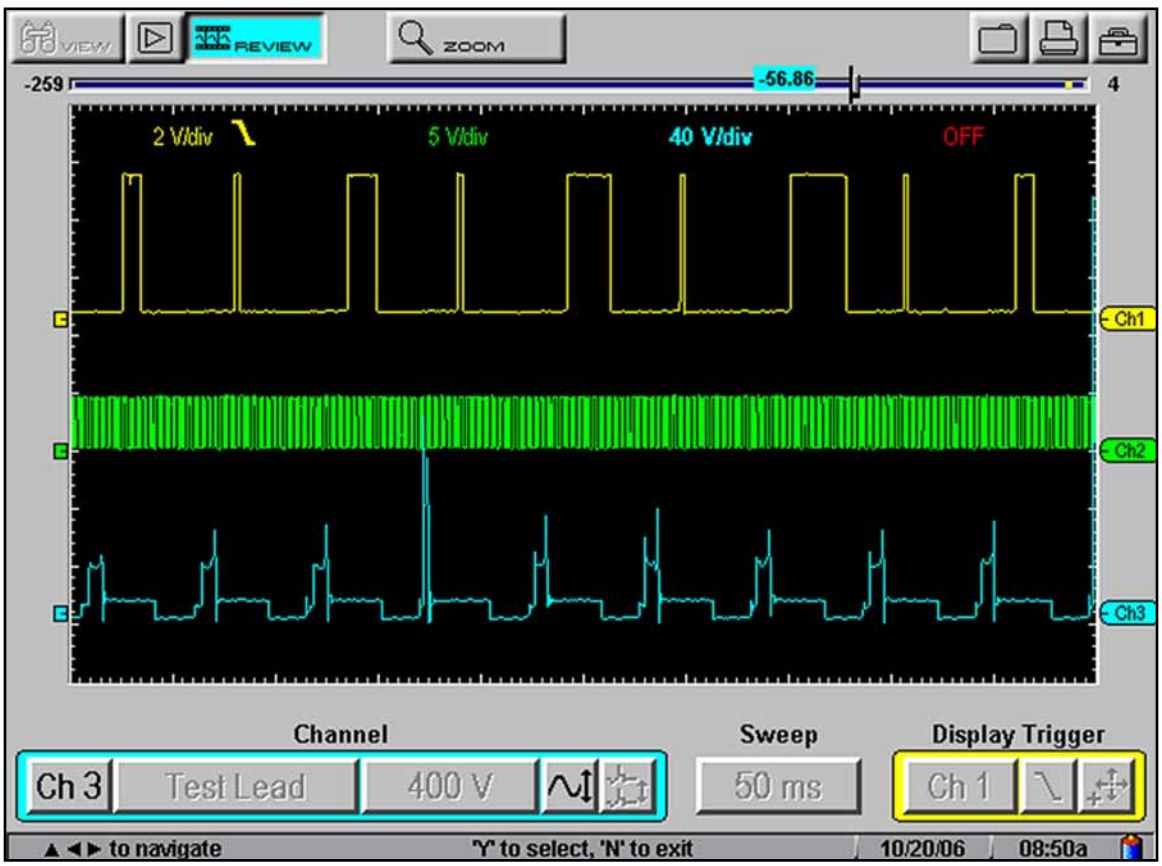
starting running real erratic. It was racing up real fast and then idling back down and racing up again. I could not believe how bad it was running. I grabbed my MODIS to scan the ECM to see what was going on within the DataStream. I chose the main signals that were related to the idling system (RPM, TPS, CTS, IAC counts, Desired Idle, etc). The IAC counts were all over the place and I thought at one point I saw a higher than normal RPM reading without an actual high RPM event. I placed the scanner in movie mode hoping to catch some data to see the erratic RPM input. The problem happened again and I hit the movie capture. When I reviewed the data I was surprised to see one frame of data showing a 5000 RPM increase (Figure2). There was no way the engine reved that high while I was standing there! I next placed the scanner in a graphing

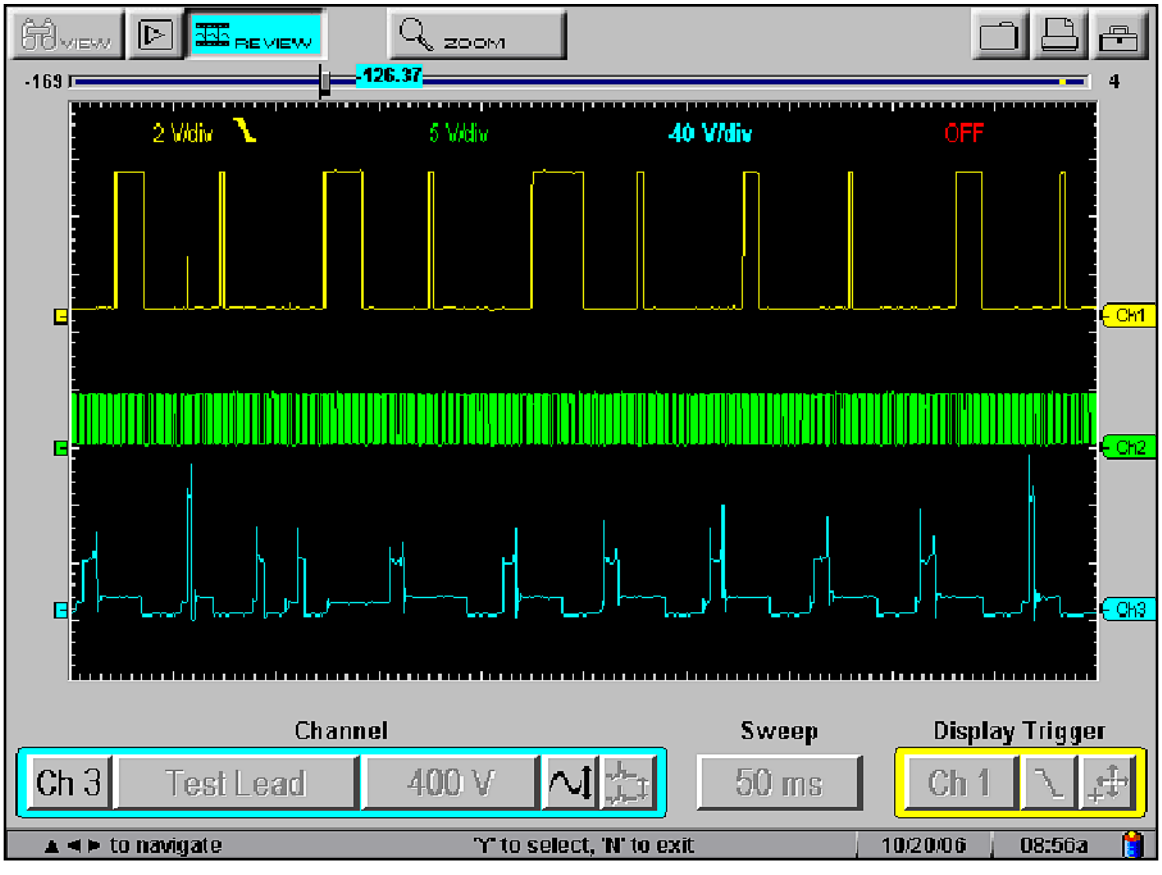
Figure 4: The low resolution signal, high resolution signal and the coil primary and everything seemed fine except for one primary pattern showing a higher than normal spike.



mode to get a better picture of what was going on. Number crunching is not made for the human mind and I would rather leave that work up to the MODIS.

While graphing the data (Figure3) I was able to see what was finally going on. The ECM was seeing false high RPM inputs and was only doing its job to counteract the high RPM's by moving the IAC motor accordingly. The culprit had to be the crank angle sensor because it was responsible for RPM input. I backed the MODIS out of its scanner mode and placed it into a scope mode to get a better look at what was going on with the crank angle sensor. I tagged the low resolution signal, high resolution signal and the coil primary and everything seemed fine except for one primary pattern showing a higher than normal spike (Figure4). Then the engine raced up again and at this point I stopped the scope to play it

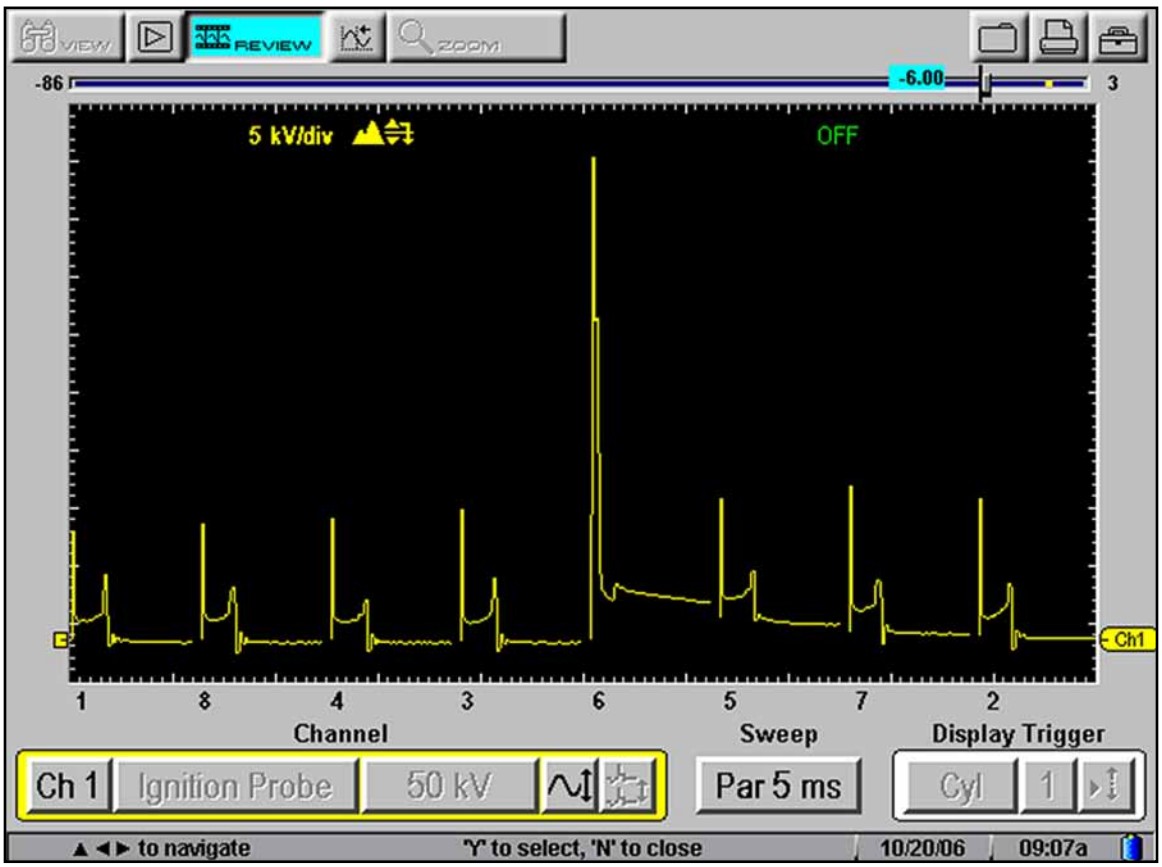
Figure 5: the coil trigger was erratic at one point but just prior to the event the low resolution signal had a spike in its pattern.



back. I quickly saw that the coil trigger was erratic at one point but just prior to the event the low resolution signal had a spike in its pattern (Figure5). By looking a little closer you could see that this spike was caused at the exact time that one primary pattern was spiking. The spiking event would occur every one revolution of the low resolution sensor every time one particular cylinder was fired. I wanted to get a closer look at the secondary patterns because it seemed that the spike was caused every time that one cylinder's primary was released to create secondary voltage.

I backed the MODIS out of the scope mode and went next into the engine analyzer section. I placed the analyzer in parade mode to view all the cylinders and I was stunned to see that the #6 cylinder was spiking close to 45 KV's (Figure6). This car

Figure 6: the analyzer in parade mode to view all the cylinders and I was stunned to see that the #6 cylinder was spiking close to 45 KV's.



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had a bad plug wire that was kicking back high KV's into the distributor housing causing a corruption of the low resolution signal. Think about this poor crank angle sensor only trying to do its job while getting hit with some serious lightning bolts. Just imagine you going out to the back yard during a stormy night while carrying in some wood for the fireplace and then all at once a lightning bolt heads your way. Do you really think that you would continue walking to the house carrying the wood or would you drop the wood and run for your life?

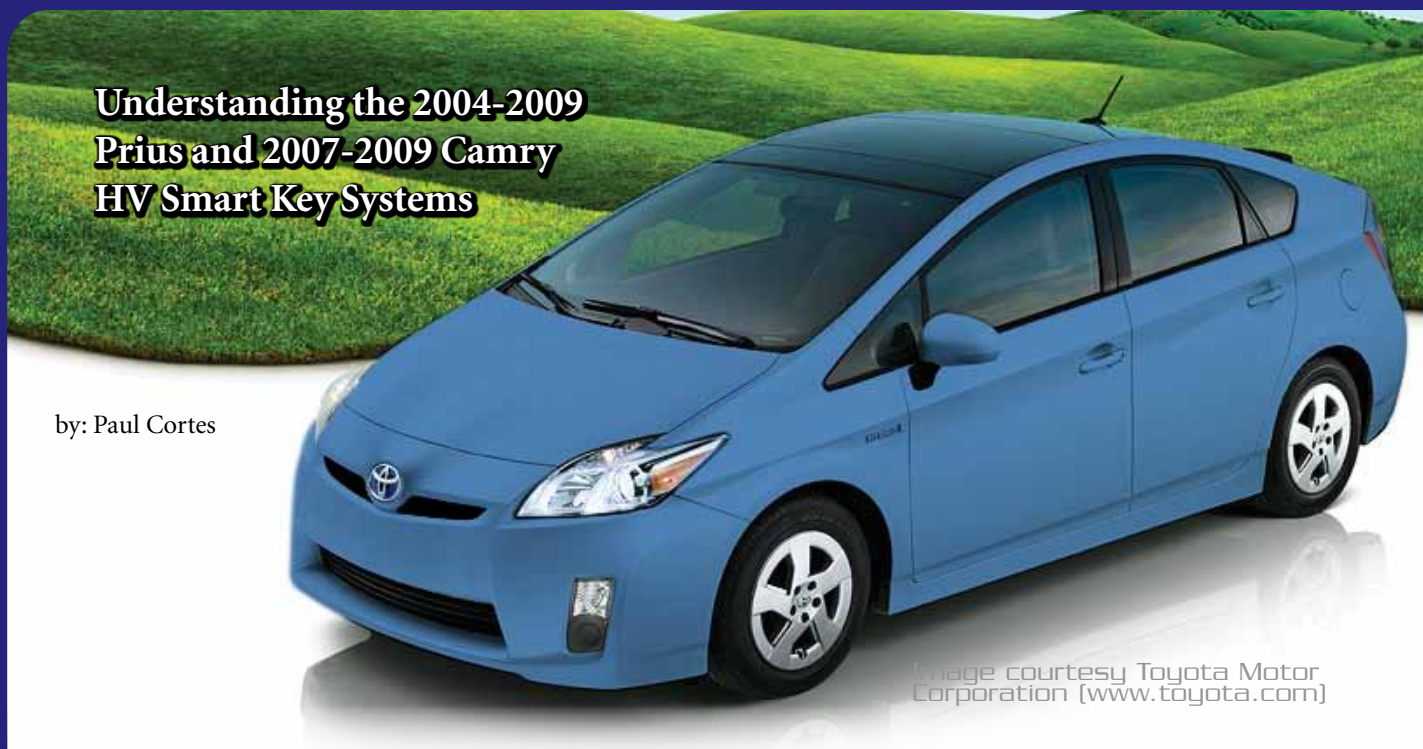
I took a closer look at this engine and noticed that someone had changed the stock exhaust and installed header pipes (Figure7). There was no room to get at some of these plug wires from the top of the engine. The #6 plug wire was only accessible from

Figure 7: Someone had changed the stock exhaust and installed header pipes.

underneath the vehicle. We lifted the vehicle and removed the #6 spark plug wire and the boot actually separated itself from the wire (Figure8). By the looks of the boot end you could see that these new wires were exposed to some serious heat. I had suggested that maybe the owner may have to invest in another wire set that would be able to handle the heat from these header pipes.

I must say that this was one interesting story with a happy ending and I hope all you techs out there have learned from it. It just amazes me how a high resistance in a secondary wire did not cause a serious misfire but yet created a serious drivability problem. Thanks to the MODIS and its multi-use capabilities I was able to stay in one place with one piece of equipment to nail this problem to the cross.

Figure 8: We lifted the vehicle and removed the #6 spark plug wire and the boot actually separated itself from the wire.



Understanding the 2004-2009 Prius and 2007-2009 Camry HV Smart Key Systems

by: Paul Cortes

Image courtesy Toyota Motor Corporation (www.toyota.com)

# Toyota Smart Key systems Pt. 2

## Complaint: Customer states car is beeping

Before beginning to diagnose a symptom, it's best to make sure it's actually a problem, not a normal function. The Smart Key system attempts to protect the driver from himself with lockout prevention and safety warnings. When the Smart Key system detects an unadvisable condition, it will use the interior and exterior beepers to alert the driver.

You'll find beep code charts in the owner's manual and on TIS in both the Service Information section and Reference Information sections.

## Maximum diagnosis with minimum effort

The Toyota TechStream allows a technician to check many Smart Key functions quickly by using data lists and active tests to find out what is

going on. However, you can also learn a lot with a few simple actions and observations. No matter how fast you can connect a scanner, these simple tests will be faster.

## How to check the Smart Key Cancel Switch

If Smart Key functions are not working, check the Smart Key Cancel Switch first. Just sit in the driver's seat with the Smart Key in your hand, press the Smart Cancel switch once, and then press the power button without pressing the brake pedal. If the power button LED turns green, the Smart Key system is now working. Congratulations, you fixed the car! If not, press the Smart Key Cancel button again to restore the original setting.

If you're willing to kneel down and wedge you head between the steering wheel and seat, you can also check whether the Smart Key function is ON or OFF by checking the switch position. The push button switch will protrude more when the Smart


Smart Key Cancel Switch: If Smart Key functions are not working, check the Smart Key Cancel Switch first.

The Camry Smart Key LED is well camouflaged when it's not lit.

The Prius Smart Key LED is a little easier to see.

Key system is active, and it will be closer to flush when the Smart Key functions are locked.

## How to check the Smart Key battery condition

A low Smart Key 3V battery will cause intermittent loss of Smart Key function at first, then no function at all. You can check battery condition by pressing the lock or unlock button three times in a row and observing the LED. Each time you press the button, the LED should respond immediately with each press. No response or slow response indicates a low battery.

If the Smart Key battery is failing too often, advise your customer to keep their Smart Keys away from electronic interference. If a Smart Key thinks it "hears" an oscillator, it will respond, and in doing so will drain the battery.

Likewise, if the car is parked near a source of 315 MHz interference, the 12V battery may go dead.

## Observations and Conclusions without any tools

**Test 1** – Lock the car and walk out of range with the Smart Key, about three meters is enough. Wait for a moment or two, and then walk toward the driver's or passenger's door with the Smart Key in hand while watching the LED on the Smart Key. The LED should blink once when you are about a meter away.

**What happened?**

- The car is locked and Certification ECU is pulsing the Exterior Oscillators.
- When the Smart Key comes into range, it "hears" the Wake Up command and the Vehicle ID Code request.
- The Smart Key sends its Vehicle ID code to the Door Control Receiver, and the Door Control Receiver relays it to the Certification ECU.

If the Vehicle ID code in the Smart Key matches the Vehicle

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ID code in the Certification ECU, the Certification ECU tells the Exterior Oscillators to ask for the Key ID code.

The Smart Key then sends its Key ID code to the Door Control Receiver, and flashes the LED.

### What do the test results tell you?

- The 12V aux. battery has at least a partial charge.
- The Smart Key battery and Smart Key worked.
- The driver's door Exterior Oscillator is working.
- The Door Control Receiver is working.
- The Certification ECU is working.
- The Vehicle ID code in the Smart Key and the Certification ECU match.

**Test 2** – Right after the LED on the Smart Key flashes, check the dome light, it should come on (assuming the bulb is OK).

### What happened?

- The Door Control Receiver received the Key ID code and relayed it to the Certification ECU.
- The Certification ECU verified the Key ID code matched.
- The Certification ECU requested the Body Control ECU to turn on the dome light.

### What do the results tell you?

- The Smart Key is fully registered in the Certification ECU.
- The Body ECU is working.

**Test 3** – Touch the sensor on the driver's door handle. The door or doors should unlock, depending on the configuration, set in "Customize" menu with the Techstream.

This is the wrong way to test a touch sensor. Holding the Smart Key too close to the Driver's Door Oscillator Antenna (the door handle) can interfere with the signal.

### What happened?

- The Certification ECU received the touch sensor input, and told the Body Control ECU to unlock the door(s).

### What do the results tell you?

- The touch sensor is OK.
- The door lock actuator(s) are OK.

**Test 4** – Open the door while watching for the "door open" light on the combination meter.

Door open icon.

### What happened?

- The door courtesy switch closed when the door was opened.
- The Body Control ECU received the courtesy switch signal and illuminated the door warning light.

### What do the results tell you?

- The door switch, Body Control ECU, and door open light are all working.

**Test 5** – Get into the car with the Smart Key while watching the Smart Key LED. It should flash once.

### What happened?

- The Body Control ECU informed the Certification ECU the door had opened.
- The Certification ECU started to pulse the Interior Oscillator.
- The Smart Key broadcasts its Key ID code.

**What do the results mean?**

- The Interior Oscillator is working
- The Front Room Antenna is OK.

**Test 6 –**

**CAMRY HV:** Step on the brake pedal while watching the LED on the Power Button. It should be green.

**PRIUS:** Press the brake pedal while checking the brake lights.

**What happened?**

- The brake switch closed.


Security icon for Prius.



Wrong key icon for Prius.


Wrong key message for Camry HV.

- The signal reached the Certification ECU.
- The Certification ECU told the Body Control ECU to turn the Power button LED green and the brake lights on.

**What do the results mean?**

- The brake switch signal was OK.

**Test 7** – Press the power button while pressing the brake pedal. Verify the Security light turns off.

**What happened?**

- The Certification ECU verified Smart Key was registered (using the same process as before).
- The Certification ECU (Smart Key ECU) compares S-codes with the Immobiliser ECU (ID Code Box)

**CAMRY ONLY** – The Certification ECU checks for matching L-codes in the Immobiliser ECU and Steering Lock ECU.

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**CAMRY ONLY** – The Steering Lock ECU successfully unlocked the steering and sent a verification message to the Certification ECU.

### What do the results mean?

- The S-codes in the Certification ECU (Smart Key ECU) and the Immobilizer ECU (ID Code Box) match.

- The L-codes in the Immobilizer ECU (ID Code Box) and the Steering Lock ECU match.

**Test 8** – Verify "Ready" is displayed on the dash cluster.

### What happened?

- The G-code matched in the Immobilizer ECU (ID Code Box) and the HV ECU.

Performing this entire series of tests takes about 30 seconds once you've done it a few times, and it will give you all the information you need to choose and intelligent diagnostic path.

## Adding Smart Keys or Replacing Lost Keys

In order to register new Smart Keys, you'll need a Techstream or the older Toyota Intelligent Tester can also work with a CAN adaptor. The Techstream is vastly superior, and once you own it, you'll kick yourself for not having bought it sooner.

The new Smart Key emergency insert will be blank and will need to be cut to match the lock cylinder in the driver's door. The key cut code can be obtained from TIS with a Security Professional subscription and VIN, but if you don't have machine capable of cutting the new key based on this code, it won't do you much good.


The Smart Key insert can be removed when the release button/slider is actuated.

Some locksmiths will be able to cut the key insert with the VIN or the key code. All Toyota dealers will be able to cut the key insert for you, but their willingness and fees will vary wildly.

Be sure to take care of the dealership(s) that take care of you! It's like Darwin's theory of natural selection. Reward dealerships possessing desirable traits with a steady stream of parts orders if you want them to be around to help you in the future.

The key blank can also be copied from the existing Smart Key blank at a hardware store or other business with a key cutting machine.

The key blanks can be purchased separately from the Smart Key, so if key insert is cut incorrectly, it's not the end of the world.

## Prius registration procedure

When replacing a lost Smart Key, always ask your customer if they have any other Smart Keys at home and inform them any keys not in your possession will not open or start the car. You would be amazed how many people will fib in order to avoid the inconvenience of collecting all keys if you don't explain why you need to have all keys.

## There are four steps to replacing a lost Smart Key.

1. Perform the Key Code Erasure procedure in the Immobiliser ECU (ID Code Box).

2. Register all existing and new keys in the Immobiliser ECU.

3. Perform the Key Code Erasure procedure in the Smart Key ECU (Certification ECU).

4. Register all exiting and new keys in the Smart Key ECU.

**Author's note:**

Whatever changes are made to the keys registered in the Immobiliser ECU should also be made to the Smart

Key ECU and vice versa. The S-code is stored in both the Immobilizer ECU and the Smart Key ECU. The S-code is created using all registered Key IDs in each of the ECUs. Since the S-codes must match, presumably the Key IDs in each ECU should also match. Registering three Key IDs in the Immobilizer ECU and one in the Smart Key ECU is possible, but probably a bad idea. Exactly when and under what circumstances the S-code is (re)created is a mystery to me. Mismatched S-codes will prevent a Seed Reset (a procedure explained below). Mismatched S-codes may be an issue that can only be caused by installing a used Immobilizer ECU or Smart Key ECU, but unless you know for sure, better safe that sorry.

## If your customer is just adding a Smart Key, there are only two steps.

1. Register the new key(s) in the Immobiliser ECU (ID Code Box).

2. Register the new key(s) in the Smart Key ECU (Certification ECU).

## When all Smart Keys have been lost

If all keys are lost, you'll need to perform a Seed Reset.

It's a good idea to register at least two new keys when a reset is performed so your customer does not end up in the same boat later. Although you may find that a customer who lost all of their keys will also be resistant to spending additional money on "extra" keys. You can lead a horse to water…

You'll need to be a licensed locksmith in order to qualify for a TIS Security Professional subscription, and without a Security Professional subscription, you won't be able to perform a Smart Code Reset.

Currently the TIS Security Professional subscription is only available as a stand-alone subscription. In other words, if you already have a TIS or TIS Professional Diagnostics subscription, Security Professional is not added to your account, it's an entirely separate account with a different login and password.

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Before performing a seed reset, you must check the customer's identification, registration and vehicle to make sure they match (think of yourself as a Certification ECU). Your LSID will be associated with the reset, so if your customer's ownership is disputed, you'll be the one on the hook. At best, you may loose your license. At worst, you may be caught up in a criminal investigation.

**A slight digression --**

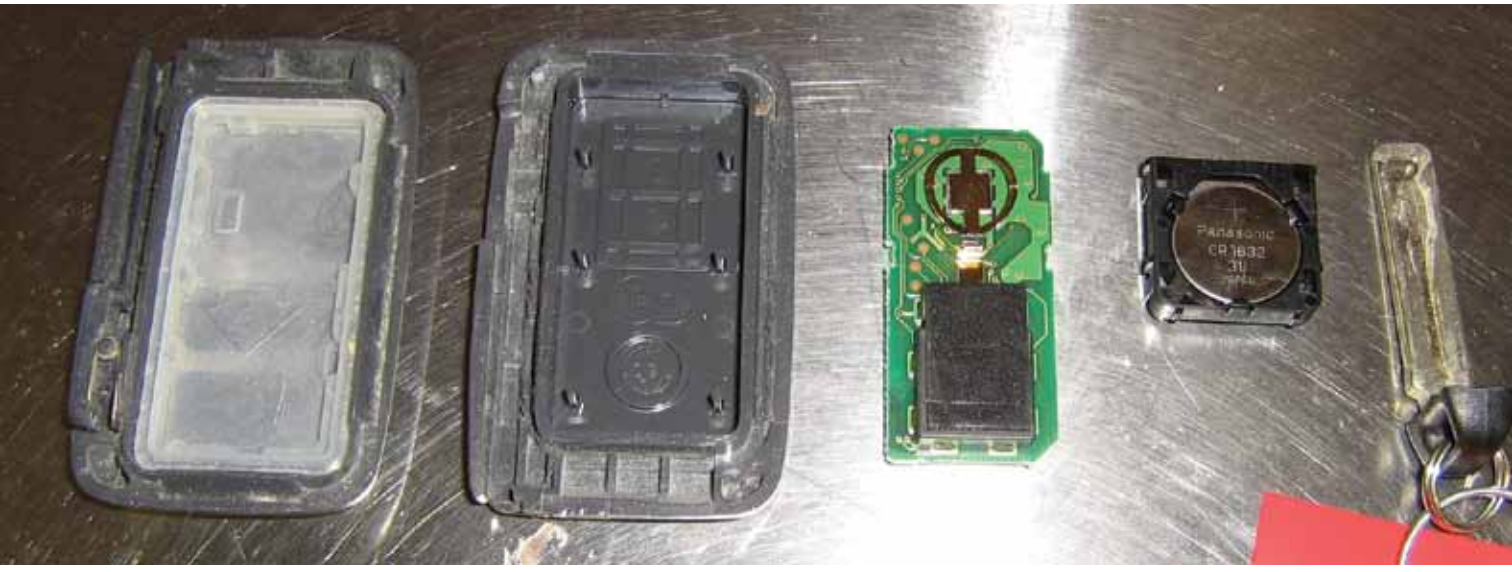
Obtaining a locksmith license will be very important for shops that want to stay in the business of diagnosing and repairing cars. Even if you don't care about doing seed resets, you'll find an LSID is necessary to replace ECMs on many modern cars. It's a little bit of a hassle (a lot of paperwork), but jumping through hoops when required is part of being a professional. You'll find the information you'll need to get started here – **http://www.aloa.org**

**Here are some tips for a successful seed reset:**

- Before embarking on a Smart Code Reset, make sure the time and date on your computer are correct. An


When testing Transponder Key Amplifier on a Camry, there no need to reassemble the Smart Key after removing the battery. Just hold the guts next to the Power Button and press the power button. Removing the Smart Key battery is unnecessary on the Prius; just press the Smart Key Cancel switch and insert the Smart Key in the Key Slot.]

A disassembled Camry Smart Key




incorrect date or time may cause the reset to fail.

•Make sure the Techstream has over 60% charge or is plugged in.

•Use a charged booster pack on the battery

•Have your LSID and password handy

•Make sure you can connect to the internet

•If you have a working key, verify it works in the key slot with the Smart Key Cancel switch on (Prius), or when held next to the Power button with the 3V battery removed (Camry). This will verify that the Transponder Key Amplifier & coil are functional.

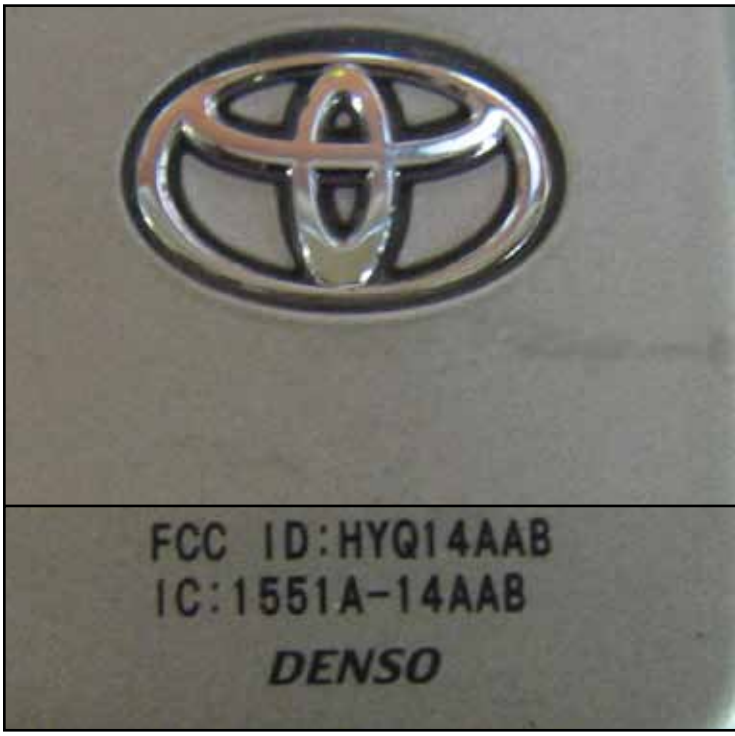
## Used Smart Keys/ EBay Smart Keys

New Smart Keys come with a Key ID burned in at the factory, but the Vehicle ID is blank. If a customer brings a key in with a Vehicle ID already burned, you will be able to register it in the Immobiliser (ID Code Box). However, you will not be able to register the key to in the Smart Key ECU (Certification ECU). In other words, you have a key that will start the car when the inserted in the key slot, but none of the wireless functions will work.

**Author's note:** These procedures have worked for me. There may be other methods, but this is what I've found to work through trial and error.

If a customer-supplied key won't register in the Smart Key ECU (Certification ECU), check the model and FCC numbers to make sure they match (you'll need to remove the back key cover on the Prius Smart key). Then check the Smart Key battery (using the 3 button press method mentioned earlier). If the numbers and the battery are OK, the next step is to erase all keys from the Immobiliser ECU (ID Code Box) and the Smart Key ECU (using the same key). Then try registering all of the remaining keys, including the new key. Sometimes this works, sometimes it doesn't.

If the erasing all key codes did not solve your wireless registration woes, try a Smart Key Reset, followed by an Immobiliser Reset. VERY IMPORTANT – use the suspect key for the resets. When finished, you will have one key registered in the Immobiliser ECU and no keys registered in the Smart Key ECU. Go ahead and register the key in the Smart Key ECU. It should work.




The FCC ID is on the back of the Camry Smart Key.


The FCC ID is under the back cover on the Prius Smart Key.

Don't let failure freak you out. It happens sometimes. If at first you fail, try again. It's not a one shot only deal (although there may be some sort of limit).

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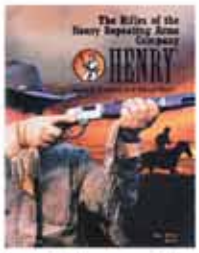


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## Other Registration Woes

The Immobiliser registration always seems to go smoothly. If there's going to be trouble, it's likely to occur when registering the key in the Smart Key ECU (wireless registration). The scanner will offer the following advice when registration fails. "Make sure the Smart Cancel Switch is off and the IG ON". The manual will offer even less.

Check to make sure the wireless functions are working properly with the registered key using the techniques in the observations and conclusions section above. If the interior oscillator or door receiver is not working, the key can't be registered.

Don't forget about the Smart Key Cancel Switch, the scanner will remind you, but the reminder is only effective if you are carefully reading the prompts.

Wireless interference can hamper wireless key registration efforts. Put your cell phone in airplane mode, move the car away from transformers, wireless routers, fluorescent lights, etc.

Rogue keys can be very frustrating. If one of the Smart Keys in the car has a stuck lock or unlock button, it can ruin your day. Remove all but essential keys from the car, and then try again.

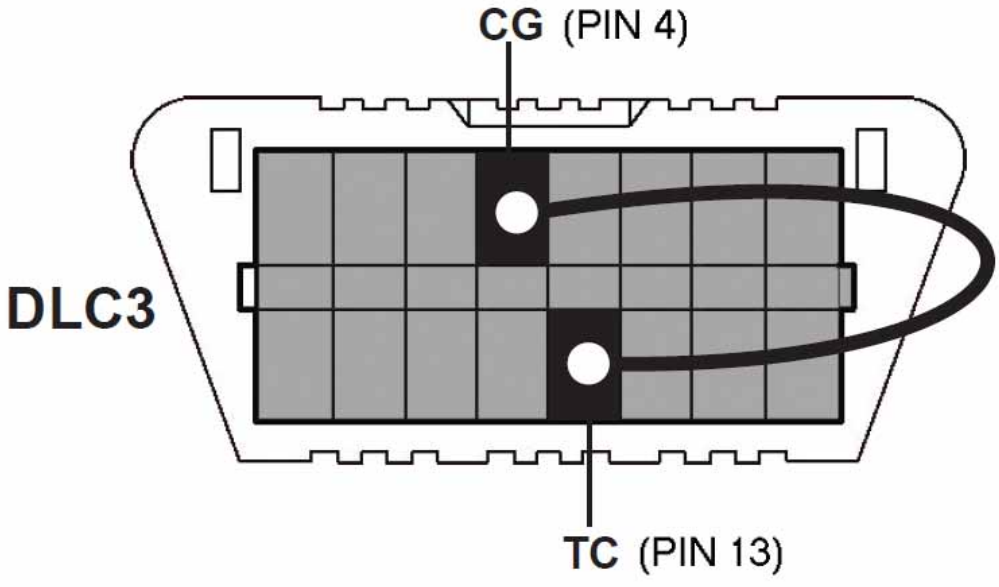
The first Smart Key registered after a Smart Key Reset will be registered with the power off, despite the scanner's post-failure troubleshooting tip, "Was the IG ON?"

## Replacing ECUs

Imagine a car towed in from another shop with the following write up –

*Customer states dealership said needs new HV ECU. Customer declined repair and had another shop install a used HV ECU from EBay. Customer states car will not Ready with replacement ECU, but will Ready with original HV ECU.*

You'll only have 20 ignition cycles or less to do the right thing.




## New ECU/ECM Registration

| New Component | Key ID | S Code | L Code | G Code |
|---|---|---|---|---|
| Key | Techstream (Smart Code Registration) | - | - | - |
| Certification ECU | Techstream (Smart Code Registration) | - | - | - |
| ID Code Box | - | Automatic | Techstream (ECU Communications ID Registration) | SST at DLC3 (TC to CG for 30-44 min.) |
| Steering Lock ECU | - | - | Techstream (ECU Communications ID Registration) | - |
| Engine ECM* | - | - | - | Automatic |
| Certification ECU & ID Code Box | Techstream (Smart Code Registration) | Automatic | Automatic | SST at DLC3 (TC to CG for 30-44 min.) |

Required after installation of NEW Components
*If a used Engine ECM is installed, Manual G Code registration using the SST at DLC3 (TC to CG for 30-44 minutes) must be completed.

Chart compliments of TIS & TMC

**Do you –**

1. advise the customer to get another used HV ECU under warranty?

2. advise the customer to buy a new HV ECU from the dealer?

3. advise the customer to re-flash the HV ECU?

4. advise the customer to connect terminals TC to CG for 45 minutes at DLC3?

Remember the G-code is stored in the Immobiliser ECU (ID Code Box) and the HV ECU and they must match or the car will not Ready.

If the HV ECU is replaced with a unit from another car, the G-codes will not match, so a different used ECU will have the same problem.

A new HV ECU from the dealer will solve the problem because it comes in automatic G-code registration mode. However, it's costly and isn't necessary.

A reflash probably won't be possible, and won't solve the problem.

Connecting terminals TC to CG for 45 minutes with the IG ON is the best answer. This will force G-code registration on an HV ECU that is not in automatic registration mode.

Be sure to use a power supply type charger to keep the battery from discharging, since leaving the power mode in "ON" for 45 minutes is far more than most Prius batteries can handle.

Also, take the time to find or make an appropriate tool for jumping the connectors. The OBDII port will need to last the life of the vehicle, and poor pin fit caused by paper clips or oversized spades can be a real pain later on.

## Replacing other ECUs

Other ECUs will need to have their codes in agreement when they are replaced. The following chart from Toyota indicates what must be done depending on which ECU is replaced..

Full procedures as well as a lot of additional information can be

found at **http://techinfo.toyota.com**. Smart Key information can be found in the following areas –

- Vehicle interior ->Theft Deterent / Keyless Entry
- Vehicle Interior -> Door Lock
- Engine / Hybrid System -> Starting
- General -> Introduction -> Repair Instructions -> Customize Parameters
- There is also a lot of information in the Technical Training section. (It may be the best source of plain English explanation).

## Review questions to spark further thought or additional research

If you cannot open the car door or start the car with the Smart Key in your pocket, but the doors unlock when the Smart Key unlock button is pressed, and the car starts with the Smart Key in the slot, what should you check first?

If the Smart Key LED flashes when you walk toward the car, but the door doesn't unlock when you touch the sensor, what would you check?

If the power mode changes to ACC and ON, but does not Ready, what simple test would you do next?

If you are able to enter the car with the Smart Key in your pocket, but cannot change power modes and the Security light continues to flash, what would you suspect? What simple test would you do next?

A Prius is towed to your shop from another shop. The other shop reports they replaced the Certification ECU with a used part, and now the car will not start. The dealer says they need to buy a new Certification ECU. What would you do?

A customer requests an additional Smart Key. You own a Techstream, but you are not a licensed locksmith. Can you do this job?

A customer has lost all of their Smart Keys. What do you need to do an Immobiliser and Smart Reset?

You've just registered a customer-supplied key in the Immobiliser ECU, and the car will start with the key in the key slot. However, no matter how many times you try, the key will not register in the Smart Key ECU. What next?

You are performing a routine Health Check during a service and you find a code B2795. What should you do?

A customer owns two Prius and has four Smart Keys. He wants all four Smart Keys to start either Prius. Can you do this? Why or why not?

**Congratulations**, you've just read an extremely long article on a complex subject. I hope you learned enough to make it worth the time you invested. If you found errors, disagreed with statements, know how to do it better, **contactus@mastertechmag.com**

A performance upgrade that's easy to sell and easy to install.

# COLD-AIR INTAKE SYSTEMS

by: Steve Campbell

While original-equipment repair and service is the mainstay of most independent shops, some aftermarket products provide opportunities for increased revenue that are just too good to pass up. Cold-air intake systems offer quick installation at only 30 to 60 minutes using basic hand tools in most cases. In fact, many consumers are able to install such systems themselves with no prior experience at making automotive repairs or modifications. Even so, the majority of repair and service customers either do not feel capable or do not wish to perform such tasks themselves, which opens a vast market for shop owners and technicians. Simply explaining the benefits of such systems is often the only sales technique required.

This neat installation on a hot Subaru doesn't look too difficult, does it?

## Where you need it

"Generally speaking, a well-tuned intake system delivers more air to the engine, which means it works more efficiently to create power and torque," said Lawson Mollica, marketing manager for AEM/DC Sports, a well-known manufacturer of cold-air intakes. "That not only affects how much power over stock an intake can make, but also where on the power band the increases occur. Ideally, we tune our systems to create more low-end torque and mid-range power and will sacrifice peak power gains to deliver gains where they will most benefit the driver."

In addition to replacing some of the restrictive tubing found in many original-equipment intake systems, aftermarket systems also rely on greater filtration than the OE paper-style elements. In most cases, the aftermarket filters are made of permanent materials that may be cleaned and reused so that the customer never needs to buy another replacement.

"The great selling point of a performance air intake system is the fact that there is no downside," said Jason Cobb, national sales manager for intake manufacturer True Flow. "With our intake systems you do not

give up something to get something. Performance filters offer lower restriction for better air flow and greater efficiency."

Not every cold-air intake offers improved efficiency on every engine, however. In diesel applications, in fact, the intake most often must be coupled with engine-management tuning to produce optimum results.

"For most late-model gasoline applications, an improvement in air density will be measured by the engine electronics, and the fuel calibration will be adjusted accordingly," said Peter Treydte, director of technical communications for Banks Power.

"This is not the case with diesel applications. Diesels commonly won't realize the added power potential from denser intake air unless a tuning device specifically designed to do so adds more fuel based on the fact that the incoming air is cooler, contributing to lower exhaust gas temperatures."

## Hot Air?

Treydte also pointed out that some intake systems leave the air filter partially or fully exposed in the engine compartment in an effort to maximize air flow. But that may allow hot air to be inducted into the engine, which might be worse for performance than the more restrictive OE system. Banks Power advocates an enclosed air filter with well-designed ducting to provide optimal air flow.

While cold-air intake installations are simple and require no permanent modifications to the vehicle (allowing the customer to reinstall the original equipment if desired for any reason), some manufacturers also advocate enlarging the mass air-flow (MAF) sensor on vehicles that use that type of system.

"Your cold-air intake is only as good as the weakest link in the chain," explained J.R. Granatelli, president of Granatelli Motor Sports. "Large aftermarket cold-air intake systems are often negated because the customer fails to enlarge the

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The only potential problem is the placement of the MAF sensor. If you deal with a company that has good engineering, you shouldn't get a DTC and an illuminated MIL.

mass air-flow sensor that runs in line to the cold air. If you increase your air intake to 100mm throughout but stick with the stock 70mm MAF, then you really have a 70mm air intake."

## Don't expect more mpg if you've got your foot in it

Some sources tout mileage improvements in addition to the power gains provided by cold-air intake systems, but that can be a slippery slope. While performance improvements can be noticeable, fuel economy is dependent upon more than the hardware installation.

"The car sounds different when one of these kits is installed," said Joe Chuan, national sales manager for Neuspeed. "It sounds a lot throatier, and people get more aggressive with the throttle. Any gains that they may have seen if their driving habits remained the same are negated by the fact that they're heavier on the throttle because they like hearing the sound and feeling the rush of the extra power they get from the kit."

In most cases, there are no legal ramifications to installing a cold-air intake system. Because the intake is upstream of sensors and emissions equipment, the upgrades don't affect other components, and modern computers can adjust for the changes in air flow that result from specialty intakes.

## MIL potential

"Generally, if a cold-air intake system has been assigned a CARB E.O. number, it is legal for sale and

Customers should be made aware that the installation is a simple bolt-on process and usually does not require modifications to the vehicle, so the factory intake system can be easily re-installed at any time. Customers are sometimes hesitant to modify a new vehicle due to warranty or resale concerns, so this is important.

use in all 50 states," Treydte said. "There are some instances that may not require a CARB E.O. However, some systems may have a negative impact on certain engine sensors and could cause OBD II codes [DTCs, with the accompanying MIL/check-engine lights] to occur. Techs and shop owners should install systems from reputable engineering companies that design their products to avoid such circumstances. This will minimize comebacks."

Granatelli also pointed out that, while most systems do not pose an issue with emissions compliance, changes in tubing may require further calibration.

"If the tubing is changed between the MAF and the throttle body, then testing is required," he said. "The mass air-flow sensor is critical to telling the ECM [electronic control module, more accurately the powertrain control module, or PCM] the exact amount of air that the engine is ingesting, so the air passing through the sensor in turn changes the calibration."

While all types of vehicles and engines can benefit from cold-air intake upgrades, some see better results than others. David Vespremi, brand marketing director for K&N, said that his company doesn't release an intake systems unless it can guarantee a horsepower gain.

"Obviously, bigger displacement, bigger horsepower engines see the numerically largest power gains," he said. "For example, a Ford Mustang SVT owner can expect to see as much as a 30 rear-wheel horsepower gain

with just a K&N air intake system. However, the percentage of gains seen on most vehicles is generally fairly even across the board, so scaled for engine size and output, the gains are fairly consistent on most makes and models."

## Combo up-sell

Another benefit to offering intake upgrades to service and repair customers is the opportunity for up-selling to other performance enhancements. Depending upon how far the shop wishes to expand into other areas, a host of possibilities exist. Aaron Morant, vice president of sales and marketing for the Outlaw Power division of Envisia Technologies, said that the list is practically endless, but there are two other components that are natural adjuncts.

"If a customer enters a retailer intending to purchase a cold-air intake system, the retailer can easily up-sell an exhaust and a computer programmer upgrade,"

As one expert says, "If you increase your air intake to 100mm throughout but stick with the stock 70mm MAF, then you really have a 70mm air intake."

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If you should have a DTC develop at some point after the installation, check the downstream duct before you start complaining to the intake air system manufacturer. You might just have "false air," as was coming through this deteriorated plastic part. Not uncommon.

he explained. "While they are not required for the cold-air intake system, the trio of parts allows the retailer an opportunity to increase the performance of the vehicle while simultaneously increasing sales. The cold-air intake system can also be used as an up-selling tool because it is relatively less expensive when compared to an exhaust or computer programmer. A customer intending to purchase an exhaust or programmer can easily be upgraded with a intake system for a small additional investment and a nice performance enhancement."

Each shop's customer base varies to some degree, so inventory may vary depending upon the type of customer encountered on a regular basis. Still, carrying components that apply to the greatest percentage of vehicle types served can be a wise policy.


Intake systems that enclose the air filter protect it from airborne particles, moisture and heat, which might be worse for performance than the more restrictive OE system. An enclosed air filter with well-designed ducting to provide optimal air flow provides a cooler, denser charge for better performance.

"The difference between having a system immediately available versus forcing the customer to return can be the difference between a sale and lost revenue," Morant said. "Customers don'tlike to wait for something that they want, and forcing a customer to wait may give him time and motivation to shop the competition."

In addition, Morant pointed out that many distributors and manufacturers may have flexible inventory programs that can assist the shop owners in maintaining and servicing inventory levels with period adjustments or inventory swaps. "It is highly recommended that shops coordinate with their sales representatives on behalf of the distributors and manufacturers and ask them for special inventory programs that are available to retailers who will stock the product," he advised.

It's also a good idea to take advantage of a supplier's point-of-purchase displays, brochures or other sales materials. POP displays can help the customer understand the benefits of cold-air intake systems as well as explain how the benefits are obtained.

All of our sources were adamant that shop owners and technicians should fully understand their suppliers' products and procedures before offering any cold-air intake system.

Point-of-purchase displays may be the most effective tool a salesperson can utilize to market cold-air intake systems. Outlaw Power provides displays that include a complete system, giving customers the opportunity to see actual components and allowing the salesperson to point out and explain key features that can help customers understand the reasons why they might benefit from the purchase of a cold-air intake system.


"Do your homework," Mollica counseled. "Ask the companies what the rate of return is on their products, what the filtration efficiency of their filters are, if any of their intakes throw check engine lights, what their warranty policy is, whether or not their intakes include complete installation hardware, what their return policy is, what their manufacturing processes and materials are, what their engineering procedures are. I also suggest visiting local races and car shows and getting feedback from enthusiasts who are knowledgeable and have experience with the products. Finally, don't be afraid to contact the manufacturer directly if you are having an issue with something or have questions that your distributor cannot answer. Often, a retailer will contact the distributor with an installation question and it could take days to get an answer when a phone call to the manufacturer could net an answer in a few hours or less."

And investing a little research into this lucrative product line could net your shop a simple and profitable revenue stream.

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# Duramax Engines

by: Phil Fournier

Images courtesy GM

I am gas guy; I've always been a gas guy. To my way of thinking fuel was always meant to be ignited by spark. Those smelly things marketed by GM for their light trucks were gutless and smoky. One of my employees bought one many years ago and was so disgusted with the performance that he ended up pulling the diesel out and replacing it with a 403 Olds gasoline engine. Nevertheless, in the last couple of years several things have coalesced to change my mind about the fuel ignited by heat of compression; yep, now I'm a diesel convert.

## Diversification

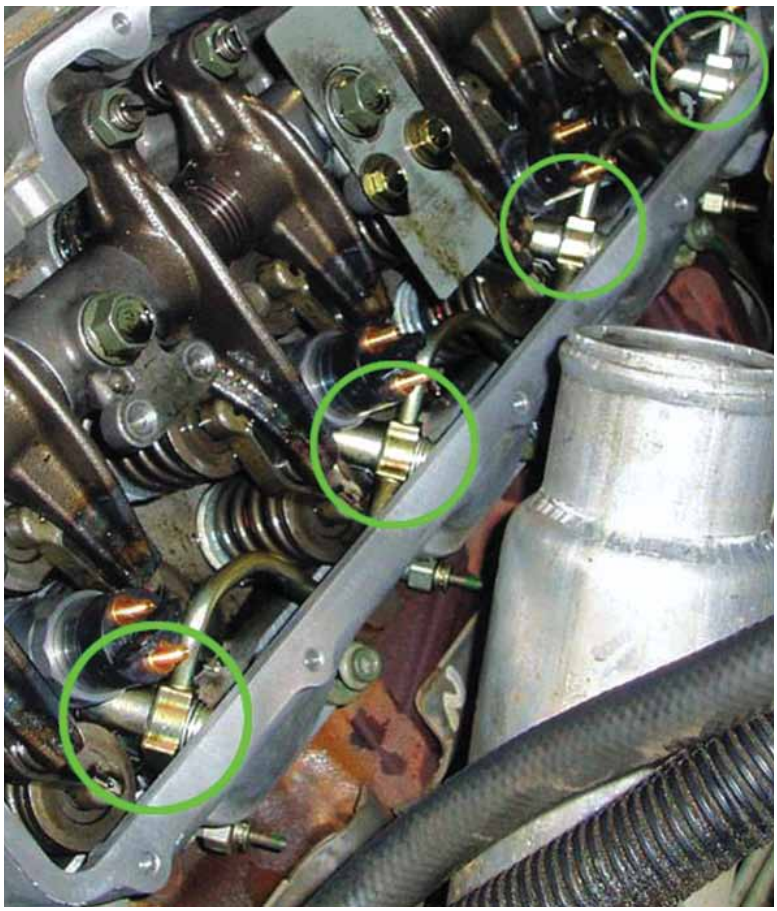
While many management consults are promoting specialization as a means to reduce capital costs and increase expertise in a more narrow range of vehicles, I have found it necessary to go in a completely opposite direction to survive in today's marketplace. Improvements in vehicle quality in the last ten years and reductions in service intervals (many of which are very realistic in spite of our efforts to illustrate the contrary opinion in certain cases) have reduced by a large margin the number of vehicles showing up in my service bays in a broken condition. I needed to broaden my range of expertise, not narrow it down. I began to explore the option of servicing light truck diesels. What pushed me over the edge into buying one for myself was the birth of my first granddaughter, an epiphany which influenced me to purchase a 2001 Duramax-power GMC 2500HD and a 5th wheel travel trailer. Besides wanting to spend time with my granddaughter, I rationalized that there is nothing like owning a vehicle to gain experience in its service. That assumption turned out to be more than correct.

## The common rail diesel

My early impressions of the diesel motor were largely influenced by GM's poor showing with their 6.2 naturally aspirated and 6.5 turbo diesel motors. Though the turbo was definitely a step in the right direction, real success came to GM when in

2001 they went to the high-pressure, common rail, Bosch fuel injection system coupled with the turbo-charged motor licensed by Isuzu, the Duramax 6.6 liter. Factory rated at 300 horse power and 520ft/lbs of torque, this isn't your grandfather's Olds diesel. Anyone who has driven one cannot help but be impressed the way this power plant will push you back in the seat and light up the rear tires on most road surfaces. This is a direct-injection, 4 valve per cylinder motor without the pre-combustion chamber used on older diesel motors. Fuel pressure varies between 34mpa (5000psi) to 160mpa (23,000psi).

Figure 1: The biggest and most public issue with the motor was its tendency to crack the fuel injectors here.



## The LB7 VIN 1 motor, 2001-2004

This first rendition of the Duramax was called the LB7, distinguished from the LLY VIN 2 motor that came out in 2004.5. As might be expected with technology new to GM, there were some issues with this motor and fuel system, though overall it was a smashing success. The biggest and most public issue with the motor was its tendency to crack the fuel injectors (Figure 1).

The tell-tale sign of this issue was a steady climbing of the engine oil level as the diesel fuel under very high pressure leaked into the engine oil. Other problems existed too, such as erosion of

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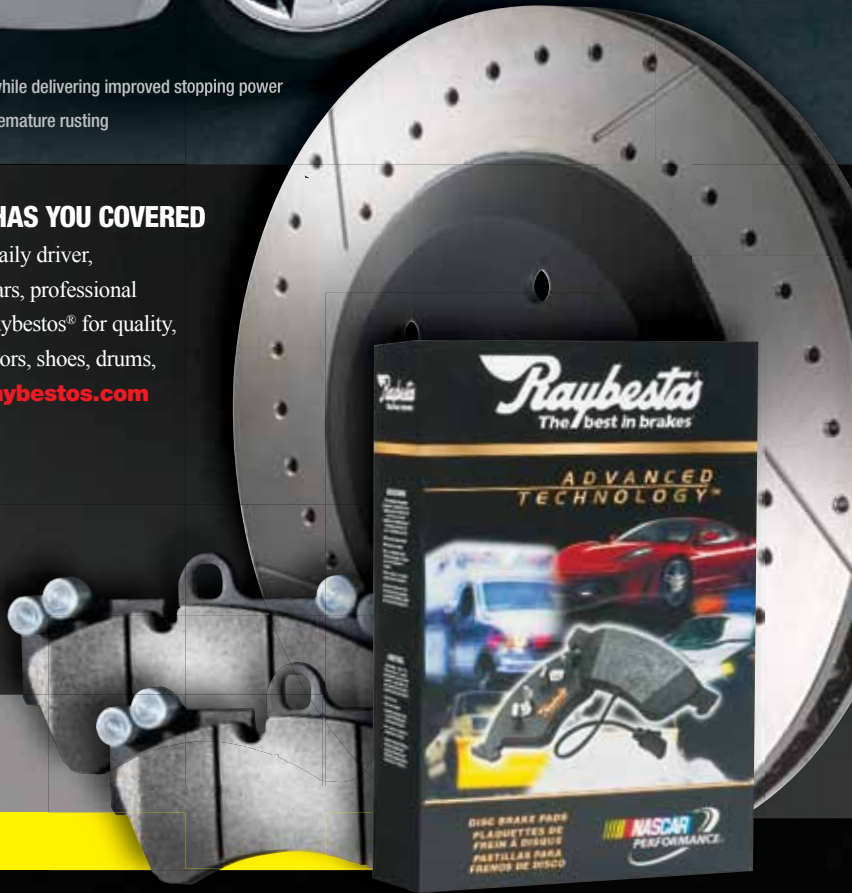


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the injector seat, which made for white smoke at idle and occasional hard starting/long crank issue. GM recognized these problems early on and issued several campaign's, such as this one dated 11/19/2007:

## Subject:

Special Coverage Adjustment - Injectors-Replace # 04039B - (11/19/2007)

## Models:

2001-2004 Chevrolet Silverado
2001-2004 GMC Sierra
2004 Chevrolet Kodiak
2004 GMC TopKick

Equipped with 6.6L Duramax Diesel (RPO LB7 - VIN Code 1) Engine

**THIS BULLETIN IS BEING REVISED TO ADD 2004 MODEL YEAR TRUCKS. PLEASE DISCARD SPECIAL POLICY BULLETIN NUMBER 04039A, DATED OCTOBER, 2006.**

## Condition:

Some customers of 2001-04 model year Chevrolet Silverado; GMC Sierra; 2003 Chevrolet Kodiak and GMC TopKick vehicles, equipped with a 6.6L Duramax Diesel (RPO LB7 - VIN Code 1) engine, may experience vehicle service engine soon (SES) light illumination, low engine power, hard start, and/or fuel in crankcase, requiring injector replacement, as a result of high fuel return rates due to fuel injector body cracks, ball seat erosion, or high pressure seal extrusion (refer to Corporate Bulletin Number 04-06-04-007G and SI).

## Special Policy Adjustment:

This special policy covers the condition described above for a period of 7 years or 200,000 miles (320,000 km), whichever occurs first, from the date the vehicle was originally placed in service, regardless of ownership. The repairs will be made at no charge to the customer.

My own truck was purchased at 148,000 miles. I was happy as a clam for the first 4 or 5,000 miles with everything about the truck, including its 18mpg mileage on the highway. But I started to notice the white smoke issue at idle fairly soon. I had heard

about the injector problems and called my friend Jim Wilson, a Chev dealer technician, and asked him to check my VIN to see if the injector campaign had already been done. He found that it had not been done, and in fact almost no warranty work at all had been done on the truck, which gave me reason for encouragement. I ignored the white smoke for a while along with the climbing level of oil in the crankcase. But soon I had a bigger problem to worry about; my low coolant light came on after a trip out to the desert. I was disconcerted to find that it took a full gallon of coolant to refill the cooling system. Unfortunately, it was only 100 miles later that the light came on again, and another gallon was added.

## Diesel engine design & durability

What I'm about to tell you I'm not particularly proud of, but I tell you anyway because it proves a point about the cooling characteristics of this diesel engine. As might be expected, the heat of combustion in a diesel motor is high. In order to protect hot pistons, the Duramax has oil jets that shoot oil up at the bottoms of the pistons. The oil is then cooled in the oil cooler, and this becomes an integral part of the cooling system. I knew I was in trouble with my motor. I was using coolant without a leak, and two minutes after starting the motor, my upper hose was rock hard, indicating undue pressure in the cooling system. I had a teaching gig up in central California and had planned to combine it with a few days in Yosemite National Park, using my travel trailer at a campground outside the park. Being a hard-head, I hooked up the 5th wheel and took off, taking the precaution of adding 6 gallons of coolant to my truck bed contents. As it turns out, I needed all six gallons, but the amazing truth is that the temperature gauge never cleared 200 degrees, even with the weight of a 32 foot, 10,000 lbs trailer behind the truck. On my way back from the trip, my passenger side running board became liberally coated with anti-freeze from the pressure forcing the coolant out the overflow. But, the truck never even thought about overheating.

Having made it safely home, I had to confront the looming issue of my diesel fuel contaminated engine oil and my over-pressurized coolant system. But where these two issues somehow related? And was there any chance the long warranty on the fuel injectors would somehow be extrapolated to include the repair of my coolant consumption? In theory, it was possible for the two issues to be related due to the design of the Duramax LB7 injectors and cylinder heads. Note the two illustrations in Figure 2.

LB7 injectors sit in a coolant-cooled sleeve that is pressed into the hole in the cylinder head with GM special tool J 45910. That taper you see at the bottom of the sleeve seals against the surface of the bore in the cylinder head with nothing but Locktite and are held in place by the injector hold-downs themselves.

Figure 2: LB7 injectors sit in a coolant-cooled sleeve that is pressed into the hole in the cylinder head with GM special tool J 45910.


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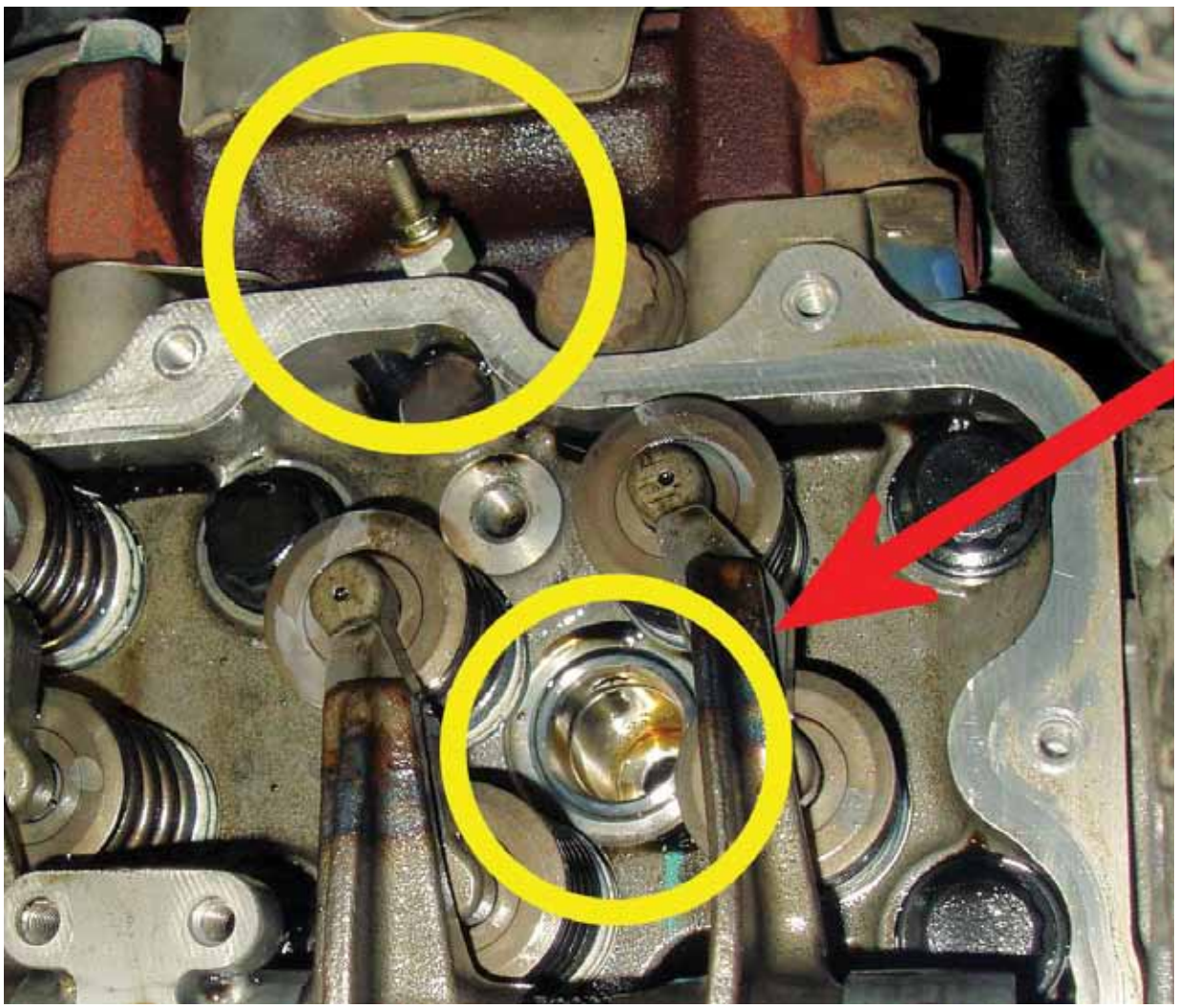
So, nothing but a press-fit aluminum sleeve under the injector separate the coolant from combustion pressure (Figure 3)! Is it not possible, then, that combustion could push past the sleeve and get into the coolant? The answer is yes; but herein lies the controversy. Does this condition EVER happen due to normal wear and tear? Or maybe due to Dexcool extended life coolant (known for eating up lots of other stuff; how about aluminum?) So, if my truck needs injectors replaced, and those injectors are covered under an extended warranty, AND the campaign includes replacing the injector sleeves "as needed", maybe I can get all my problems solved at GM's expense!

Figure 3: Nothing but a press-fit aluminum sleeve under the injector separate the coolant from combustion pressure!



## Injector replacement procedures, flat-rater style

As you can readily see, this sort of situation quickly becomes complicated. Some very experienced GM techs say that injector sleeves NEVER leak until the injectors are done without proper care. If the technician doing the job is a "flat-rater" he might choose to ignore injector sleeves that pulled up slightly when the injector was removed. If that happens, it means more work for the technician. The sleeves must be extracted, the bores carefully cleaned, o-rings replaced, and sleeves

Figure 4: First design: Head gaskets from a crimped type gasket.

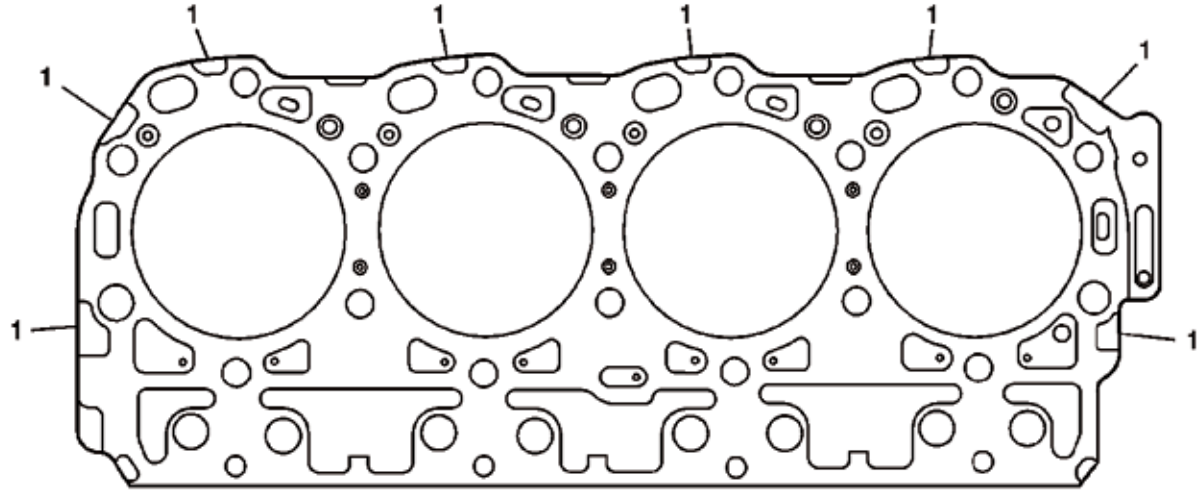
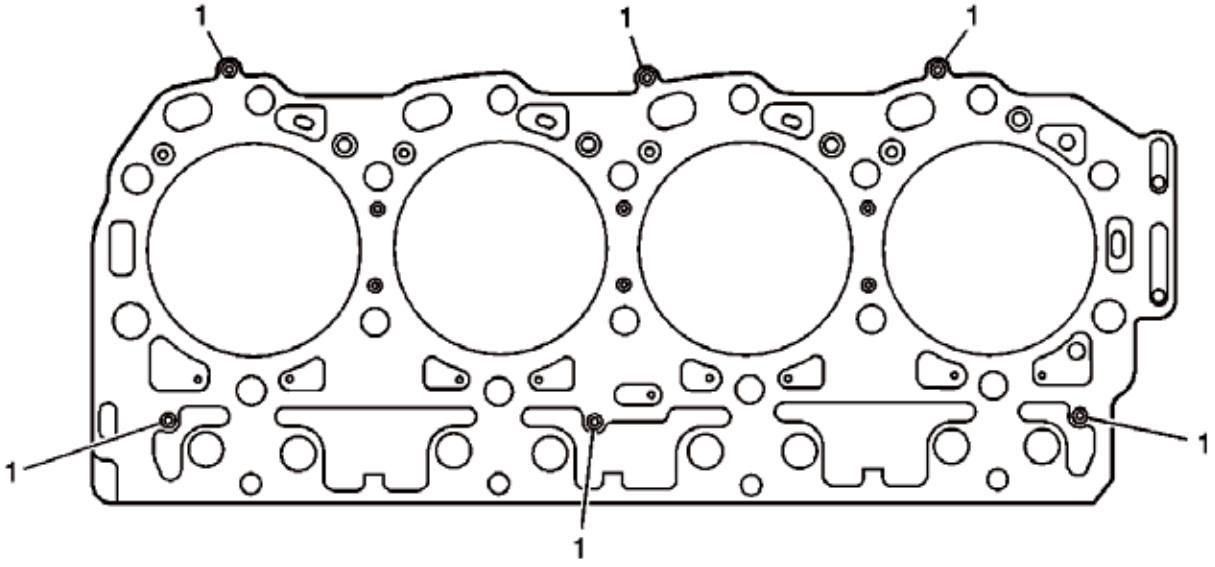



Figure 5: Second design: riveted type gasket.



reinstalled using appropriate locktite sealer. Technicians that skip this step are likely to generate a come-back with coolant consumption and a pressurized cooling system.

But, my injectors had never been touched before, as near as could be told based on available information. So, my coolant problem was much more likely due to a head gasket issue than to an injector sleeve issue. I was going to have to pull my cylinder heads to find the answer.

## MLS head gaskets

The Duramax motor uses multi-layered steel head gaskets due to the expansion rates of the aluminum heads versus the cast iron block. As has been know to happen with MLS gaskets, constant warm-up and cool-down can eventually scrub the coating off the gasket and allow combustion to leak into the coolant passages. GM has updated the head gaskets from a crimped type (Figure 4: First design) to a riveted type (Figure 5: Second design) gasket.

Notice too, the right side end of the gasket and the hole at the extreme end of the elongated passage. The position of that hole identifies the thickness of the head gasket. There are three different gasket thicknesses, and left and right are not necessarily the same. Since these identifying holes cannot be seen with the heads installed, the ordering of the proper head gaskets has to wait until the heads are off.

## Block cleanup

Most of us by now have stopped using 3M brillo pad type sanding disks for cleaning off head and block surfaces, since we have been warned that residue from these disks may get into the engine oil and wipe out the bearing. But how about using the plastic bristle type clean up disks? Not on this motor, according to GM. Out of GM service information:

1. Inspect the gasket sealing surfaces for corrosion, especially in the areas that were in contact with the crimped tabs of the first generation

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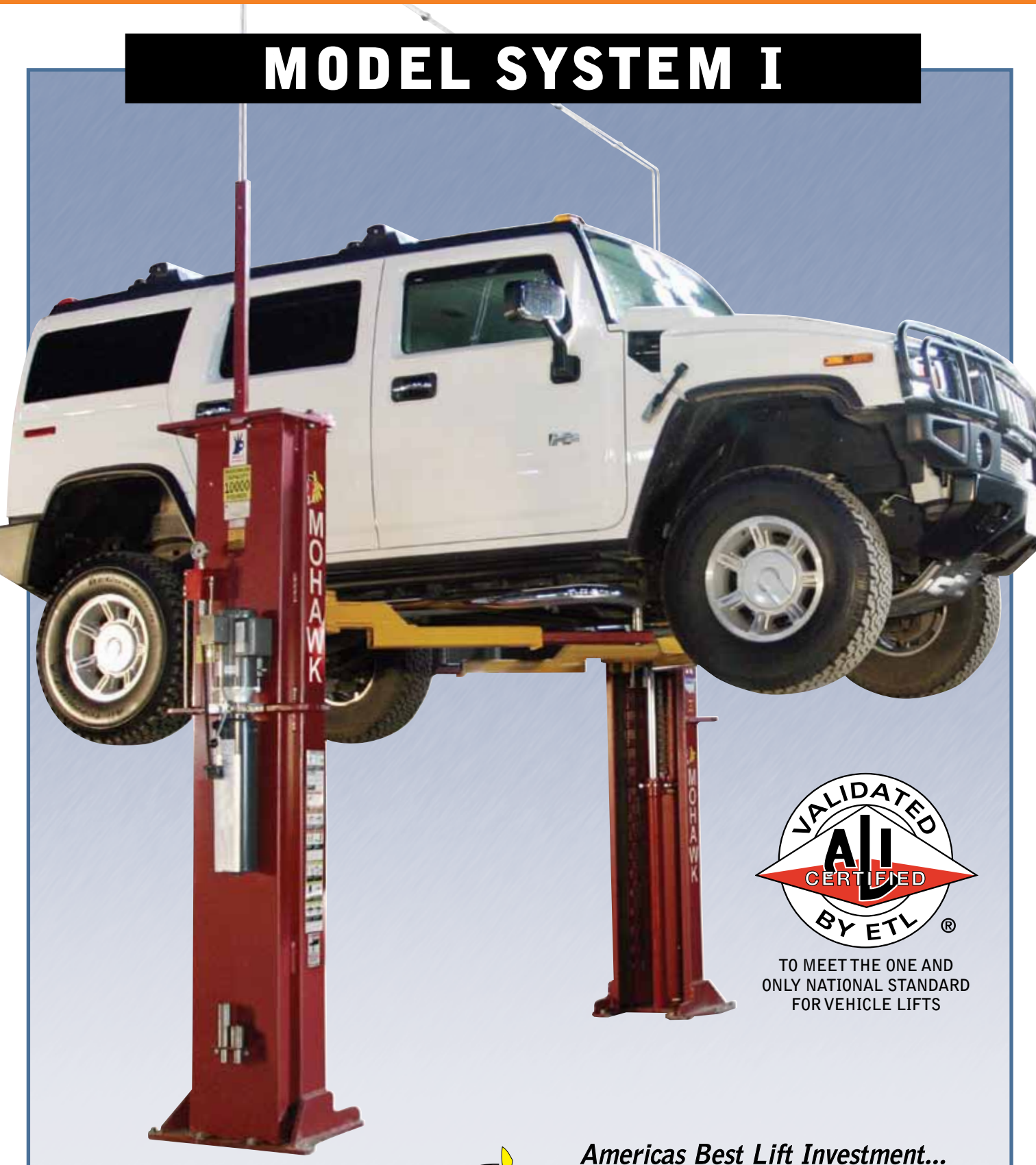
# MODEL SYSTEM I

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head gasket. If corrosion is present, continue with the rest of the steps in this procedure for proper cleaning. If the sealing surface is sufficiently clean and smooth, use the revised torque specification listed towards the end of this bulletin and continue with published service manual procedures to complete the repair.

2. For surfaces that have corrosion or pitting, wrap a piece of flat steel (4"x 2" or larger) with 600 grit wet grade sand paper. Using Moisture Displacing Lubricant, P/N 88862629 (in Canada, use 89020803) or equivalent, wet sand the block surface to remove any remaining gasket material or corrosion. Do not use any paper coarser than 600 grit.

Notice:

- Do not use any power type sanding devices.
- Do not use a wire brush or wheel to clean gasket surfaces.

They seem pretty serious about it, don't they?

## Removing the heads

The actual job of pulling the heads was not much different than a gas motor, with a few notable exceptions. First, there is a lot of stuff in the way. The high and low pressure fuel lines are a real tangle with lots of complicated brackets holding various items. While I am rarely brilliant, I had a flash of intuition on this particular job and used my digital camera to shoot pictures as stuff came apart. My only regret was that I should have taken more pictures more often, as I became engrossed in working my way down to the heads and sometime forgot to shoot my pictures.

Figure 7 gives some idea of the spider web of the high pressure fuel lines.

Removing the inner plastic fender panels gave pretty good access to the exhaust manifolds, glow plugs, and lower valve cover gasket bolts. Probably the most difficult part was the removal of the 12mm head, 12 point bolts that held the turbo exhaust tubes to the back of the right

side exhaust manifold and to the back of the turbo. The intense heat of the turbo causes these bolts to become very, very tight. Access to the bolts is very limited and only a box wrench will fit. You had better make sure it is a very good quality wrench, because a rounded off bolt in one of these places would be a nightmare I don't even want to think about. The second big issue is the lower rear head bolt on the driver's side head will not come out because it hits the cowl. This also means that it must be installed in the head before the head is set down on the block on the way back together. I solved this problem by securing the head bolt with a rubber band, just high enough to clear the gasket surface, but low enough to clear the body obstruction.

The turbo itself does not need to come off, nor does the high pressure pump, which sits in the valley of the block, just ahead of the turbo (Figure 8).

Figure 6: Lots of stuff in the way even after the accessories are off the front. Note the dual thermostats.

Once I got the heads off, the blocked sanded per GM instructions, and had the correct thickness head gaskets, assembly was pretty much the reverse of disassembly, but I took the precaution of replacing every single one of the injector sleeves, even though I probably didn't need to, as there was not the slightest evidence that any of them had been leaking. My local GM parts supplier was gracious enough to allow me to install the warranty injectors so that I didn't have to risk a flat rater doing the job with the heads already installed. And then there was the exhausting process of head bolt torqueing. 22 torque-to-yield head bolts are used to hold down the heads in four separate steps; 1st step, 37 lbs. 2nd step, 59 lbs. 3rd step, 60 degrees, 4th step, a final 60. Multiply all that by 44 head bolts and the Snap On electronic torque wrench with audible and vibration signals to tell me when I had reached the appropriate torque or rotational

Figure 7

angle became worth the price of admission. Even so, the day after this job, I awoke feeling like someone had beat me with a stick.

Final assembly became a matter of following my photographs. Lack of experience made them an invaluable aid to avoid repeating endlessly the installation and the dis-installation of the many brackets and holders which had to go back on in the right order. The job ended up taking me 30 hours to complete, and with a book time of 23 hours, I didn't feel too bad about having completed the job in that much time. The GM dealer in Fresno, California had quoted me $4,500 to do the job, a not-unreasonable price given the level of difficulty. I felt confident when I was done that our shop was completely capable of doing this kind of work on light truck diesels, in our ultimate quest to remain profitable within the framework of our rapidly changing industry.

Figure 8.

# MISTAKEN IDENTITY


by: John Anello


Figure 1: 1997 Chevy van with a 5.0L engine with a hard start no start problem.

I was called to a shop for a complaint on a 1997 Chevy van with a 5.0L engine (Figure 1) with a hard start no start problem. The shop had just replaced the engine because the old engine had a lower knock in it caused by a worn bearing. The old engine did run and the customer drove the van to the shop with no problem other then the knock in the engine. This is a situation that many of us have been in before working in the automotive field at one time or another. It's a bad feeling to drive a vehicle into the shop and later having to push it out. The blame solely lies on the shop even if it isn't the fault of the shop because a jury conviction will sway to the customer's side in court in this case.

The mechanic who put this engine in was well experienced in small block and big block Chevys. He actually restored a 1969 Chevy Chevelle with a 396 to senior show level specifications and even went as far as to make sure the replacement water pump fell within the correct serial number runs to pass show criteria. So you can only imagine how this mechanic felt after installing this engine in a flawless installation

and now ending up with a no start. He did discover that if he pulled the cam sensor connector the engine would start up but run poorly. This prompted him to replace the cam sensor but the problem still remained. He even tried a crank sensor just in case it was damaged during the install procedure. It seemed as if the timing was off so he even checked the orientation of the distributor 3 times. He was very tempted to replace the Engine Control Module but at this point the shop decided to call me in for a second opinion.

When I arrived at the shop I attempted to start the engine but the engine labored to start and would not catch. I removed the cam sensor connector as per the mechanic's suggestion and the vehicle started up but ran very poorly. The engine did not rev up well and had no power in drive while I power braked the engine. It was at this point I decided to grab my pressure transducer and place it within the cylinder so I could determine if the engine rebuilder had indeed properly lined up the timing chain. I placed one of my scope leads

Figure 2: cranked the engine and captured a waveform

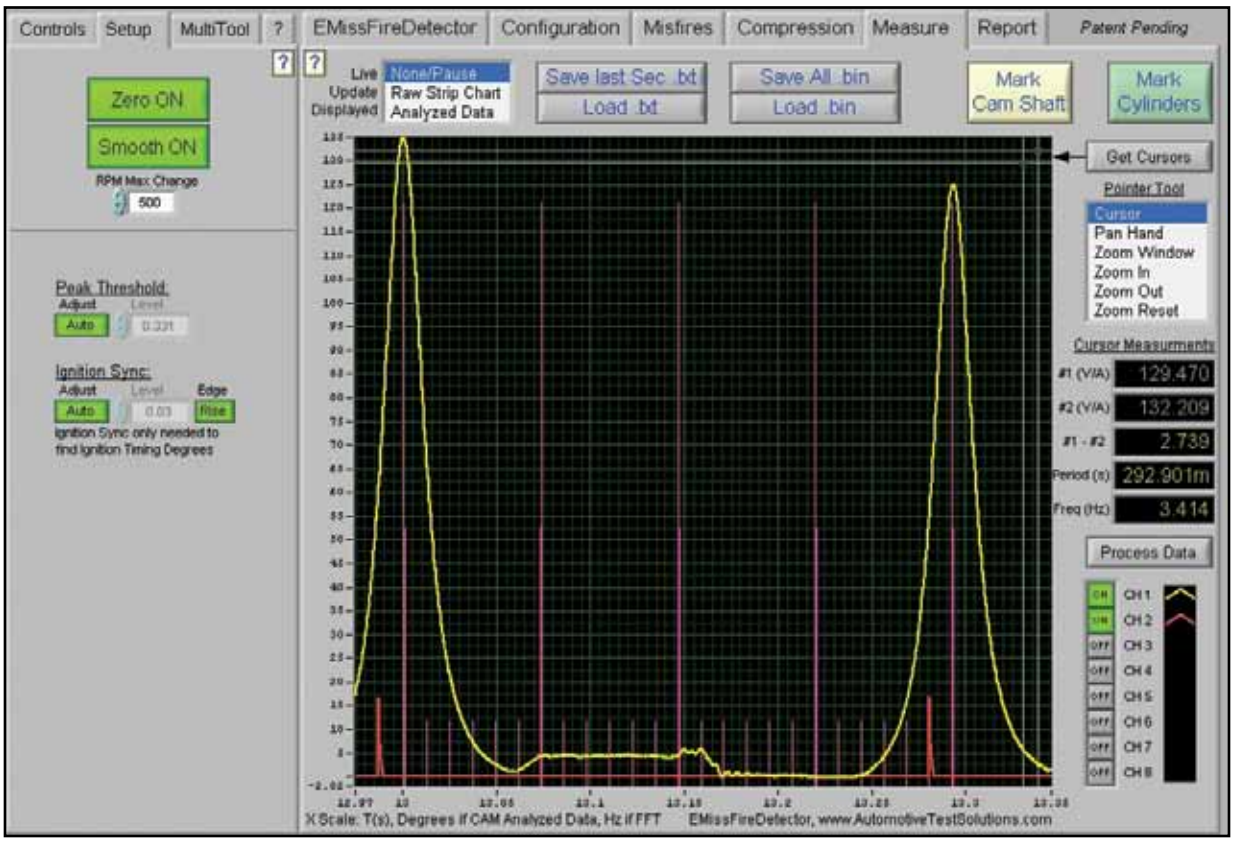

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Figure 3: The distributor housing base was marked with the intake manifold to guarantee a correct orientation of the distributor housing location.

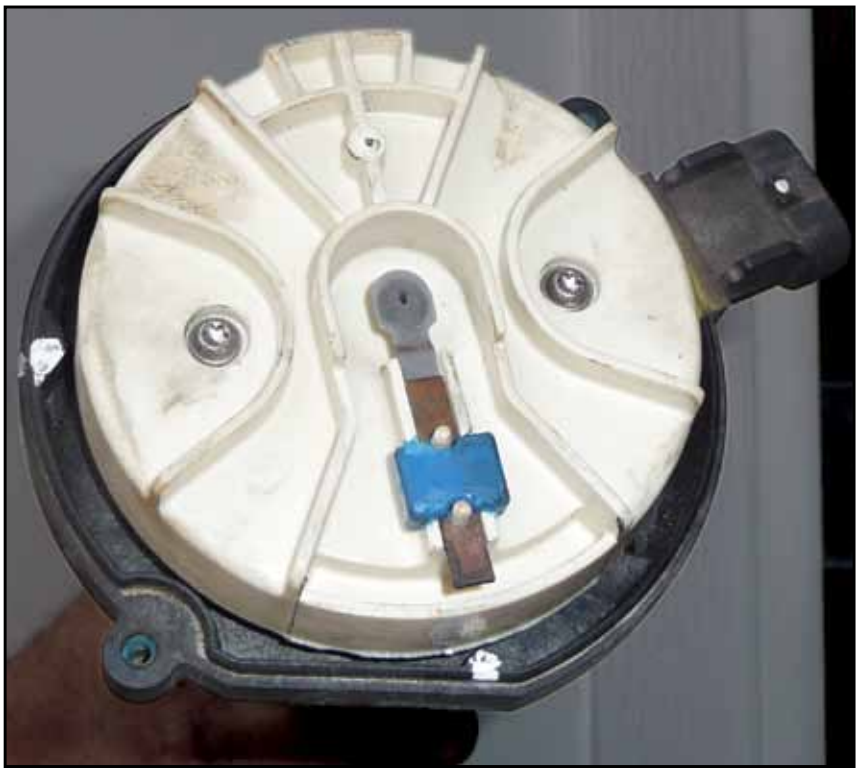

Figure 4: the same distributor being used for both the 4.3L and 5.0L and how there were two different positions to index the rotor to the distributor housing.

on the pressure transducer to check valve timing and another scope lead on the inductive clamp placed around the plug wire for the same cylinder with a spark tester to check spark timing. I cranked the engine and captured a waveform (Figure 2). Each large purple cursor represents 180 degrees of crankshaft rotation while each small purple cursor represents 30 degrees. The large pressure peak represents TDC compression and the first large purple cursor after the large pressure peak represents BDC of the power stroke. After the peak rise the waveform should drop drastically and starts to rise about 30-45 degrees before BDC of the power stroke. This is the point when the exhaust valve will begin to open. By viewing this waveform it was determined that the valve timing was correct.

If you look at the red synch waveform representing spark timing you can see that the spark was occurring about 30 degrees before TDC compression while cranking the engine. The only way this could happen is if the crank and cam sensors were out of correlation.

At this point I turned to the mechanic and questioned his ability to set the distributor in properly. He gave me a look like "Are you kidding me dude?". But I had to ask anyway because the waveforms don't lie. The mechanic proceeded to show me how he was careful to mark the distributor housing base with the intake manifold to guarantee a correct orientation of the distributor housing location (Figure 3). He next schooled me about the same distributor being used for both the 4.3L and 5.0L and how there were two different positions to index the rotor to the distributor housing (Figure 4). The 6:00 position as viewed in Figure 4 was labeled with a number 8 for correct orientation. It was then only a matter of dropping the distributor into place on TDC compression for #1 cylinder which he did three times.

To prove things further I decided to scope check the crank sensor, cam sensor and the. coil primary to see if the signals were in synch and to make sure we had 8 good coil firings without dropouts. While cranking the engine I captured a waveform (Figure 5) to compare to a good known waveform from Thompson

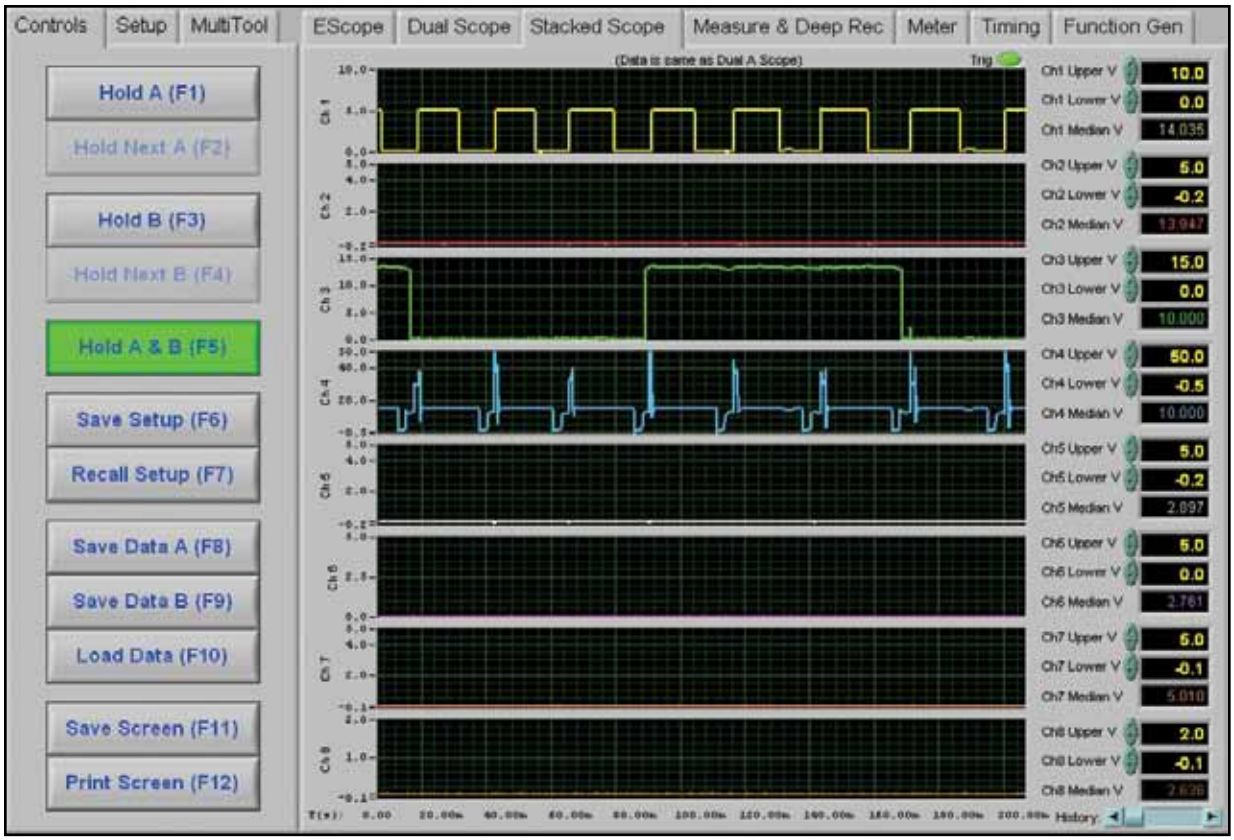


Figure 5 (Above): cranking the engine I captured a waveform to compare with Figure 6 (Below).

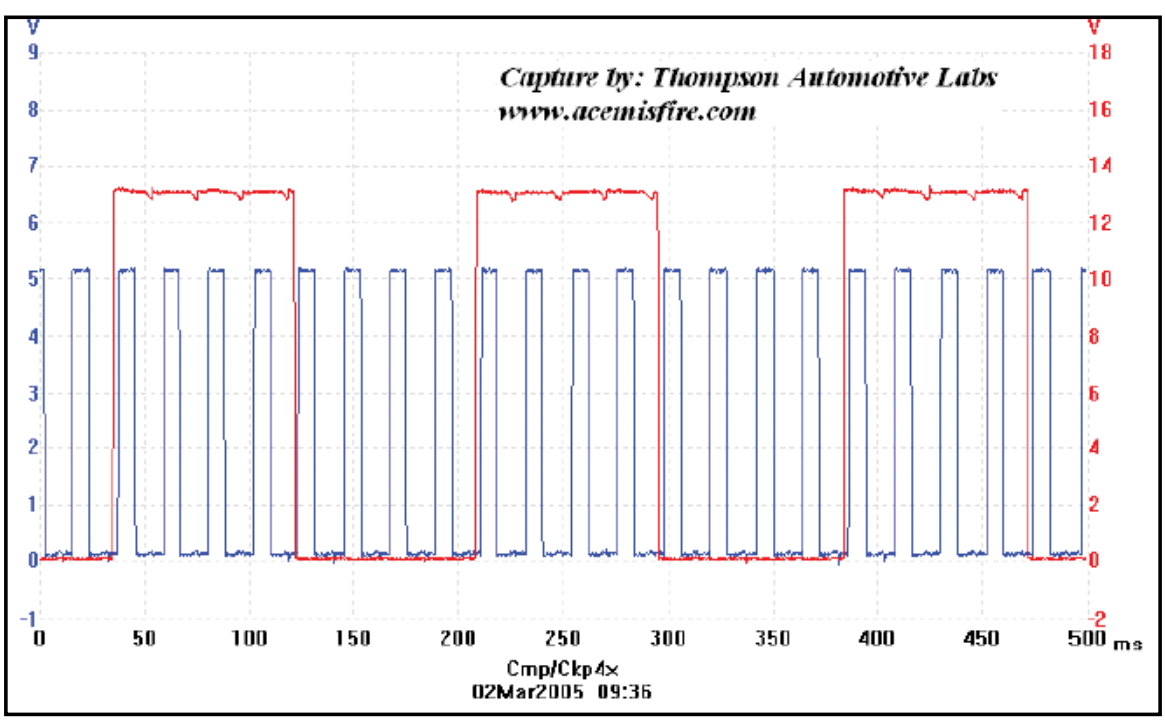


Figure 6: a good known waveform from Thompson Automotive Labs (GM 5.0 --Index).

Automotive Labs (Figure 6). As I looked closer at both waveform files I noticed that the one captured from the vehicle showed only 6 coil firings with one revolution of the distributor and looking at the crank signal I only saw 6 square waves. This engine had to have a wrong crank trigger wheel in it.

To prove my findings I waited at the shop while I had the mechanic remove the front crank pulley and timing cover. When the timing gears were

Figure 7: The engine rebuilder had accidentally installed a trigger wheel onto the crankshaft for a 6 cylinder engine instead of one for an 8 cylinder.

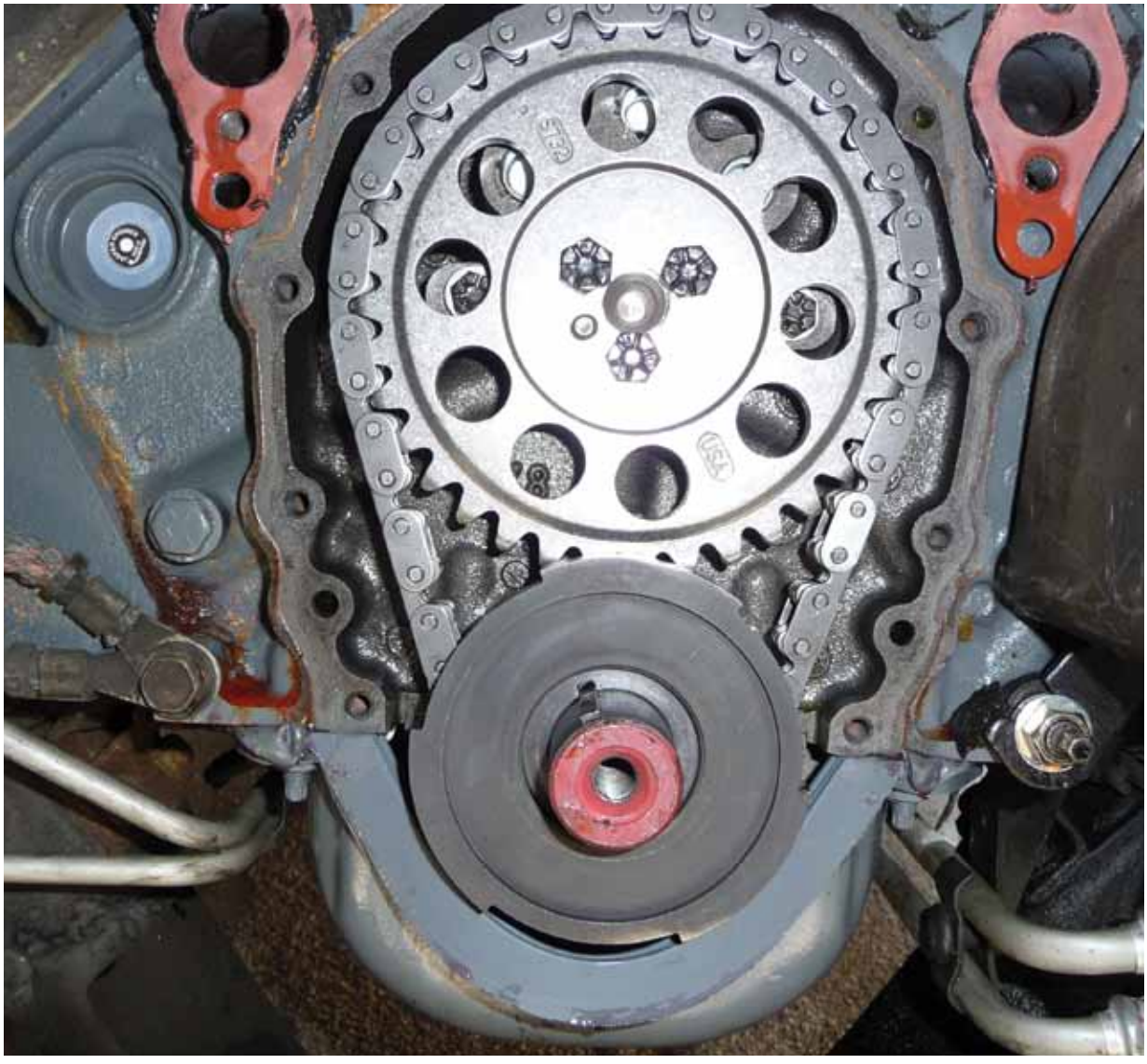

Figure 8: Both trigger wheels are configured to fit on the same crankshaft with no problem. The correct one had four triggers per revolution, instead of three.

revealed, to our surprise we found our culprit (Figure 7). The engine rebuilder had accidentally installed a trigger wheel onto the crankshaft for a 6 cylinder engine instead of one for an 8 cylinder. What a nightmare unveiled! I kind of felt sorry for the shop for all the time they had into dealing with this dilemma. You can't always trust parts you buy and now it's a point where you can't even trust a rebuilder to do his job.

I went back the next day to capture a picture of the correct trigger wheel. You can see by laying both trigger wheels side by side that they are both configured to fit on the same crankshaft with no problem at all (Figure 8). The only difference here was that the correct one had 4 triggers per revolution. The mystery was now solved but this was some battle for the shop who could not be paid for all their lost time and unwanted parts. The rebuilder did however apologize and said plainly "It Happens!" I just hope that this one will help to teach you to never take anything for granted and always go with your first feel when you encounter a problem vehicle.

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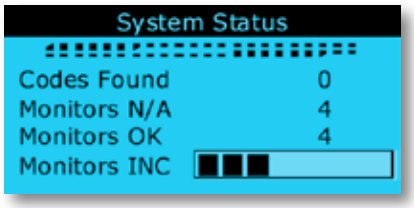


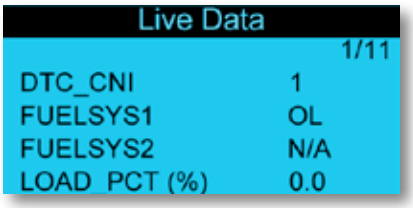


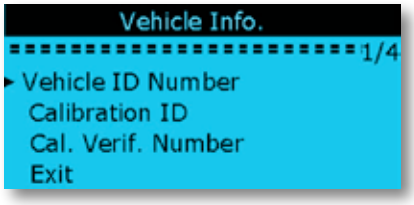


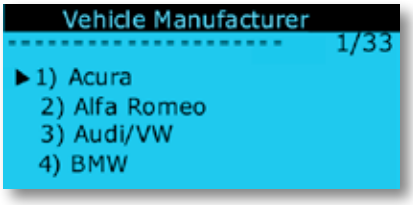


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# Performance Suspension

## Offer more than just OE handling to attract higher-end customers


by Steve Campbell

Many service and repair shops offer stock-replacement suspension components and provide basic alignment services. But there is more potential under the car than what is found in original equipment. It takes an enthusiast of at least moderate technical knowledge to appreciate the benefits of a well-tuned and matched system that minimizes body roll and optimizes weight transfer. When such a customer enters a shop looking for springs, dampers, bars and bushings—or even just a performance alignment for an existing handling package—he'll expect to pay a fair price for top-quality parts and service. A shop that offers performance packages may also see customers who are looking for cosmetic changes only, wishing to lower a car to utilize a wheel and tire combination that better fills the wheel well. While those packages also promise good profit margins, the customer must be made aware that simple lowering doesn't necessarily enhance performance.

"A good shop can prosper from adding performance suspension upgrades to its abilities," said Edelbrock's Arty Feles. "Many shops stay away from the installation of aftermarket performance upgrades because they have had bad experiences

or problems with something not fitting properly. Shops can eliminate these types of problems by dealing with only products from reputable companies focused on design details, performance and high-quality workmanship. Look for complete, tested packages. Choose parts that are designed to work together. Do not attempt to piece together selections from various sources."

A complete system will include springs, struts, dampers and additional specialty parts that will allow proper

Performance suspension products are available for a wide variety of vehicles. The three shown in this photo from the Hotchkis Performance development garage include a 2003 BMW M5 that was given a special track-day alignment, a Nova that received a complete suspension system installation and a 1967 Camaro that was fitted with upper and lower A-arms, subframe connectors and an X-brace as well as a special performance alignment. (Photo courtesy of Hotchkis Performance)

This "Bullitt" Mustang has been equipped with nearly all of Maximum Motorsports' suspension parts. As seen in the following two photos, the customer powder coated most the specialty components yellow, so they stand out very well on the bottom of the car. (Photo courtesy of Maximum Motorsports)

installation and alignment. In most cases, a performance suspension system designed to improve handling will include lowering springs with a higher rate, meaning a stiffer spring.

"The stock shocks will not be able to properly dampen and control a spring that is stiffer than stock," said Chuck Schwynoch, CEO of Maximum Motorsports Inc. "Keeping the stock shocks will cause the car to be under-damped. It will feel bouncy and disconnected from the road. Installing shocks that match the spring rates will improve both performance and ride quality. Knowledgeable vendors offer more complete packages to ensure that an emphasis on improving appearance does not sacrifice ride quality and handling. A shop just getting into selling performance parts should stick with a vendor that is an expert in the area and should consult directly with manufacturers of aftermarket parts. The shop should avoid trying to put together its own packages until it has gained a lot of experience in this area. The shop should be wary of

customers who want to cut corners to save money. An example of this would be a customer who wants only lowering springs but does not want to purchase the matching struts and shocks. This sets the shop up for a comeback when the customer discovers that his car is under-damped, causing poor ride quality and poor handling."

The automakers design cars with economies of scale and middle-of-the-road performance in mind. A shop that wishes to attract performance enthusiasts must be able to offer products that will provide crisper handling and enhanced cornering capabilities.

"Service and repair shops may wish to limit aftermarket support to bolt-in products only," advised Matt Jones, an engineer for Art Morrison Enterprises. "These types of products require little or no fabrication or welding, but they improve performance and aesthetics. They can range from items such as A-arm bushings to full suspension kits that replace almost every OEM component."

Lowering a vehicle through a shorter but stiffer spring also reduces the travel for absorbing a bump. Without progressive spring rates that increase when the wheel travels up or stiffer linear rates such as those found in motorsports applications, the suspension will bottom out more easily. Going too stiff will not only affect ride quality but, depending on the road conditions, available grip as well, according to Oliver Rathlein, director of sales and marketing for Eibach Springs Inc.

"The appearance customer is looking to get rid of the ugly fender gap without losing ride quality when going to plus-sized wheels and tires," Rathlein said. "The smaller the sidewall, the more the fender gap is exaggerated. The performance customer is looking for a lower center of gravity, increased spring rates for reduced body roll when cornering and reduced squatting or nose-diving when accelerating or braking. With progressive spring rate designs, the initial rate is only slightly higher than stock, and the spring rate will increase, offering more performance as the suspension

travels. I would recommend that shops use manufacturers that have TUV QS9000 and ISO 9001 quality approval, which allows them to be Tier 1 suppliers to any of the big automotive manufacturers. We make a lot of springs and sway bars for several OEs and private label for their performance divisions and select tuners."

It is also crucial that the shop determine what specific effect the customer is looking for. The suspension components used for street cruising will be different from those for canyon carving or track events such as autocross or drag racing, said John Hotchkis, president of Hotchkis Performance.

"A performance alignment for aggressive street driving has more negative camber and less toe-in than stock specs," Hotchkis noted. "A car

The full list for the front end includes Bilstein struts with coil-over conversion kit; a Maximum Motorsports (MM) K-member that supports the engine and the front suspension; a MM front control arm that is used only with a coil-over conversion kit, since it has no provision for mounting a spring in the OEM location; an aftermarket driveshaft safety loop, which constrains the driveshaft in the event of a catastrophic U-joint failure and is required by drag-racing sanctioning bodies; and an MM crossmember that provides the front mounting point for the MM torque-arm. (Photo courtesy of Maximum Motorsports)

used for track-day events will have an even more aggressive alignment set-up. Repair shops should shy away from performance work if they are not equipped to tailor a vehicle to the owner's needs. A certain amount of specialized work is required for each vehicle. Too low, and negative things happen to the suspension, including excessive camber, limited or no bump travel, driveline vibration, damage to shock absorbers, accelerated tire wear and vehicle instability. Properly designed suspension products can alleviate these problems. For example, camber plates and camber links can help restore and improve alignment specifications. A-arms can correct and improve camber curves and increase caster for more high-speed stability. Adjustable trailing arms and driveline shims or brackets can eliminate vibrations at a lower ride height."

The rear of the Mustang has been fitted with Maximum Motorsports products that include a panhard bar chassis mount; a rear lower control arm that mounts the OEM rear swaybar but has no provision to mount a spring in the OEM location; a rear coil-over conversion kit; aftermarket Bilstein shocks; and MM torque arm that converts the OEM four-link suspension to a torque-arm suspension design and requires removal of the upper control arms and addition of the panhard bar; and full-length subframe connectors (black) that were welded into place. (Photo courtesy of Maximum Motorsports)

For a suspension system to work properly, each component must be carefully matched to the others. For instance, higher-rated springs require more substantial shocks that may be adjustable and contain more fluid to control heat buildup during extreme conditions.

"Shock valving must complement spring rates," explained Craig Morrison, marketing manager for Art Morrison Enterprises, "and spring rates must accommodate the vehicle's characteristics, such as center of gravity, vehicle roll axis and desired ride stiffness." Morrison reiterated that the goals for the vehicle, such as

In some cases, a shop may install an entire system to dramatically improve the handling of a classic musclecar. This bolt-in front clip for 1967-69 Camaros from Art Morrison Enterprises also fits first-generation Firebirds and 1968-72 Novas. It requires no cutting or welding and can be installed using commonly available tools. It is designed to accommodate small-block Chevy, big-block Chevy and LS-series engines as well as virtually all popular manual and automatic transmissions, including Richmond five- or six-speeds and T56, TKO, Muncie, PG, TH350/400, 700-R4 and 4L60E units.
(Photo courtesy of Art Morrison Enterprises)

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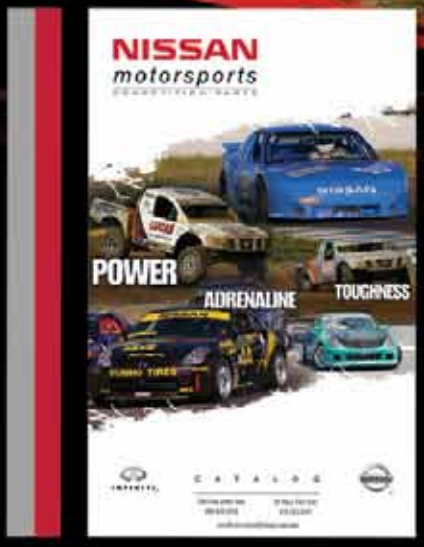


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**SHIFT**_the way you move

Many older vehicles may be updated with the Mustang II front spindle, so Wilwood Engineering and Art Morrison Enterprises developed a premium quality, state-of-the-art replacement. The spindle's design has been refined to reduce roll-center migration, Morrison says, and it is taller than the original for improved geometry. It can accommodate radial-mount calipers and brake rotors up to 14 inches in diameter to enhance braking potential. It can be retrofitted to any front suspension currently using Mustang II-type components. (Photo courtesy of Art Morrison Enterprises)

the desired cornering performance, must be matched with suspension hardware to maintain structural integrity yet minimize weight. "Anti-roll bars are often calculated after spring rates as a way to fine-tune body roll during cornering," Morrison said. "Even small items such as anti-roll bar end links and A-arm bushing durometer can be used to fine-tune how a car handles at its limits."

Tailoring the handling to vehicle purpose entails understanding the geometry built into the vehicle at the factory and then adjusting the components to suit.

"You want to replace the OEM dampeners whenever you lower a vehicle because the increased rates will eventually wear out the stock dampeners over time anyway," said Joey Berry, an inside sales consultant for Progress Technology. "Pick a spring that caters to the driving style and the road conditions. If you want more roll resistance without a sacrifice of ride height, anti-roll bars will do the trick. Keep alignment in mind when lowering a vehicle, because tires are another area with many choices. Price, road conditions and road noise all become factors in that decision."

In fact, tires and wheels are usually the starting point in determining suspension changes. Sidewall size and stiffness as well as wheel size and weight may create chassis demands that limit other modifications.

"The wheel and tire package is often overlooked," cautioned Bob Adams, business development manager for Steeda Autosports. "There has been a movement over the past several years to go to large-diameter wheels and reduce the size of the sidewall, but you have to have a satisfactory amount of deflection in the tire through a stiffer sidewall. Sometimes it's better not to go with the absolute largest wheel you can buy. It makes more sense to go with a plus-one or a plus-two wheel and a performance tire that gives you aggressive sidewall construction. As you upsize the wheel, you're increasing wheel weight, and that is unsprung weight."

Unsprung weight consists of mass that is not supported by the vehicle's springs, including the tires, wheels, brake rotors and spindles as well as live rear axles and some portion of the struts, shocks, springs and control arms. Sprung weight consists of the load that is suspended on the springs, which is the majority of the car.

"The lower the unsprung weight, the better the handling and the ride quality," Schwynoch said. "Less unsprung weight allows the tire to more easily follow irregularities in the road surface because the struts and shocks have less weight to control. Keeping the tire in better contact with the road improves traction and cornering grip over rough surfaces.

Reducing rotating weight by installing lighter tires and wheels will improve acceleration and braking because the engine has less mass to bring up to speed and the brakes have less work to do when stopping."

Because of their bulk and vehicle-specific nature, performance suspension products may be difficult to keep in continuous inventory along with stock-replacement parts.

"You could have a guy with a Camaro one day and a Mustang the next day, so it might be tough to stock exactly what will be needed for a specific car," said Kevin Doyle, sales

The aluminum spindle on this classic GM suspension was made by American Touring Specialties. The set-up also includes a Global West upper control arm, which comes assembled with ball joints, bump stops, billet cross shafts and Del-A-Lum bushings with a black powder coat finish. Global West says that these arms provide a better camber curve to keep more tire on the ground for better straight-line stability, corner entry and overall drivability. The G-Plus lower control arms are available for either coil-overs (QA-1 model shown installed) or standard coil springs. The coil-spring version has a spring cup with a polyurethane cushion that rotates to allow proper indexing of the spring. (Photo courtesy of Global West)

and marketing manager for Global West. "You probably want to keep inventory down so that you don't have your money tied up, and you may not have the shelf space for a lot of parts. An installation shop is probably better off to order per job and then schedule a time for the customer to bring the car back for installation. A reliable warehouse distributor in the area might have everything in stock and be able to provide it all at once."

As with other types of performance products, marketing suspension modifications is a matter of reaching the niche enthusiasts who are looking for competent technicians and shops. Displaying at track days or offering contingency sponsorships at local autocross events as well as car shows will go a long way toward establishing credibility. Advertising in local publications that target enthusiasts is also beneficial, and most performance-suspension manufacturers offer literature and point-of-purchase materials to their dealers.

"You definitely need to get the message out to the enthusiasts," Morrison advised, "so it's best to go where they go. In addition, be sure that your company's website is up to date, if you have one. It should include all of the information about what aftermarket parts you carry and, if possible, a few installation shots or 'before and after' pictures to help customers visualize what their own vehicles might look like. Lots of product information, catalogs and flyers are always helpful as well when customers are gathering information."

Marketing to the appearance customer may generate even more sales than seeking only those who want improved performance. Don't alienate the more hardcore customers who are willing to sacrifice comfort for handling ability, but be honest about the pros and cons of different packages.

"The majority of customers want to improve the appearance of their cars," said Schwynoch. "Their definition of improved appearance typically means a lowered stance and aftermarket wheels and tires. Most people will tolerate a slight degradation in ride quality, but they

should be made aware that extreme changes would have a significant impact. The average consumer is more interested in appearance but would also appreciate an improvement in performance as long as the sacrifice in ride quality is not too great."

The automotive specialty-equipment industry is now selling parts to the tune of more than $35 billion per year. Personalizing a vehicle is no longer confined to a small group of enthusiasts. Now, even new-car dealers are using accessorization as a means to draw customers to the showroom, and performance modifications have become a significant source of profit for many shops. To learn more about the types of performance suspension products that may bring buyers to your business, seek advice and installation information from quality manufacturers. As Schwynoch put it, "They want to help you sell their products."

This is Total Vehicle System (TVS) suspension package for 1964-72 Chevelle, El Camino, GTO, 442 and other GM A-body cars from Hotchkis Performance is designed and engineered to work as a system for handling and performance improvement. Hotchkis says that its sport suspension packages are designed to provide better performance for a variety of domestic, European and sport-compact cars. The systems come complete with all hardware and are easy to install. (Photo courtesy of Hotchkis Performance)


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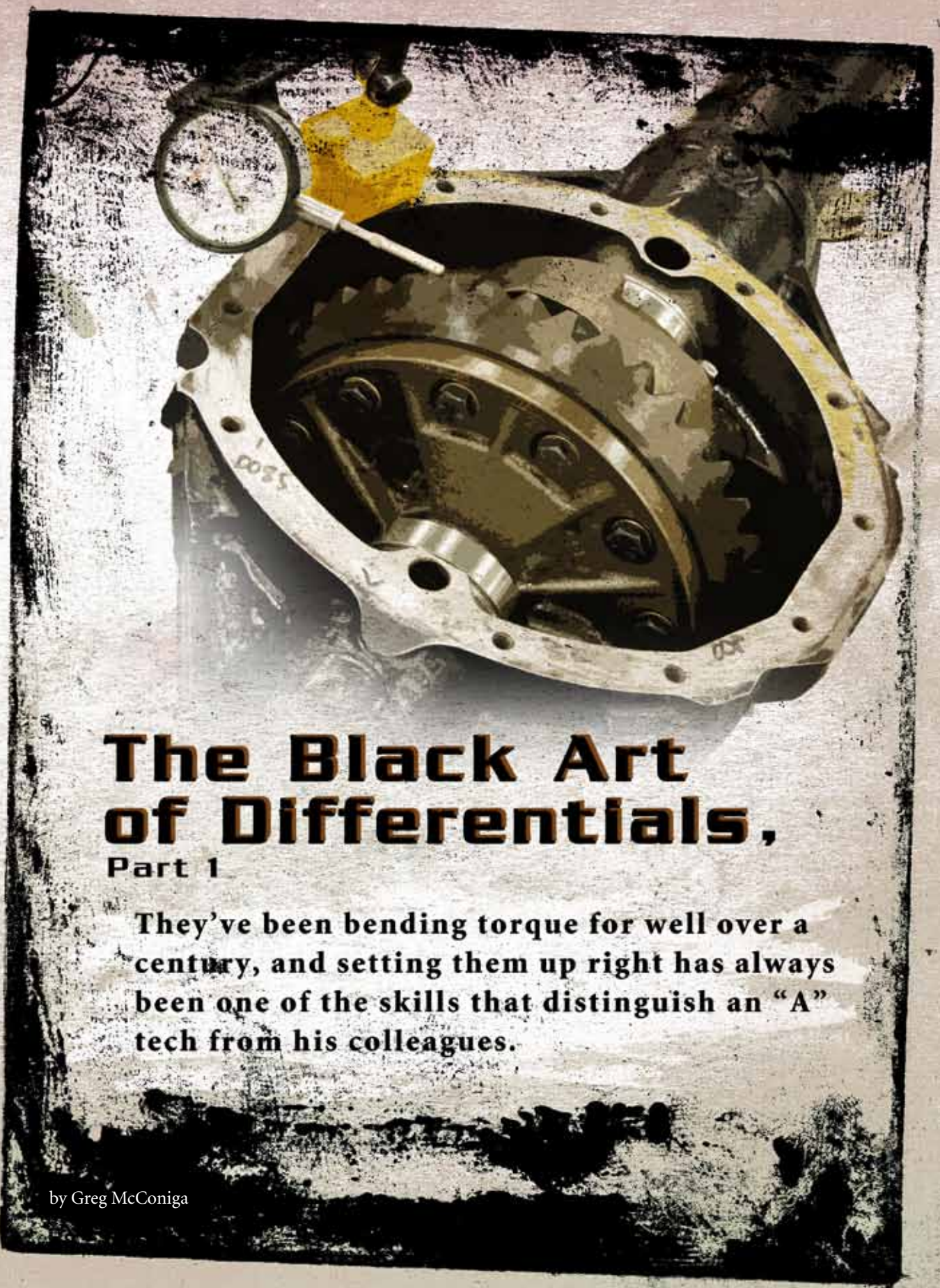

# The Black Art of Differentials,

## Part 1

**They've been bending torque for well over a century, and setting them up right has always been one of the skills that distinguish an "A" tech from his colleagues.**

by Greg McConiga

When it comes to setting up differentials, urban legends and the old "I knew this old racer guy once, and all he did was…" war stories reign supreme. You hear it all the time. I was having a discussion with a guy not long back about rod bolt stretch installation techniques, and he said he just torqued them to specs and gave 'em an extra quarter turn. Said he never had one fail. Well, all righty then. I guess I can put that expensive tenth-reading dial indicator and stretch bracket up for sale on ebay. If I'd only known…

Look, there are lots of things we can get away with -- for a while. And there are lots of guys out there who will tell you that time is money, and checking things takes time, but checking is cheaper than comebacks, won't-leaves and can't-make-it-backs, and that's a fact. It's not just the time to redo your work that costs you money. In these economic times, it's lost customers and reputation that will really burn your business to the ground. You don't ever want to become the guy who always has time to do it twice, but never the time to do it right.

Differential repairs are a growing part of our business. There are lots of them out there and more of them are being built every day. America's insatiable demand for larger vehicles, SUV's and light trucks, combined with our love of rear-wheel drive guarantees that differential repairs are going to remain a source of profit for some time, so let's get into it.

Checking backlash.

## What is it?

Differential gears as used in modern vehicles are sometimes mistakenly called hypoid gears when

they are actually spiral bevel gears, defined by the conical shape of the drive pinion head. There are advantages to this design. More than one drive pinion tooth at a time is engaged with the ring on a spiral bevel, thus dampening resonance noise by controlling load/unload sounds and vibrations and smoothly "handing-off" power from tooth to tooth.

Spiral bevel gears are inherently quiet and more efficient than true hypoids, and as a side benefit the conical shape of the pinion head allows the pinion to be offset below the center of the ring or crown gear, allowing for a larger pinion drive head for increased strength. A below-center offset also lowers the driveshaft in the chassis, which reduces the hump that intrudes into the cabin, resulting in more passenger room.

## How's it Fail?

With "normal people," you may occasionally see a damaged ring or pinion, but in most cases rumbling noises emanating from under the chassis brought on by a failed bearing will bring the customer to your door long before the unit is smoked. Putting in a ring and pinion will usually be a performance upgrade, or a repair generated when Race Car Eddy side-steps the clutch at 6,000 rpm.

False brinnelling.

The most common problem will be a bearing failure due to either spalling, or loss of lubrication. Spalling occurs when the surface of a bearing's inner or outer race begins to chip out or peel. It's mostly the result of work hardening, where

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the maximum shear stress occurs just below the surface of the race, loosening the surface after which the next passing roller shears the spall off. The ball or tapered roller of a bearing shoves a tiny wave of metal ahead of it as it rolls across the race, and the surface of the race eventually just fails. Spalling is characterized by irregular pits and chunks missing from the races and bearings. The process is accelerated by lubricant type, level, purity, and duty cycle (how long has the bearing been in service and how has it been loaded?).

The other type of failure you might hear about is brinelling. This occurs due to impact, and can be induced by road shock or improper bearing installation. It's characterized by what appear to be "dents" in the race or races that are about the same length as the rollers in a tapered roller, or coincide with the contact points of the balls on a ball bearing. You may also encounter false brinelling, which is damage caused by fretting, with or without corrosion. False brinelling looks very similar to brinelling, but is caused when lubricant is pushed out of a loaded area by a repeated shock or motion, as in vibration.

In normal operation, a roller bearing has the rollers and races held apart by a thin layer of lubricant. In fact, should any two bearing elements ever actually touch, failure will occur within seconds. Although the lubricant appears to be fluid and not solid, under high pressure it acts like a solid and keeps the bearing and race separated. Think of it this way: A belly-flop into the pool from three feet up is fun, but try it from 2,000 feet at and you'd be hard-pressed to figure out if you're landing on water or on the hood of a Buick. This looks-like-a-liquid-acts-like-a-solid principle is exactly the same for any roller, ball or insert bearing and any lubricant you've ever used on a motor vehicle, including crankshaft and cam bearings, rocker pivots and pistons. There is one immutable rule for bearings of all types: If it touches, it's toast.

The piece we're looking at today is a GM 12-bolt, but the principles of setting up a differential are the same, no matter who makes it. Shim locations and side bearing pre-load and backlash adjustment methods

may vary, and pinion bearing pre-load methods differ, but the fundamentals remain the same.

First, you need to pre-load the bearings to compensate for forces that are trying to shove them apart. Second, you need the top of the head of the drive pinion a specified distance from the centerline of the ring gear, and, third, you need some backlash between the ring and pinion gears. In theory, backlash could be zero, but in the real world some backlash must be allowed to prevent gear tooth interference or bind due to tooth cutting errors and expansion from heat.

## A Little Secret for You...

For simple re-bearing jobs, the dirty little secret that most old hands with differentials know is that in 98% of the cases you can simply reuse the old pinion depth shim and the original cast factory side shims and the depth, backlash and carrier preload will be on the money. Think about it: If the vehicle comes in with a roaring front or rear pinion bearing, or side bearings that are spalled, none of the critical dimensions have changed. The housing, carrier, drive pinion and ring are all the same, and if you're using a quality bearing the bearing inner race, dimensions will be within .0005 in. of the originals, which means that replacing them just puts you back at the starting point for that differential. Even if you replace a ring and pinion, using factory or even aftermarket parts, I can tell you that the factory-installed pinion depth shim will usually be pretty close to what you'll need with the new setup. At the very least, it's a great starting point.

Pinion depth shim.

## Getting started ... easy stuff first

Clean, clean, clean!

Once you've identified the problem, teardown is straightforward. Driveshaft out, rear cover off, carrier bearing housing caps off, carrier and ring gear out (keep the side shims and caps on the correct sides -- I take the lube off them with brake cleaner and mark them with a Sharpie). Then, flange off and drive pinion out, and all that's left to do is drive out the pinion races. Now, clean, clean, clean, especially if there's shrapnel involved. Even if there's not, clean anyway. You don't know if you're the first guy in this rear end, or just the next guy, and maybe the last guy didn't clean like he should have. I've

There can be lots of swarf in the tubes.

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Nice and clean now.

Depth shim under rear pinion bearing.

got a piece of ¾-in. electrical conduit to which I duct-tape a bunch of rags and run through the axle tubes like an artillery man swabs a gun bore. Then, I wash the tubes down with plenty of brake cleaner and blow them out with plenty of air. Take a look at the picture. See all that swarf on the rags? This was a performance upgrade with no customer complaints, but at some point in the past this rear axle shucked its guts, and someone didn't get the axle tubes cleaned. The rebuild looked fresh, so that previous repair was a comeback in deferred status. You can't run a chunk of metal twenty or thirty thousandths of an inch thick through a gear set with eight thousandths of backlash in it without bad things happening.

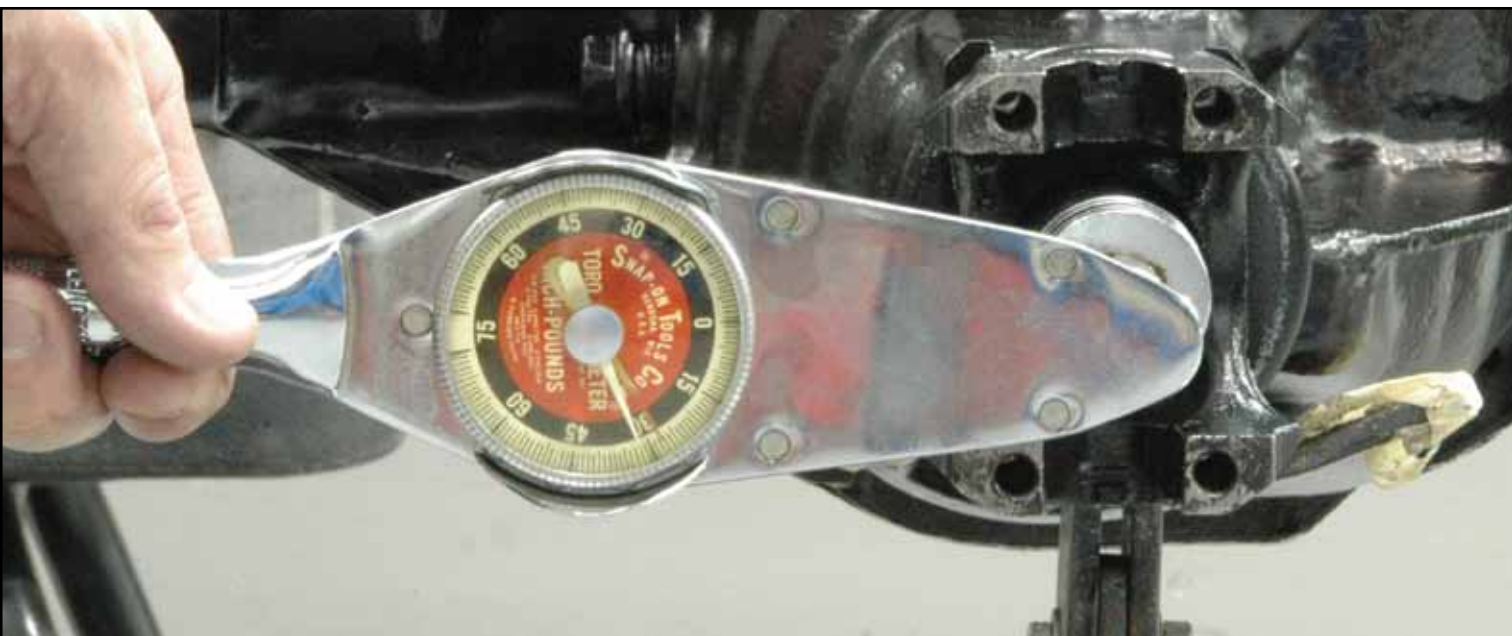
If you're just putting bearings in, press the side bearings and the rear pinion bearing off, keeping track of the depth shim that's between the bearing inner race and the backside of the head of the pinion. Solvent wash everything, air dry everything and inspect the ring, pinion, side gears, differential pinions and pinion shaft for wear. If it all looks good, press a new pinion bearing onto

the drive pinion – don't forget the shim! – and press new side bearings onto the carrier. Using a race driver, install both pinion bearing races and put the front bearing in behind the pinion seal and drive the seal home. Make sure to lube all bearings with gear oil before installation. Now slip a new crush sleeve onto the pinion and slip the pinion through the front bearing. Install the flange, install the washer and nut, and tighten to the correct preload.

While I'm thinking about it, here's a little trick to speed things up. Check and record the backlash before you take the differential apart. If you've got a set of depth micrometers you can also check the distance between the ground, flat surface where the carrier bearing cap bolts to the housing and the drive pinion head before you loosen the drive pinion. Compare that measurement to what you've got after the new bearings are installed just to make sure there were no major changes in the pinion depth that occurred with the new bearing. In my experience 98% of the time you won't see enough change in depth or backlash to make a difference.

Now, just install the carrier with new bearings and races, keeping the side shims on the correct sides and tighten the bearing caps to specification. Check your backlash -- again, I've never seen a significant change with new bearings, but that doesn't mean it can't happen, so check it anyway. Fill the differential with lube and your customer is back in business.

Pinion bearing preload.



# Resource iATN

compiled by Chip Keen

The International Automotive Technicians' Network, www.iATN.net, is a group of nearly 54,000 automotive professionals representing 145 countries. Its mission is "to promote the continued growth, success and image of the professional automotive technician by providing a forum for the exchange of knowledge and the promotion of education, professionalism, and integrity."

Master Technician's "Resource: iATN" is dedicated to promoting the iATN mission by publishing examples of noteworthy postings.

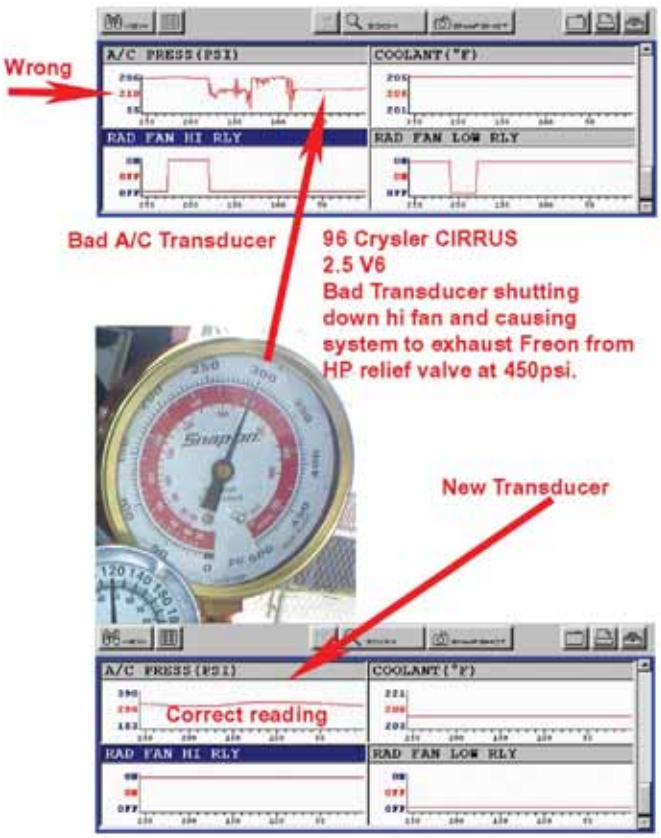



Figure 1: A bad transducer fails to signal true A/C system pressure.

## A Picture Saves a Lot of Typing

Posted July 26, 2006 by George Catanbay, owner/engineer of Advanced Conversions in Orangevale, California (Figure 1):

"The System would get up to 450 psi, then vent its charge because the computer wouldn't turn the Hi fan on.

"The shop I served, suspecting a restriction, had replaced the thermal expansion valve and dryer. It still went POOF.

"Without a scanner, there's no way to know if the ECM is seeing reality.

"Hope this helps others during this wonderfully hot season. "

Figure 2: Cabin filter on Chevy Venture.

## Check those Cabin Filters

Glenn Farrell, Owner of Farrell's Auto Air Conditioning Service in Kenner, Louisiana, contributed a pair of this issue's postings.

His cautionary "Don't Forget to Check Those Cabin Filters," was posted July 7th, 2006:

"I had two customers with the same complaint: 'Not Enough Air.'

"One was a Chevy Venture, the other was a Pontiac Transport. I tested air flow from the center ducts, and got 3 mph. Then checked their cabin filters (Figure 2), (Figure 3):

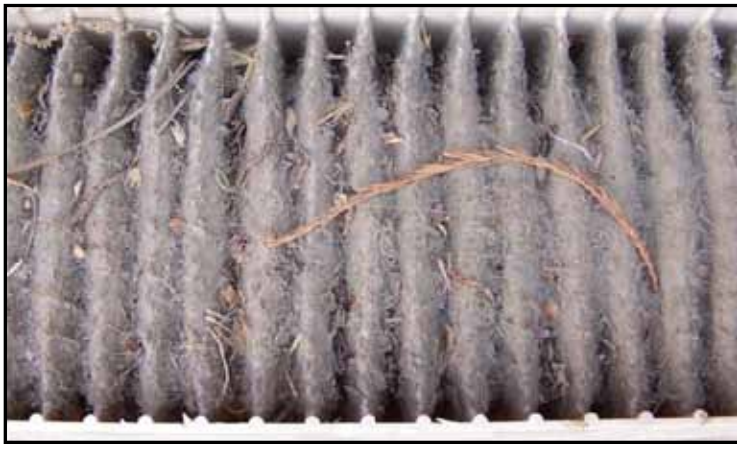


Figure 3: Cabin filter on Pontiac Transport.

"Both customers came in thinking they needed their A/C Systems recharged. When I was done, both systems were blowing ice cold, with no refrigerant added, and air flowing 15 mph out the ducts."

# Farrell's Helpfull Hint of the Day #1

For removing stuck or broken expansion tubes was posted on August 3rd, 2006:

"I've never found a tube extractor that actually works.

"I have a set of three extra long needle nose pliers – straight, 45 degree, and 90 degree – that remove 90% of them (Figure 4):

"But for the ones that break off, fear not. The tool to remove them is as close as the nearest hardware store. Get a #10 X 4" deck screw. Screw that sucker into the broken tube just a turn or two – not too deep – then pull it out.

"If it pulls out without the tube, try again, only this time screw it in a little deeper.

"If you screw it in too far, it will expand the tube, making it impossible to move.

"Sometimes just the brass tube inside the plastic tube comes out. That's fine, just screw it back in and get the remainder.

"I've never found a broken tube I couldn't remove. Some, like Ford Rangers, are harder to get to, but they still all come out sooner or later.

"Oh yeah, one more thing. Be sure the screw goes exactly in the center. I once had an over-ambitious employee put the screw through the side of the evaporator inlet."

Figure 4: Farrell's "Expansion tube extractor set."

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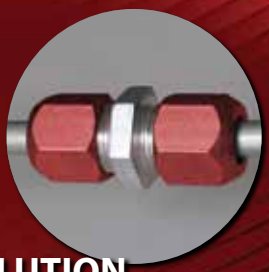

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# Close-quarters Tool for GM A/C Actuators

Posted April 14th, 2006, by Bob Duncanson, a technician at Dick Norris Buick-Pontiac-GMC in Palm Harbor, Florida:

"A recent thread about mode actuators got me thinking I should post this tip and tool.

"We seem to have a lot of problems with temp actuators, recirc actuators and mode actuators. Some just quit working, some make noise. Many of them require removing the instrument panel carrier for replacement, and pay 3+ hours under warranty.

"Being a flat rate dealer tech, I'm always looking for ways to NOT pull that whole dash. Hence, this tool (Figure 5), (Figure 6), (Figure 7):

"This is just a cheap 5.5 mm 1/4" drive socket with emery paper glued to it.

"The rivet is just for leverage to break the actuator screws loose, and for final tightening.

Duncanson's GM Actuator Removal Tool:

Figure 5: Side view.

Figure 6: Top view.

Figure 7: Disassembled.

"The sandpaper gives better grip than a knurl would. You can spin the little screws right out with your fingertips.

"It fits in a lot of places where you can't get any kind of ratchet or driver, and it works equally well on the easy ones with lots of room.

"It even makes me look forward to 'right side blows hot' complaints!"

## Jaguar XJ8/XK8 AJ V8 Service Tips

Posted to the Technical Tips Forum by George Boevers, a CMAT/L1 technician at the Maple Hill Auto Group in Kalamazoo, Michigan, on February 8th, 2006.

"Jaguar's AJ-V8 engine-powered vehicles have several areas of interest that should be inspected when you see these come in for service. The vehicles primarily covered here are the '97-'02 XK8 (X100) coupe/convertible, and the '98-'03 XJ8 (X308) sedans. The following service items are ones that I see on a daily basis.

"The AJ-26 designated engine is easily identified by locating the cruise control chamber on top of the throttle body assembly, as seen in Figure 8.

"The AJ-27 designated engine does not have this chamber fitted, as shown in Figure 9.

"The presence or absence of the cruise control chamber is the quickest way to identify which

Figure 8: The AJ-26 engine has the cruise control chamber on top of the throttle body assembly

Figure 9: On the AJ-27 engine, the throttle body assembly lacks the cruise control chamber.

engine you are working on. There are several differences between the two engines, so being able to identify them is critical.

"One of the most common problems I have seen is an intermittent no-crank /no-start condition. First verify that you have a good strong battery, then check the terminal connection shown in Figure 10.

Figure 10: The false bulkhead stud connector.

"This connection tends to loosen up over time, and cause intermittent no crank conditions. This has fooled many a tech into thinking there was a security-related fault, when in fact, this was the culprit.

"Here is a closer view of the terminal (Figure 11).

"The connector is located on the passenger side false bulkhead under the hood. Make sure it's good and snug.

"Radiator hoses are another common failure area. Notice in Figure 12 how the inlet hose is slowly walking off the thermostat housing.

"While you're at it, check the hose shown in Figure 13 as well.

"Both hoses tend to walk off the fittings. Here you have to make a decision of whether to retain the original clamp, or change it out for a screw type clamp.

"Hoses starting to slip are also an indication that the cooling system may be overheating. Monitoring the coolant temp through the ECM may yield that the engine is running hotter than normal. If it is, a new thermostat should be fitted.

"Since we are here, there are a couple of other items to inspect. Check the base of the water outlet housing where it bolts to the block (Figure 14).

"There is an o-ring at the base that tends to leak. You may also find the housing base is warped. Fixing this leak properly means removing the intake manifold, since two of the four retaining bolts are partially restricted.

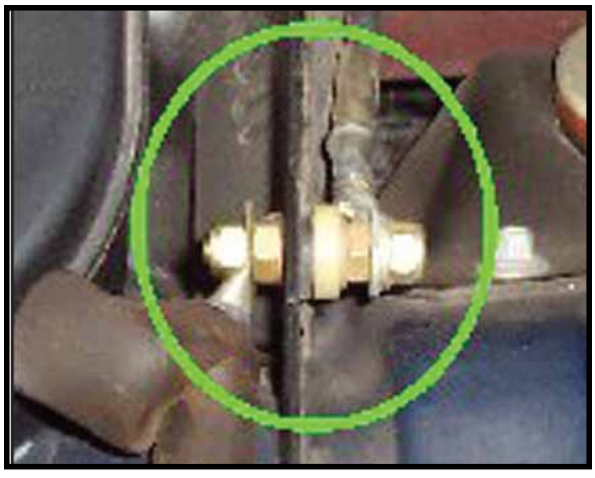

Figure 11: This connection should be good and snug.

Figure 12: This upper radiator hose is nearly ready to blow off of its fitting.

Figure 13: This hose is starting to slip as well.

"You'll see a place for a 10 mm hex socket at the top of the water outlet housing. Remove this cover and inspect the retainer that holds the seal in place (Figure 15).

"You may find it either cracked, or missing entirely as shown in Figure 16.

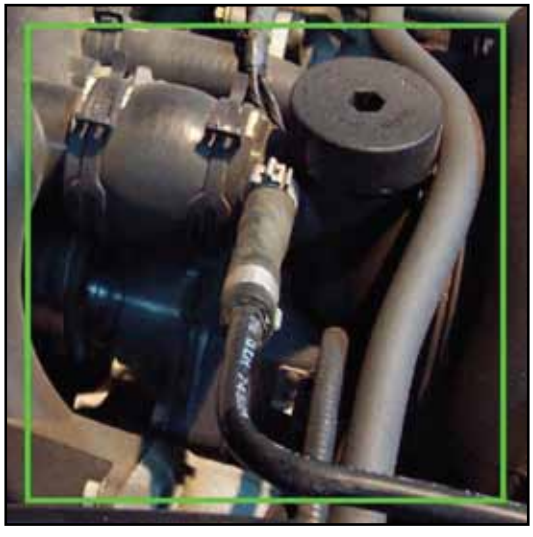

Figure 14: The water outlet housing is prone to seepage past the o-ring at its base.

Figure 15: Remove this water outlet cap to check its seal retainer.

The cap on the right is missing the seal retainer completely; the one on the left is in place.

"However, look at the retainer's 12:00 o'clock position. It's developing a crack. If the retainer falls away, the seal will be forced down into the water outlet, and you'll have a leak.

"One last place to look is the water pump. There has been an issue with the early models losing their impeller fins. If you have an overheat condition, and the thermostat has been replaced already, you may have to remove the water pump to inspect the fins. There are only five bolts, so it only takes a few minutes. The newer style pumps have white impellers. Figure 17 shows the two styles.

"If you find a heavily sludged-up throttle body assembly, or oil in the air cleaner assembly, check the part-load breather fitting on the driver's side valve cover (Figure 18).

"Remove the vacuum hose carefully!!! It tends to be brittle. Make sure the orifice is clear. The straw from a can of spray cleaner is about the right size for the orifice. Insert it to clear the passage.

"Inspect the full length of the vacuum hose that leads to the fitting (Figure 19).

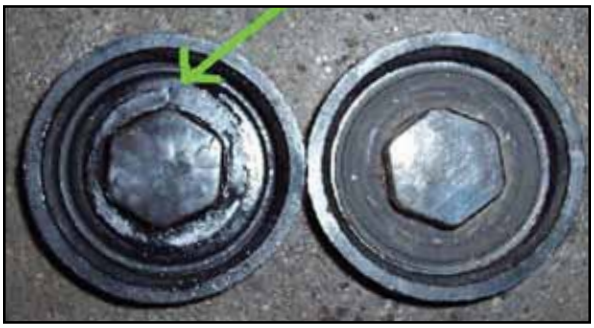

Figure 16: This seal retainer is starting to crack.

Figure 17: The white impeller distinguishes the newer style pump.

Figure 18: The part-loaded breather fitting is prone to sludge build-up.


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"Look between the intake runners and check it for cracks. This hose can cause quite a few lean codes.

"While you've got the vehicle, lift it up to check a few things underneath.

"Look at the tires. If the edges are excessively worn, inspect the front bushings on the lower control arms. The early versions tend to crack, throwing off the alignment (Figure 20).

"Check the inner and outer u-joints on the rear half-shafts; they are greaseable and often overlooked (Figure 21).

"Inspect the rear pinion shaft seal. You may find it leaking (Figure 22).

"For alignment, the rear camber is adjusted by replacing a spacer

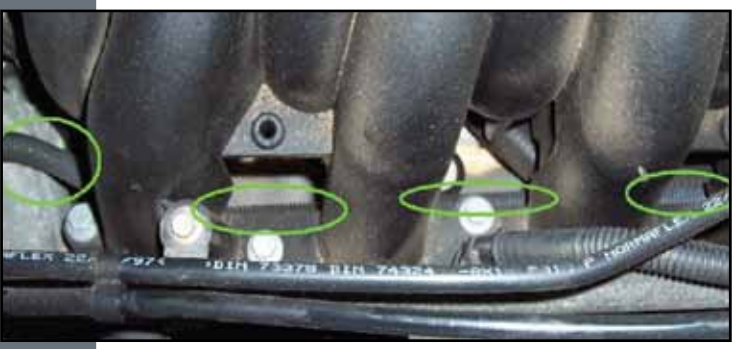


Figure 19: The part-load vacuum hose is routed beneath the intake runners.

Figure 20: This lower control arm bushing is cracked.

Figure 21: All four rear half-shaft u-joints are greaseable, yet often overlooked.

Figure 22: The differential pinion seal is prone to leaking.

[Left] Figure 24: Rear toe adjuster.

[Above] Figure 23: The rear camber adjustment shim is sandwiched between the differential and half-shaft flanges.

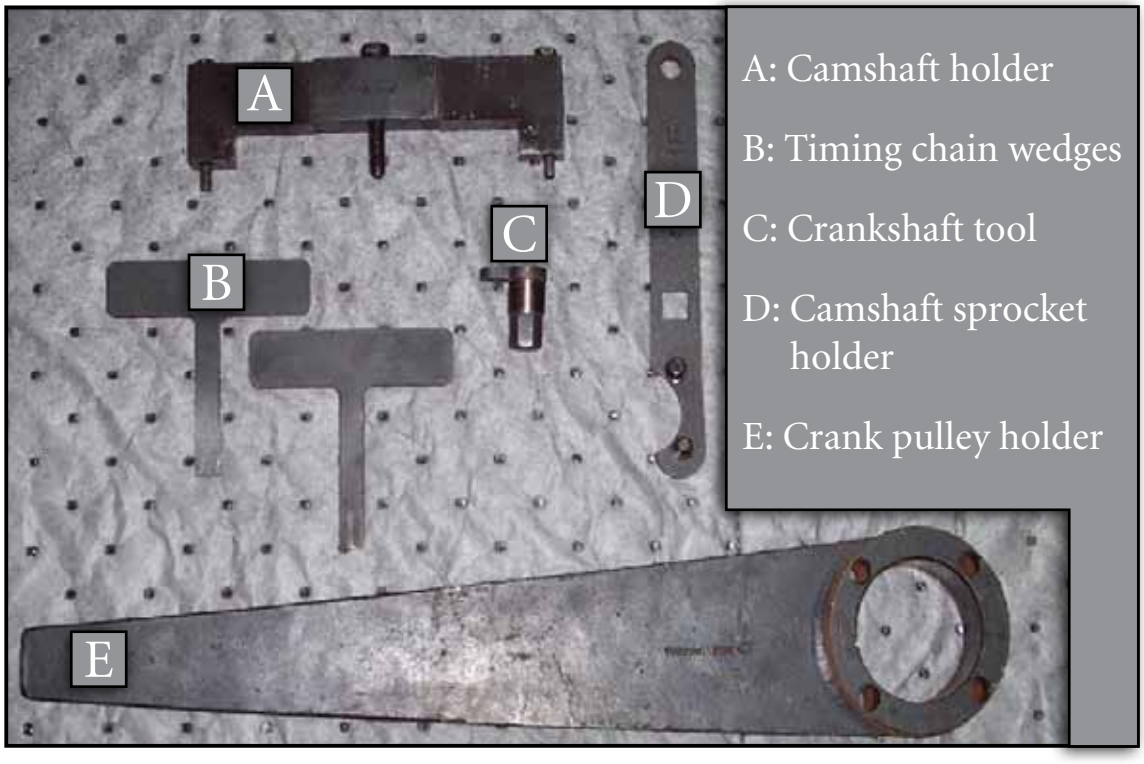
shim sandwiched between the output shaft flange and the half-shaft yoke (Figure 23).

Rear toe is set with an eccentric on the rear control arm (Figure 24).

"Finally, Figure 25 shows all the tools needed to service the timing chains. These are the minimum you should have on hand when tackling the timing components. Note: the S-Type V8 uses a different crankshaft setting peg tool.

"These are a few of the areas that I tend to look over on every car that comes into my bay. I don't always find them all, but I usually find at least one or two areas to up-sell. I hope this will help you the next time you find a Jaguar sitting in your stall."

[Below] Figure 25: The tools needed to replace or service jaguar AJ26 and AJ27 timing components.



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