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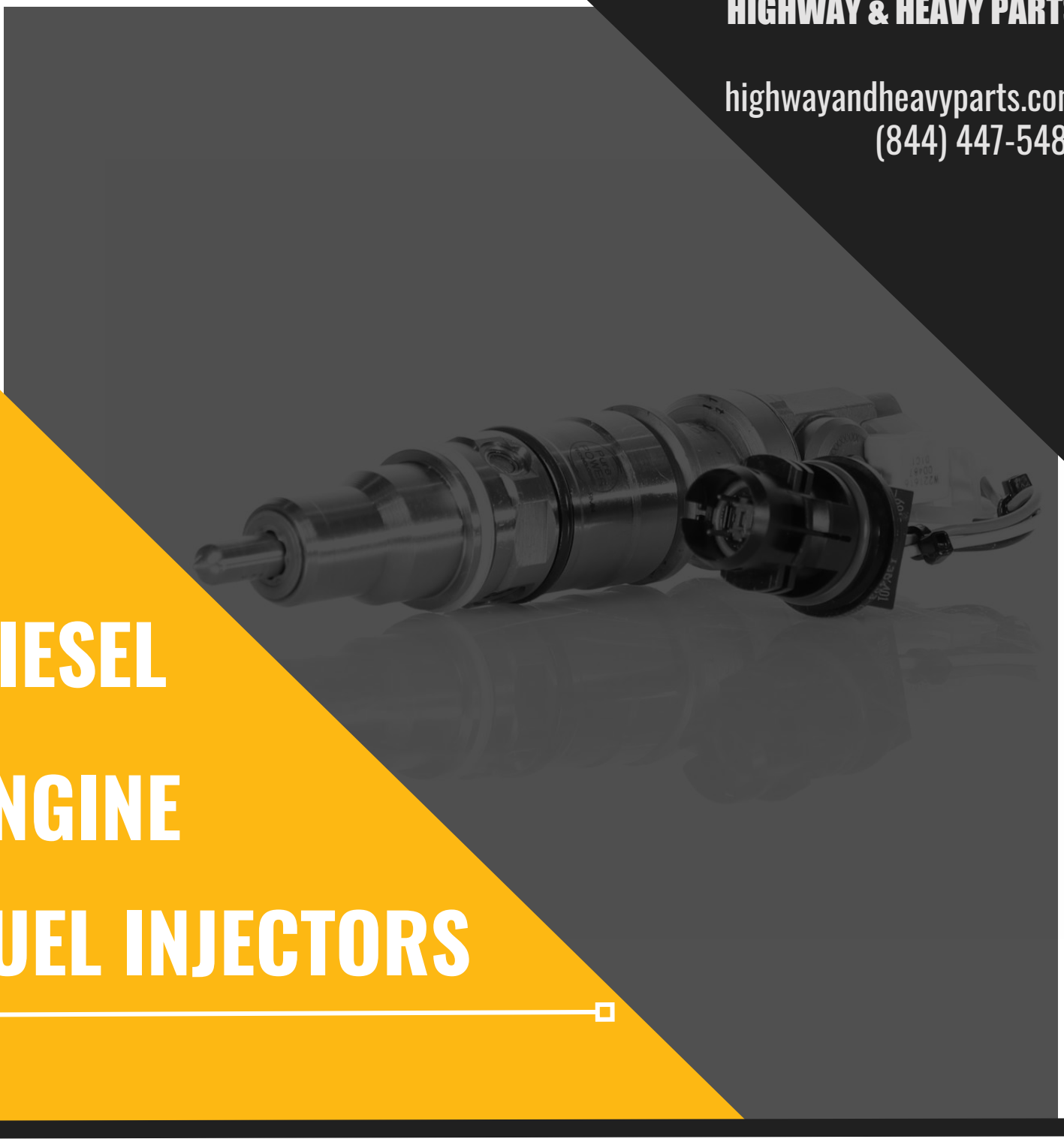

DIESEL ENGINE FUEL INJECTORS

A Highway & Heavy Parts eBook

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Introduction

How much do you know about fuel injectors? We're here to help! We've compiled the best information regarding fuel injectors to give you everything you need to know.

This book is designed to be a resource to help you understand this critical component of your engine. If you still have questions, or you're looking for parts for your diesel engine, give us a call at (844) 447-5487! We have ASE Certified Techs on staff who can help you with all your diesel engine needs!

You can also get more information from our website. You can read our blogs or request a quote.

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Fixing the Problem: Identify and Replace Faulty Diesel Injectors

As the name says, a diesel fuel injector literally injects fuel into the cylinder as part of the combustion process. In modern engines, the camshaft and ECU control the injectors, optimizing injection timing and engine function.

The injectors mix air in with the fuel, releasing it into the combustion chamber as a high pressure spray. It's a complicated part of your engine, made of many smaller components, but if you want your engine to run, it's vital that you maintain the health of your injectors.

CAUSES OF INJECTOR FAILURE

While injectors for different engine models may look and operate slightly differently, they experience similar causes of failure. Some reasons your injectors may fail include:

- Air or water in the fuel system
- Secondary damage as a result of internal engine failure
- Age and wear
- Clogging
- Cracking
- Busted seals and leaking
- Internal injector components failing

Whatever the cause of your injector failure, you want to have the issues properly diagnosed in order to address it effectively. Some other engine damage causes the failure, but if you just replace the injectors, the failure is likely to happen again. And you just threw away your money.

REPLACING INJECTORS

You may find yourself wondering if you need to replace all your injectors if just one fails. There is no simple answer to that question. It depends on the type of failure you experience, if you have your injectors on the same replacement schedule, and what you're willing to spend on the overall work.

You might want to replace all your injectors at once because if one fails, it's likely that the others aren't far behind. The is especially true if the injector fails due to age or wear. This will save you from having to tear into your engine each time an injector fails, as well as preventing the headaches that can come along with multiple failures. It's also possible that multiple injectors may fail at the same time, making it easier to just swap them all out at once.

It can be more cost effective in the long run to replace them all at once. You might have to spend more money up front, but buying injectors in bulk is often cheaper, and if you choose to have mechanic do the work on your engine, you're only paying for the work once.

On the other hand, if you're short on cash and need to get back on the road quickly, it might be more efficient for you to replace just one. If you know the cause of failure and have determined that it's from an isolated incident unlikely to affect your other injectors, it's probably fine to replace the only the one causing you problems.

IDENTIFYING THE FAILING INJECTOR

If you're looking to replace just one of your injectors, it's important that you correctly identify which is the guilty party. You can go about this in multiple ways, including the following:

- Your mechanic: Obviously, you can have your mechanic diagnose the problem for you, if you're not familiar with injectors, or don’t feel confident in your ability to accurately diagnose the problem.
- Listening to the injectors: Do not put your head that close to your engine. It could result in injury. Instead, use a long screwdriver and put it on the fuel injector. If it is operating, you should hear a clicking sound. Do this for all the injectors, keeping safety procedures in mind.
- Use a test light: Connect a test light and use it to test the wires of each injector for voltage. If they are operating correctly, the test light should be lit. Again, since the engine will be running or turning over (depending on the degree of failure you're experiencing) be sure to keep all loose clothing and anything else that might be caught in the engine away from moving components.
- Use a multimeter: You can use a multimeter in a similar way to test if the injectors are receiving power.
- Temperature: With the help of an infrared thermometer, check the temperatures of the exhaust manifolds of each injector. The ones that are functioning correctly will have higher temperatures than those experiencing some kind of failure.
- Visual inspection: Check for signs of leaking or broken seals. If fuel is pooling in the cylinder, it's likely that you've found the culprit.

If you find yourself in need of new injectors, HHP can help! We offer a wide selection of diesel fuel injectors and other fuel system components.

HHP Spotlight: About PurePower Diesel Engine Fuel Injectors

As I'm sure you know, fuel injectors serve a critical function in your engine. They give you everything you want—economy and performance. So, if your fuel injector starts to go bad, you know it's important to address the issue right away. Here at HHP, we now have a full line of fuel injectors from PurePower Technologies available for your Ford and Navistar applications. These injectors were previously only available to the OEM, but now you can get them here at Highway & Heavy Parts. Not sure if you need new fuel injectors? Our video goes into the benefits of the PurePower line of injectors. Read more to find out if these injectors are a good fit for your engine!

ABOUT FUEL INJECTORS

Because the injector is responsible for pressurizing the fuel and injecting it into the combustion chamber, it is an understandably complex part of your diesel engine. It's all about timing. The injector needs to be perfectly timed for maximum power. This has led to the manufacturing of multiple kinds of injectors to help improve the process. You can read more about two of the most popular types—common rail and unit injectors—in another section..

So, in short, the fuel injector functions as the primary fuel delivery system in your engine. It's what atomizes the fuel going into the combustion chamber. The injectors mix the fuel with air and release it into the chamber as a high pressure spray. Wonder why that's important? It's this process that gives you the fuel economy and power that you want out of your vehicle.

FUEL INJECTOR PROBLEMS

Have you noticed excessive smoke? Low power? Poor fuel economy? These signs might mean that your fuel injector is starting to go bad. Check out these common signs of fuel injector failure.

Normally, your injectors help you achieve great fuel economy and engine power, but when they're not working right, this efficiency will likely decrease. You'll also want to keep an eye out for engine misfires, rough idle or engine performance, excessive exhaust smoke, or engine knocking, as these could also indicate that something is going wrong with your diesel injectors.

Any of the following problems could be the reason your injectors fail. Be sure to watch out for:

- Air or water in the fuel system
- Secondary damage from another engine failure
- Age or wear
- Clogs
- Cracks
- Leaks from busted seals
- Other Leaks
- Failure of internal components
- Blown injector tip
- Poor timing

An earlier section can help you identify your faulty injector so it can be replaced.

ABOUT PUREPOWER INJECTORS

Injectors from PurePower are going to come with all the benefits you want to ensure your engine runs at its best. These injectors are going to come with a 15-month unlimited mile warranty on them. *And* they have less than two-tenths of a percent warranty rate. That's right—not two percent, two-*tenths* of a percent. That's a quality injector!

These injectors boast such a high success rate because of the quality of the testing they're put through. All remanned assemblies and production testing are conducted using OEM manufacturing equipment. They're assembled in a certified 100,000 cleanroom using original process equipment, advanced end of line checks, delivery, leakage, and opening characteristics to provide you with the highest quality product.

Our PurePower HEUI injectors feature the latest design fixes. They're going to have improved end caps with the cold start fix and they're going to have precision machined spool and control valve that'll eliminate leakage, giving you the best performance available on a HEUI injector. The intensifier body and plunger are matched to eliminate fuel dilution. And of course, the injectors are going to be tested for nozzle flow, nozzle leakage, and needle lift. 100% of the O-rings, hardware, and springs are going to be replaced in this injector. You want quality? We've got it!

Is your truck low on power? Lacking fuel economy? Or maybe your crankcase is overfull and diluted with fuel leakage. If so, you're probably looking for some new injectors. We've got 'em here at Highway and Heavy Parts!

Adjusting Diesel Injector Timing: ISX Injectors

In another section, we talk generally about adjusting injection timing. We focused primarily on advancing timing, though, and the benefits and risks that it poses to your engine. In this section, we're going to take a look at other reasons you might need to adjust the timing on your engine and looking specifically at what you might need to do to adjust your ISX timing.

ABOUT INJECTION TIMING

Injection timing is literally when fuel is injected into the cylinders for combustion. Depending on what type of fuel system you have, the timing is controlled by different components. Injection timing is a delicate operation, and having it programmed incorrectly for whatever reason (system failure, overcorrection, etc.) can negatively impact your engine. Optimal timing assists in fuel economy and engine power, and it also reduces your emissions. Manufacturers try to find the balance between engine power and emission regulations in their factory timing settings, leading some to want to advance the timing for increased power.

SHOULD I BOTHER ADJUSTING MY ENGINE TIMING?

In short, yes, situations may arise where you may need to fix an injection timing problem in your engine. Poor timing can significantly reduce your engine efficiency and cause misfires, among other problems, so it's important to the health of your engine to ensure that your injection timing is accurate.

When done correctly, adjusting your timing, especially advancing it, can improve your fuel efficiency and engine power. This can increase emissions, however, which is something to be aware of. If pushed too far, advancing could also cause damage to pistons and other components, so it's always something to handle with care, especially if you are doing it yourself.

Other times, you might need to adjust the timing because of a rebuild or injector replacement. When timing gears or other key components have been removed during repairs, you want to make sure that everything is put back and positioned properly for optimal timing. Otherwise, you might not get the same benefits from the repair that you were hoping for. Refer to your owner's manual for manufacturer recommendations on timing following a repair.

Sometimes, timing might be off due to a failure somewhere in your engine. You'll not only want to fix whatever caused the failure, but you'll also want to ensure that injection timing has been set back to its optimal position to maintain proper engine performance.

Again, in any situation, adjusting injection timing should be handled with care and caution. This is especially true when it's not in response to necessary maintenance or repairs, as you don't want to accidentally harm your engine as you try to improve its performance.

IN THE ISX

Within the ISX model engine line, there are multiple specific service models associated with this engine that have different fuel system types. Therefore, there is no one way to adjust the timing on every Cummins ISX engine. Rather, it depends on what service model name you have, so it's important to know your specific application before you try to adjust the injection timing.

UNIT INJECTORS

Many pre-2010 ISX engines are dual-cam applications with unit injectors. The timing on these is controlled by the injector camshaft. In some, such as the ISXCM870/871, a timing and meter actuator controls the mechanical injectors, a unique design in the new electronic control engines.

To adjust the timing in a dual-cam engine, you'll need several specialized tools, including timing wedges to ensure you're getting the correct angle between the camshaft and the crankshaft (if it's the camshaft that's negatively impacting your injection timing). Other engine models might require adjustments to the fuel pump or the actuator. A bad actuator could be causing problems to the timing of your ISX, so it would be good to check if the component needs cleaning or replacing.

COMMON RAIL INJECTORS

In 2010, Cummins released a new ISX model that utilized common rail injectors to better adhere to emission regulations. In this system, the injectors draw fuel from a rail where it is kept at a constant, high pressure. This is a single-cam application, so the ECM controls the injection timing. This allows for a small amount of fuel to be injected into the cylinder before the main injection event to help optimize timing and fuel efficiency.

Because of this change in system, you can't adjust the timing in the same way. With injectors controlled by the ECM, you can't manually adjust components to alter when injection takes place. Instead, you have to purchase the necessary software and equipment (or take it to a mechanic with

access to it) to hook up to the ECM directly. From there, you can check the timing and reprogram it to where it needs to be. It's becomes a much more computer driven fix than in earlier applications.

This isn't meant to be a how-to guide on adjusting your injection timing. Instead, we hope to inform you a little more on what you might be seeing in your engine and why it might be a good idea to adjust the timing. For specific information on your engine application, please be sure to consult your owner's manual or mechanic.

IDENTIFYING COMMON SIGNS OF FUEL INJECTOR FAILURE

There's something wrong with your diesel engine—you can feel it (or maybe see or smell it)—but you can't quite figure out what it is. If you have any of the following issues with your engine, there's a chance you might have a problem with your fuel injectors. There are, of course, other failures that could cause some of these problems, but you shouldn't rule out the possibility that your injectors are failing. Read on to learn some common signs of failure, as well as common causes of diesel injector failure. We also released a video that details some things you can watch for.

SYMPTOMS OF FUEL INJECTOR FAILURE

Fuel injectors play a big role in the overall performance of your engine. When functioning properly, you can have great fuel economy, high engine power, and a smooth ride. If there's a failure happening, you might notice your normal engine functions decreasing in quality. This might happen gradually or suddenly, but here are some signs to watch for:

- Loss of Engine Power
- Engine Misfire
- Rough Idle or Rough Engine Performance
- Reduced Fuel Efficiency
- Excessive Exhaust Smoke
- Engine Knocking

A lot of these issues have to do with the amount of fuel being delivered to your engine. If the pressure or timing is affected even slightly, you'll notice a decrease in the quality of your overall engine performance. Sometimes the problem can be solved simply cleaning your injectors or replacing some injector seals, but other times the failure is so extensive that you'll have to replace your injectors, and possibly other components of your fuel system as well.

COMMON CAUSES OF INJECTOR FAILURE

It's not enough just to know the signs that something is wrong in your engine. You need to know what exactly might be going wrong. Here are some things that might cause your injectors to fail:

WEAR

Sometimes you don't really notice the decrease in fuel economy right away, or that your engine isn't quite as powerful as it used to be. This could be because the problems come on gradually, due to the steady wear on your injectors as part of normal engine usage. Because so much fuel goes through the injectors at such a high pressure, it causes your injectors to wear over time.

INJECTOR TIMING IS OFF

Combustion is a delicate process, and if the timing is off even a little bit, you can lose engine efficiency and power. Poor injector timing affects when fuel is injected into the cylinders, and can involve more parts than just the injector itself, depending on what type of fuel system your engine has.

BLOWN INJECTOR TIP

It is possible for an injector to blow a tip. This is most frequently caused by air or water contaminating the fuel and affecting the pressure buildup. Some injectors are more sensitive to contamination than others, namely the common rail injectors, so it's important to not only diagnose the blown tip, but the contamination cause as well. Otherwise, you'll continue to have issues with your injectors, even after you replace them.

CLOGGED FUEL INJECTORS

Buildups of old fuel, carbon, and other debris can cause blocked or clogged fuel injectors. These clogs do not let any fuel through them, leading to a loss of power in your engine, and, if the block isn't taken care of right away, engine misfires. The clogs could also be caused by poorly functioning fuel filters. Professional cleaning might solve the issue, but it also might require complete injector replacement to fix. Again, make sure you also troubleshoot why your injectors clogged in the first place to help prevent the issues from immediately happening again.

LEAKING FUEL INJECTORS

Fuel injectors can leak from quite a few place, including o-rings and seals, the top or bottom, or from the body due to excessive corrosion. In some cases, it is possible to repair the damage just by replacing the leaking o-rings or seals. A corroded or heavily damaged injector, though, will likely need to be replaced entirely. A leaking injector doesn't allow for proper fuel pressure to be maintained, which affects the

injection and combustion processes. If left unaddressed, the leak can cause costly damage to other engine components, as fuel will be able to contaminate other areas of your engine.

If you're experiencing any of these symptoms, it might be time for new fuel injectors. Be sure to take a look at all our fuel system components to find the right parts for your engine.

DIESEL ENGINE INJECTOR REPAIR KITS AND REMANNED INJECTORS

ABOUT FUEL INJECTORS

A fuel injector is one of the more complicated components in your engine. It is responsible for pressurizing the fuel and injecting it as a fine mist into the combustion chamber. It must be able to withstand intense operating conditions, and should be timed perfectly to achieve ideal fuel usage. You can read more about adjusting your injector's timing in another section.

Because it is such a complicated component, there are many things that can go wrong. A few symptoms of injector problems you might look for include:

- Loss of Engine Power
- Hard Start
- Smoking
- Knocking
- Rough Running
- Poor Fuel Efficiency

These could be caused by a number of problems, from worn injectors to cracks, so it's important to carefully diagnose your problem.

If you're experiencing a fuel injector problem, there are a number of things to think about to repair the issue, including whether you want to purchase a repair kit for your existing injectors or replace them entirely with remanufactured injectors.

WHY YOU MIGHT REBUILD AN INJECTOR

One option you have as you're looking to solve injector related issues is to get an injector repair kit and rebuild the injector yourself. Depending on the type of damage you're trying to repair, there are different types of kits you can purchase, including ones that will replace just the seals if you're having leaking issues, to kits that include most of the major components that make up a fuel injector. You'll have to evaluate your injectors and decide which kit will best help you with your particular problem.

An injector repair kit can help with a lot of minor problems you may be experiencing, like general wear and leaking seals. That, combined with a good cleaning to clear away any clogs, can keep your injectors running for miles to come. It is a little labor intensive on your end, but it is less expensive than buying all new injectors, if that's not currently necessary, and can solve many of your problems. It doesn't, however, address major injector failures, nor do you get the same testing and guarantees you'd get from purchasing new or remanufactured injectors.

WHY YOU MIGHT PURCHASE A REMANUFACTURED INJECTOR

There are some issues a repair kit just won't fix—cracks in the injector, for instance. In cases like these, you might want to consider purchasing remanned. The remanufacturing process is quite intensive, and can vary from company to company (HHP's remanned injectors are made to run like new, meeting or exceeding OEM specifications!). You want to make sure the remanned injectors you're getting are quality.

When an injector core is remanufactured, it is taken apart, cleaned thoroughly, and inspected for damage. A quality remanned part will have all old components replaced with new ones to ensure maximum life span. Depending on the individual injectors, the replaced components can include actuator assemblies, spill valves, solenoid, NOP springs, washer, shim, screw, and stop. The injector will also be tested thoroughly for leaks and functionality. In the case of the remanned injectors we sell, the testing ensures that each injector meets OEM standards, and will run like the day it was first manufactured. Buying remanufactured injectors might cost you more upfront than a repair kit would, but you get the added peace of mind that your injectors should run like new and any major injector issues you have should be taken care of.

So, depending on the extent of the damage, either purchasing a repair kit or remanufactured injectors would be options for you. A repair kit is not the same thing as remanufacturing an injector, as it's much less comprehensive. It will, however, help you with minor issues. In the end, it's up to you and your mechanic to decide which fix would be best for your engine.

If you're looking for either an injector repair kit or new/remanned injectors, HHP carries both.

THE DIFFERENCE BETWEEN COMMON RAIL AND UNIT INJECTORS

A fuel injector is a fuel injector. They're all the same, right? Well, not so much. There are actually many different methods to make the combustion process possible, but two are perhaps the most popular: unit injectors and common rail injectors.

Both of these types of fuel systems have been around in some form or another for years. Unit injectors in particular have been a popular choice for diesel engines for decades. While early designs of common rail injection systems have been around for nearly as long, it's not been until recently that they've started to grow in popularity. This is driven in part by new emission standards that common rail injectors can meet much more easily than other injector types.

FEATURES OF UNIT INJECTORS AND COMMON RAIL INJECTORS

While their primary function is the same—to inject fuel into the cylinder during the combustion process—these system types operate quite differently and likewise the injectors themselves are made up of different parts. Below, we'll take a look at the different features and problems of both systems.

UNIT INJECTOR

With unit injectors (also commonly referred to as "pump nozzles"), each injector operates independently, relying on the camshaft for proper timing. The injector and the pump are a single component, allowing for the fuel pressure to be maintained within the injector itself before being sprayed into the cylinder for combustion.

Because of its reliance on the camshaft, this system doesn't have the same level of flexibility as other injection types, where timing is controlled by the ECM. Unit injectors have been both electronic and mechanical, depending on the engine type. Because the injectors are both injector and pump in one part, the individual components themselves are slightly more complicated.

In a unit injector system, the fuel is not kept at a constant high pressure before entering the injectors. Rather, it is at a much lower pressure while moving through the engine. It is the injectors themselves that pressurize the fuel to a much higher degree before every injection, due to their dual capacity as injectors and pumps.

Unit injectors use smaller amounts of fuel in the beginning of the process, resulting in a high efficiency engine with lower soot and emission levels than could be achieved by other injection systems (excepting perhaps the common rail system). But because of the growing popularity of the common rail system, some reason that it's unlikely we'll see many changes or improvements to the design and function of unit injectors in the future.

COMMON RAIL INJECTOR

Common rail injectors utilize a high-pressure fuel rail that provides fuel to the individual injectors. Unlike with unit injectors, the rail maintains the fuel at a constant, high pressure that is necessary for injection. The injectors don't change the pressure of the fuel themselves, as it's ready for injection when it’s drawn into the injector. Because of this, the pump is a separate component, rather than a part of the injector itself. The injector itself is then a bit of a simpler design than the unit injector.

The injectors in a common rail system are, for the most part, electronic, utilizing solenoids and relying on the ECM to control their timing. With this system, a small amount of fuel is injected into the cylinder before the full injection to optimize timing and fuel quantity. This helps to make the engine more fuel efficient overall. You'll also be getting more power as a result, while decreasing the amount of noise and vibrations produced by the engine.

The higher pressure capabilities also allow for increased efficiency and improved emissions. Some even point out that the full possibilities for this technology haven't yet been realized, leading to likelihood of even further improvements being made to the overall design and function in the future, especially as regulations continue to change.

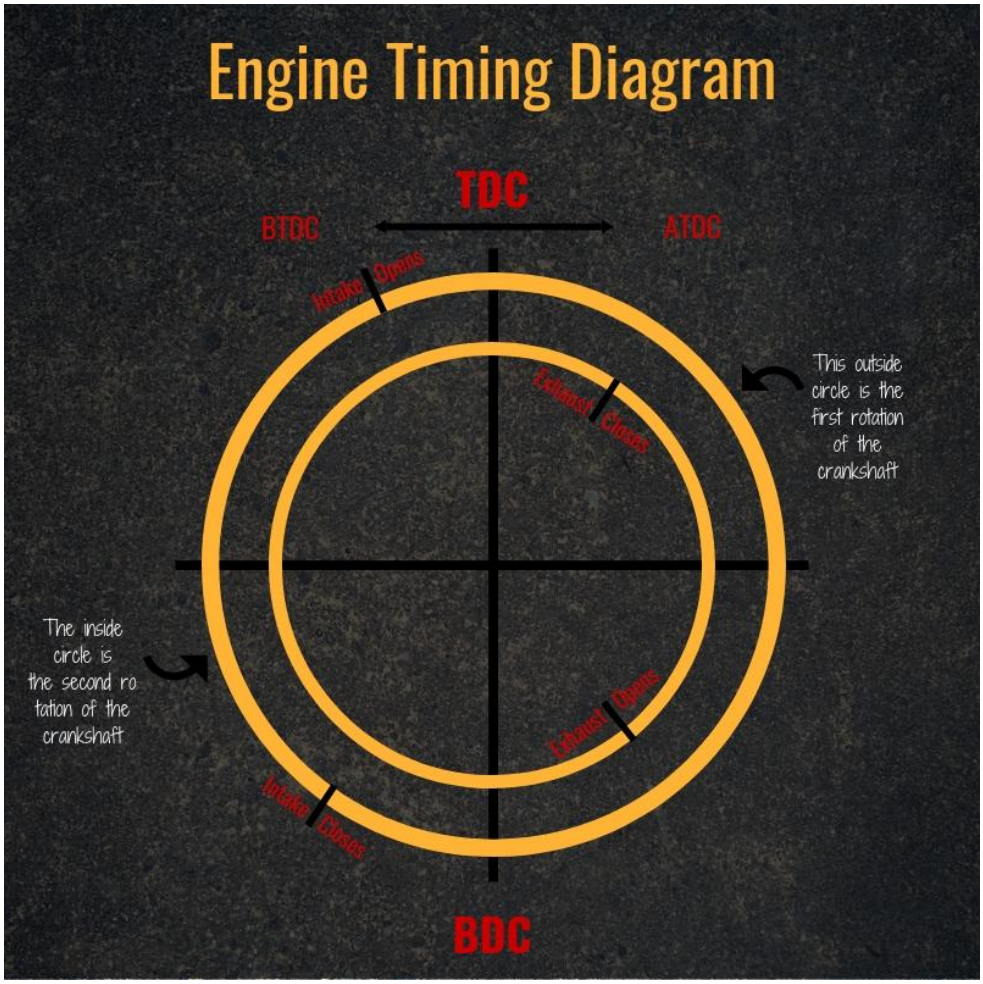
While the common rail injector system has been in production for much less time than other injection types, it has grown in popularity, and that doesn't seem to be slowing down. It does, however, bring with it its own unique set of problems.

It is more complex a system as a whole, which can lead to a higher price tag when it comes to replacing components. Because it maintains fuel at a higher pressure for longer, more components are affected by that pressure. This can result in an increased risk of damage to other components. It is very sensitive to contaminants, more so than other injector types. In fact, one of the leading causes of failure in common

rail systems is fuel contamination, yet it is one of the most frequently overlooked. If you notice a decrease in fuel economy and think it might be due to a problem with your common rail fuel injectors, you might want to have your fuel quality tested.

In the end, your fuel injection type is decided by the type of engine you have, and you're limited by the modifications made to that engine and its components. It's good to know what fuel system it is, though, to help ensure you're getting the proper parts for it.

Adjusting Diesel Injection Timing



INJECTION TIMING BASICS

We often get all kinds of calls asking for technical advice, from both owner-operators trying to troubleshoot a problem with their truck to repair shop mechanics who are looking for a second opinion. With all these calls, we notice when multiple questions pop up, meaning it must be a pretty common question. One of these questions that we've gotten a few times is "What is injection timing, and how do I adjust it?" If you've found yourself asking that same question, this section has the basics that should hopefully give you the information you're looking for.

WHAT IS INJECTION TIMING?

Injection timing is the timing of when fuel is injected into the cylinder, which alters when the combustion takes place. The time of when fuel is injected can be altered to be injected at different points in time. The manufacturer of an engine does recommend certain timing, which is the timing they set it at when the engine is first made. This timing is usually balanced to get as much power as possible, while still remaining in legal limits for emissions.

Adjusting injection timing is also often referred to as **spill timing**.

WHY ADJUST INJECTION TIMING?

Usually, injection timing is adjusted to create more power in the engine. Timing can be advanced to create more power. Sometimes timing is adjusted in the opposite direction to fix a smoking or a lag problem.

CAN INJECTION TIMING BE ADJUSTED ON ALL DIESEL ENGINES?

Young or old, timing can be adjusted on any engine. The only difference is how the timing will be adjusted.

DIESEL ENGINE INJECTION TIMING ADJUSTMENTS

ADVANCING

Advancing the timing of an engine means that you are moving the combustion up in time. In other words, you are adjusting the timing so that ignition happens earlier than when the manufacturer originally set it to occur.

When talking about timing of any kind, but especially advancing, you'll often hear or see the term BTDC, or **Before Top Dead Center**. Top Dead Center, or TDC, for a particular piston is when that piston is at the very top of the cylinder, or furthest from the crankshaft. The opposite, Bottom Dead Center, or BDC, is when the piston is at its lowest point in the cylinder, closest to the crankshaft. So, BTDC would be the point before the piston is at its uppermost point in the engine. A timing advance is the number of degrees BTDC that ignition occurs.

Usually the location is measured in degrees. For example, 10 degrees BTDC is when the crankshaft is 10 degrees before the piston is at its highest point in the cycle. In case you can't figure out degrees just by looking at the crankshaft, here is a handy calculator.

RETARDING

Retarding the timing of an engine is essentially the opposite of advancing. It is when you adjust timing so that ignition occurs after the manufacturer's original specified time. People will retard the ignition timing of their engines for various reasons, although it is less common. Some of these reasons are fuel economy and performance.

The rest of this section will focus on advancing the timing of an engine, as that is the most common timing adjustment.

HOW TO ADJUST INJECTION TIMING

There are several ways you can adjust injection timing, depending on the type of engine you have and how old it is. The most common ways to adjust injection timing are programming the ECM, adjusting the fuel injection pump, replacing the camshaft, and replacing the cam followers or gaskets.

PROGRAMMING THE ECM

For newer engines with advanced engine computer systems, adjusting ignition timing is as simple as programming the ECM. And by "simple," I mean simple for the people that know how to program them. No mechanical work needs to be done, except for getting to the ECM. From there, a mechanic can plug in a Flash tool to reprogram the computer.

Need a new ECM? Check out some of the ECM's that Highway and Heavy Parts offers here.

For older, mechanical engines, there are still several parts that you can manipulate in some way to change the timing.

FUEL INJECTION PUMP

One of the easier ways to mechanically adjust engine timing is to adjust the fuel injection pump. This is as simple as rotating the pump in the engine. Rotating the pump requires just a screwdriver and a socket wrench, which most people have in their toolboxes at home. However, to accurately measure the timing, you will need a special probe or timing meter. It's important to remember that a small movement of the pump will result in a large timing change, so do not make any drastic adjustments. For a tutorial on how to do this yourself, DoItYourself.com has pretty good step-by-step instructions that go through the fundamentals.

CAMSHAFT

Another way to adjust timing is to replace the camshaft. By replacing your camshaft with one that has differently shaped and sized lobes, you can adjust when the valves and injectors are triggered. To do this, you'll probably need to work with a camshaft guru who can do all of the mathematics to get you the cam that will do what you want. Cams are most often replaced for timing reasons when being used in performance vehicles.

CAM FOLLOWERS & GASKETS

A cheaper option for changing when the valves and injectors are triggered is replacing the camshaft followers or gaskets. These can do the same, or very similar, things that replacing the camshaft would do. For example, switching out the cam follower gaskets for thicker or thinner ones would affect when the followers and the cam lobes come into contact, and thus when the rest of the valve train is activated.

ADVANTAGES & DISADVANTAGES OF ADVANCING THE TIMING

ADVANTAGES

People advance timing, so there have to be good reasons for messing with it, right? Yes. Advancing the timing will *usually* increase the amount of power your engine produces. It will also *usually* increase fuel efficiency. The original engine manufacturers set the timing to balance power and emissions, so that the engines they produce get as much power as possible while staying within legal emissions regulations. This means that they aren't originally set to produce the most power that the engine is capable of. And if your engine is older or it's had some work done, it may just not be performing like it used to. Many little things could affect your timing, so advancing it could give you the power increase you're looking for..

DISADVANTAGES

However, just because you can up the power doesn't mean that you want to or that you should. This is often a hard lesson for some, but more power isn't always the goal. Advancing the timing can lead to more smoke. It can cause a lot more vibration in the engine, making it noisier. It will also increase NOx emissions, which is the reason manufacturers usually retard the engines slightly in the first place. And if you don't care about any of those things, it will actually affect the performance of the engine in other ways; advancing the timing will often decrease and delay boost.

A big part of adjusting the timing is doing what's right for your engine, and if you do it, doing it right. If you're considering adjusting the timing, take the time to figure out what your engine needs. Maybe you can up your power by replacing injectors, and that would be a better option for your engine. Maybe you should adjust timing. If you do, make sure you know what you're doing or you hire a mechanic that does.

What are Fuel Injector Trim Codes

Trim codes or trim files are codes that go into an Electronic Control Module (ECM) that determine how long a fuel injector injects fuel into a cylinder for. **Trim codes only apply to electronic Caterpillar injectors and some newer electronic Cummins injectors.**

WHY TRIM CODES

Theoretically, if any 10R4761 injector will fit the same way as any other 10R4761 injector, they should all have the same output. They are all made the same way, after all. But due to slight differences in machine tolerances, friction between parts, and magnetic forces, some injectors have different rates of output. By using trim codes to adjust the injection duration for each individual injector, the net output of the injector for each cycle is the same in an engine.

When some manufacturers make these specific electronic injectors, they put them on a machine when they're done to test for the correct fuel output. If the output is not exactly within the specification range, the computer will generate the code to control the current so that the net output is within spec.

TRIM CODE INSTALLATION

Any injector with a trim code should have the serial number on it. Some injectors will come with a disc containing the unique trim code file. The disc will go into a computer and the computer will get connected to the ECM. Some programming will run and the injectors' serial numbers will be inputted, which tells the ECM all of the injection data.

FINDING AN INJECTOR'S TRIM CODE

If an injector needs a trim code, it should come with one. For example, the Delphi injectors from HHP that fit Caterpillar C7 and C13 engines come with their own unique trim codes and the discs to access them.

ARE TRIM CODES NECESSARY?

Engines run best when they are consistent. Many different factors play a part in consistency, and the power generated by each individual cylinder is perhaps the most important factor that needs to remain consistent. If each cylinder is producing the exact same amount of power, they will produce the optimum power output.

Generally trim codes aren't needed unless you notice your engine is not performing the way it should. **Not installing trim codes could result in a rough idle, poor fuel economy, overfueling, underfueling, increased emissions, and generally poor engine performance.** In (very) extreme scenarios, not installing trim codes or installing incorrect trim codes could lead to engine damage.

If you recently installed electronic injectors without trim codes, let us ease your newfound fears. Most people don't know about trim codes and so do not install them, and it is very rare that engine damage will result. If you were not supplied with a trim code, you probably shouldn't worry about installing one. Even if you were, if you're buying from a reliable manufacturer or vendor, not installing it shouldn't be an issue.

The short version: install trim codes if you have them, but don't worry if you don't.

Increase Profit with Remanufactured Injectors from HHP

When it comes to running a highly profitable diesel engine repair shop, staying one step ahead of your competition is critical to success. With profit margins shrinking and customer demands becoming more and more complex, vendors are constantly searching for ways to cut costs and streamline operations without having to sacrifice the quality of their service. Though this has proved to be a difficult task for a lot of repair shops, many are discovering that making the switch from OEM parts to remanufactured components may be the answer, and **Highway and Heavy Parts (HHP)** is helping them do that.

One particular part that HHP provides that's helped repair shops increase profits has been **remanufactured fuel injectors**. Many engine manufacturers will guarantee fuel injectors on new pieces of equipment but what about when one needs to be replaced on an engine that's out-of-warranty?

One option is to simply order a reconditioned part from the original manufacturer, add a small mark-up and make a small profit. Another --more intelligent option -- is to order a remanufactured injector (with a better warranty) that meets all the specifications of your engine at half the price of the OEM. By choosing this option, you have the flexibility to lower your end-user price below the competition, market your services as the more cost-effective option and still make a significant profit – all without sacrificing quality.

HHP's Remanufactured Injectors Compared to the Competition

HHP offers a wide range of remanufactured fuel injectors that cover many of the major diesel engine manufacturers on the market today. From CAT and Cummins, to Detroit Diesel and Navistar, their extensive catalogue of parts includes injectors that meet the specifications of virtually any diesel engine model ever released.

HHP's goal is to provide customers with aftermarket parts that possess the same level of reliability and dependability that you would expect from of a brand new component. As a result, all of the fuel injectors that they carry aren't just rebuilt -- they're remanufactured. The most important part to note that is new every time is the injectors solenoid. If the solenoid fails, the injector fails. Many rebuilders don't install new every time because it jumps up the sell price. The problem with this is that a solenoid either tests good or bad. It may be good when it is assembled but fail a week after it installed. There is no way to know how long it will last. Here's what HHP puts new into every injector:

Replaced NEW every time						
Actuator Assembly						
Spill Valve	Solenoid	NOP Spring	NOP Shim & Stop	High Pressure Washer	Armature & Solenoid Screws	O-Rings
✔	✔	✔	✔	✔	✔	✔
✔	✔	✔	✔	✔	✔	✔
✔	✔	✔	✔	✔	✔	✔

In addition to their high performance, all remanufactured fuel injectors come with a same-as-new warranty. In many instances, HHP's warranties exceed those of the original manufacturer, so you can be sure you're getting the best possible value on the market.

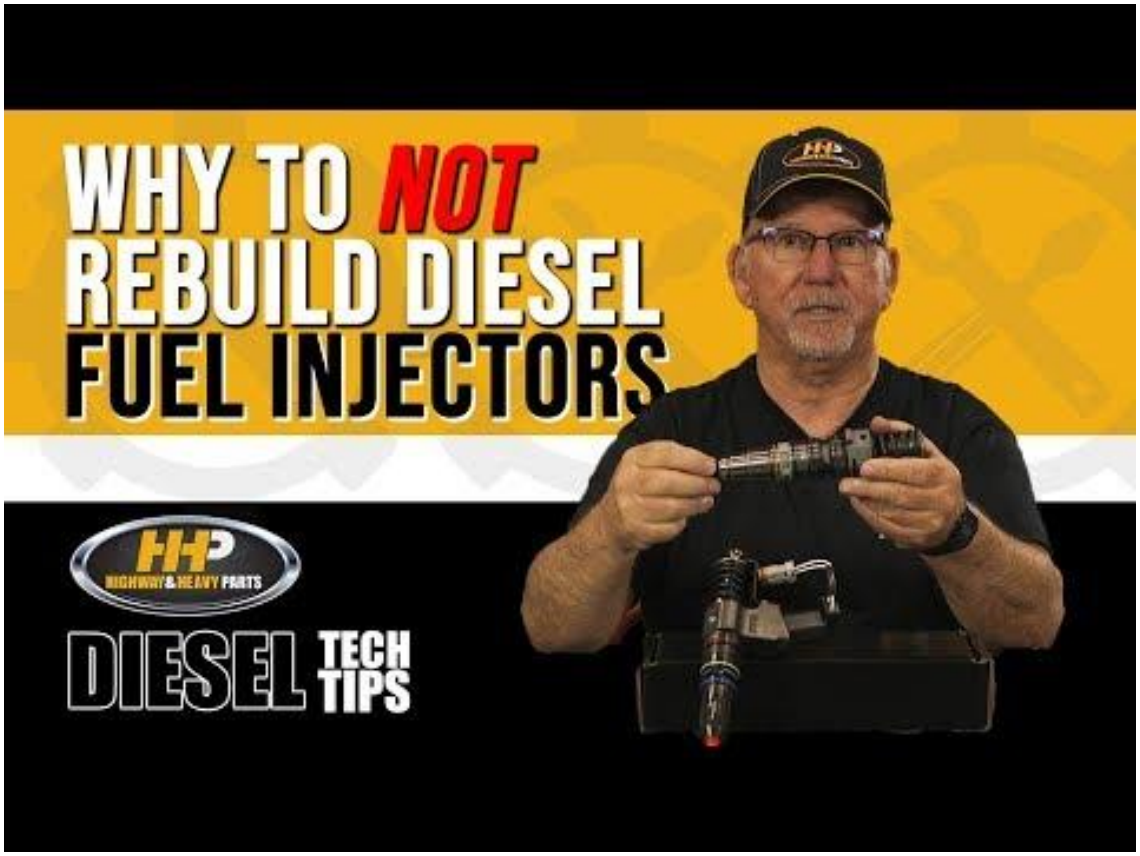
Some of the engine models covered by HHP are:

C10 / C12: 1165414, 1165425, 1165426, 1372500, 1470373, 1561011, 1602303, 1611785, 1945083, 2123462, 2123463, 2123464, 2123465, 2123466, 0R4987, 0R4988, 0R8773, 10R0725, 10R0961, 10R0963, 10R0967, 10R0968

3406E: 1022014, 1026230, 1026236, 1034562, 1095038, 1170481, 1170482, 1171146, 1171148, 1187929, 1188010, 1189027, 1189030, 1189035, 1523680, 1592479, 1592631, 1761145, 1913002, 1913003, 1913004, 21113022, 2113023, 2113024, 2113027, 0R4118, 0R4119, 0R4300, 0R4668, 0R4893, 0R4894, OR4895, 0R9256, 0R9257, 10R0956, 10R0957, 10R0958, 10R2780, 10R2781, 10R2782, 10R8501, 10R8502

Why Not to Rebuild Your Diesel Engine Fuel Injectors

Do your fuel injectors need a rebuild? Have you thought about just doing it yourself? Master Diesel Mechanic Mike Schrems discussed with us why you might not want to tackle this yourself. Read on to find out why!



As you probably know, fuel injectors literally inject fuel into your cylinders during combustion. There are different types of injectors, depending on your engine, that operate differently, but the end result is the same.

If you're looking to install a set of new injectors, check out our blog, How To: Diesel Injector Installation: Cummins ISX!

CLEANLINESS

Your injector is a highly precise device that measures and injects fuel into the combustion chamber in your diesel engine. Because it is such a highly machined component in the engine, it isn't recommended to take this task on at home. It needs to be done in a well-established, environment-controlled clean room.

These clean rooms are almost as sterile as an operating room in a hospital, and the temperature of the room and air cleanliness are key components to maintaining this environment. That's why when you visit one of these injector or fuel pump rebuilding sites, you'll see warnings and cautions to stay clear of the rooms. They don't want to introduce foreign materials that could be airborne—you could do this even by just walking through the room. If you walk something in on the floor, it could get dried out and suspended in the air as they're trying to calibrate these precise components for your diesel engine.

COMPONENTS

In addition to the need for cleanliness when working with injectors, there's also the added difficulty of the complicated nature of the components.

There is a metered amount of fuel injected into the combustion chamber through the orifices. These orifices are located on the nozzle end of the injector. They're put in at a certain angle. In other words, there is a degree of how the fuel is angled into the combustion chamber. It could prove difficult to recreate this precise angle in your garage at home.

Similarly, some of the pistons have a bowl designed into it. Fuel enters into that cup or bowl at the top of the piston at a certain angle for efficiency, to reduce the smoke, and its burning capability, or its ability to produce powerstroke. Again, the required precision could prove difficult.

Along with complicated components come chances for failure. Learn some common signs your injectors might be failing!

COST

If you're still thinking about rebuilding your own injectors, you should realize that it will probably end up costing you more.

Say for instance you want to replace the cups on it. You might be able to get the cups for the injector, put a new cup in it, and think, "Well, I'm good, I restored the original angle for fuel injection and it reduced the orifice size back to its original state." And while that might be true, it still has to be metered and the metering will change.

To accomplish this, there's an orifice under the screens. That orifice is selected so that it measures the correct amount of fuel to be injected into the combustion chamber. The necessary components to do the job right would end up costing you quite a bit of money.

In the end, we don't recommend trying this job at home. You'd be better off having a reputable supplier or repair facility doing it for you, to ensure your injectors will be operating at their best!

How to: Diesel Injector Installation, Cummins ISX

Odds are, at some point in the life of your diesel engine you'll need to remove or replace your fuel injectors. But do you know the right way to do this? Master Diesel Mechanic Mike Schrems talked us through how to install diesel fuel injectors in your ISX engine.

HHP has a large selection of injectors—if you're looking for an ISX injector, check out our Cummins ISX Fuel Injectors: Products Offered from HHP.

For an in-depth look at installing an ISX injector, take a look at our video.

INSTALLING YOUR INJECTORS

The install pictured below and featured in the video was done on an ISX 871. The exact guidelines for you will depend on which engine you're running. Refer to your manual for more information. If you want to know more about the ISX, read our Cummins ISX Engine Spotlight!

1. We began the installation with the injector out of the cylinder head. At this point, you'd have already done your repair, whether that was replacing a head gasket, or doing an in-frame overhaul. If you're doing an engine rebuild on your ISX, we have some tips for you!
2. If you're reusing your injectors, you'll want to replace the o-rings. These o-rings come in the overhaul kit or the upper gasket set. These o-rings are different sizes, so you want to make sure that you get the right o-ring in the right groove to ensure a proper fit. An o-ring hook can really help make this a little easier.
3. Next, you want to clean out the bore of the injector hole. In the pictures, we have the rocker shafts removed so that you can see how this is done.

4. Once the injector bore has been cleaned with a brush, you might want to take a shop towel, place it on the brush, and use it to clean any soot or debris left in the bore. The shop towel will pick all that up, further cleaning the bore.
    - It's not recommended that you blow into the bore of the injector hole, because you may unintentionally force debris into the combustion chamber, which would not be good.

5. Next, get your injector and lube the o-rings with engine oil before you put the injector hold down in, so that the bolt hole where the injector hold down goes is free of oil or debris. This prevents it from achieving torque before it is actually tight.

6. Carefully align the injector in the injector bore.

7. Place the hold down over the injector and start the cap screw. These particular injectors get torqued to 59 foot-pounds, if you look it up on Quick Serve online, or if you have a shop manual for the ISX engine. Make sure you look for the right vintage engine. As we mentioned, this install was completed on an 871. The injector hold down actually pulls the injector down into the bore.

8. After the injector is in the cylinder head and properly torqued, you would want to install the rocker shaft assemblies and go through and set the valve injector settings.

If you've already installed your injectors and are looking for information on how to ensure they're timed properly, read our blog on the topic, Adjusting Diesel Injector Timing: ISX Injectors!

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