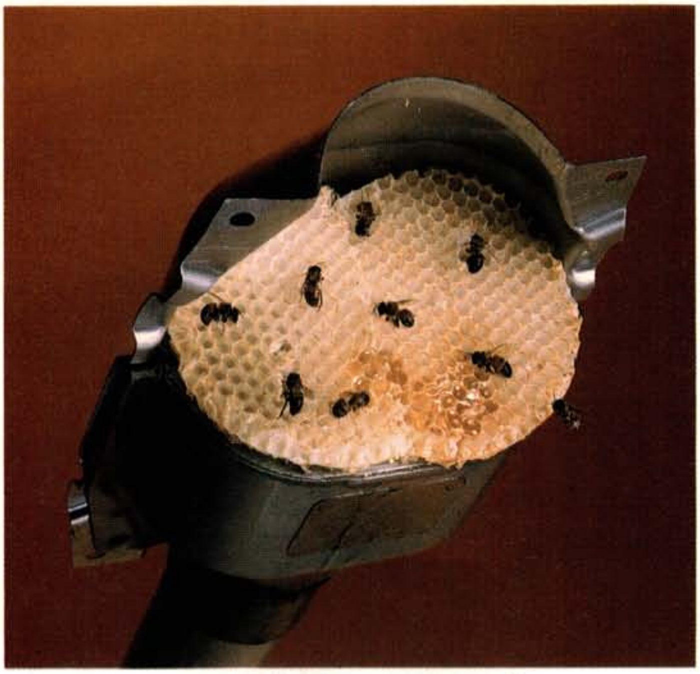


Air Sweeteners

After at least fifteen years of widespread use, catalytic converters have reached the point where they are often taken for granted. It's easy to forget how important these air sweeteners are when it comes to keeping our air fit to breathe.

We don't intend to bore you with a long explanation of how a converter works, but a brief explanation of converter operation may be helpful. If you understand how a catalytic converter works, it may be easier for you to understand what happens when it doesn't. So here's the *Reader's Digest* condensed version of catalytic converter operation.

Just as bees gather their nectar and turn it into honey, the honeycomb in the catalytic converter gathers harmful exhaust gases and turns them into non-polluting substances normally found in nature.

The worker bees in our catalytic hive are platinum, palladium, and rhodium. Two of these metals are *oxidizing* catalysts, the third is a *reducing* catalyst. It's important to understand how each catalytic metal works and the differences between them.

Platinum and palladium are oxidizing catalysts which *add* oxygen to the hydrocarbon (HC) and carbon dioxide (CO) emissions. Adding oxygen to these pollutants forms harmless carbon dioxide (CO_2) and water (H_2O).

Rhodium is a reducing catalyst. A reducing catalyst *subtracts* oxygen. The rhodium catalyst in our converter strips the oxygen from the NO_x emissions, leaving simple nitrogen (already plentiful in our atmosphere) and oxygen.

Our catalytic metals cause a chemical change to occur which converts exhaust gases into non-harmful substances without being changed themselves. They get the reaction started without getting involved or being consumed by it. Kind of like the guy in school who started food fights in the cafeteria, but left before the principal arrived.

A Honey of an Idea

The catalytic converter was an idea whose time had come. We need catalytic converters because internal combustion engines are inefficient. And inefficiency means pollution. Over the years, engineers have tried just about everything to lower exhaust pollutant levels.

- They leaned air/fuel ratios to reduce CO and NO_x levels.
- They retarded ignition timing in an effort to control NO_x and HC emissions by lowering combustion temperatures and raising exhaust temperatures.
- They even forced the engine to eat some of its own exhaust to lower combustion temperatures and NO_x emissions.

Unfortunately, these changes had their price. Performance and fuel economy suffered for awhile. A balance was needed between satisfying tougher emission standards, and the demands for more performance and economy. The catalytic converter offered an answer to these conflicting demands.

Growing Old Gracefully

The converter is a pretty simple piece of equipment with no moving parts. With reasonable care, it should keep doing its job all the way into most cars' twilight years. There are limits to how much unburned fuel the converter can handle, however. It's only one part of the emission system, and wasn't designed to clean away all the pollutants sent down the pipe by an engine with serious fuel, ignition, or mechanical problems.

It wouldn't make much sense to bolt a new converter on a car and send the owner on his way after the original converter melted down. Chances are the converter didn't fail without a reason. You need to find out why it happened in the first place. This article is concerned with diagnosing converter failure and just as importantly, determining the reasons for converter failure.

To make that job easier, we've assembled some special service tools that are designed for converter diagnosis. The results of our tests, plus a liberal sprinkling of common sense, should help us get to the root of most problems. It isn't necessary to take a converter apart to determine whether it's working properly.

Learn Not To Burn

The chemical reaction inside the converter makes a lot of heat. Internal temperatures can go over 1400 degrees F, and surface temperatures can run in the 300-500 degree range. If you've ever seen a car incinerated after it was parked in a pile of dry leaves with a hot converter, you know what we mean.

So please be careful. Let the converter cool before handling it. Third degree burns take a lot longer to heal than bee stings.

Catalytic converter for lead photo compliments of Products For Power.

—By Karl Seyfert

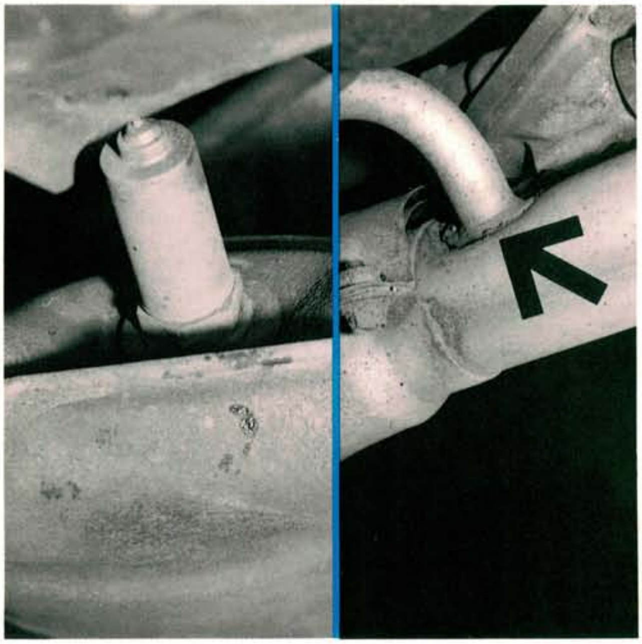
There are three types of catalytic converters:

• Two-way catalysts were first used to control HC and CO emissions on cars built between 1975-79.

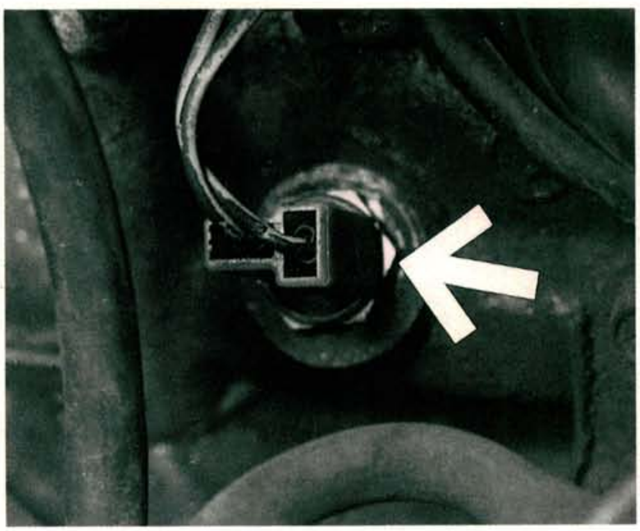
• Three-way catalysts add rhodium to control NO_x emissions as well. These were first used in 1980 and can still be found on many models.

• A three-way catalyst with air induction (sometimes called a dual bed) brings added air into the exhaust system to help the platinum and palladium oxidize the HC and CO emissions.

Three-way catalysts can only clean a controlled amount of pollutants. The rhodium in the three-way converter strips the oxygen from the NO_x emissions, leaving us with nitrogen and oxygen. For this to happen efficiently, the reduction of NO_x has to occur before extra air is pumped into the platinum and palladium bed by the air pump. The platinum/palladium bed needs the extra oxygen, since it's adding oxygen to make carbon dioxide and water.



Some manufacturers keep reducing and oxidizing catalysts apart by installing two separate converters. The front (or pre) converter on this Subaru (left photo) contains a rhodium catalyst and does not receive direct auxiliary air. The rear converter handles HC and CO emissions, so an air induction hose (right photo) provides extra oxidizing air. Other cars use a single converter with separate beds. Only the oxidizing section gets fresh air.



An inaccurate temperature sensor can fool the ECU into thinking the engine is still cold. The ECU will go on calling for a rich mixture from the fuel injection system, or carburetor, long after the engine has warmed up. A warm engine can't handle all the extra fuel and dumps the leftovers into the exhaust system. The catalytic converter isn't designed to handle the extra work load. Added heat caused by the rich mixture spells a slow death for the converter.

Even when the air induction system is working properly, the converter can be a finicky animal. The engine's air-fuel ratio must stay as close as possible to the point of maximum stoichiometric efficiency. That's just fancy talk for keeping the air/fuel ratio at a point the catalyst can handle most efficiently. Since converter efficiency goes down when the exhaust gets the least bit rich or lean, closed-loop fuel systems keep the air/fuel mix in this narrow band of operation.

Fouled spark plugs will also cause a rich mixture. If the car has air injection to the converter, the extra air and unburned fuel give you everything you need for a first class afterburner. Fuel systems that are calibrated for very lean air-fuel ratios may cause a lean misfire at cruising speeds. The little bit of fuel available to the engine doesn't get burned as a result, and goes on down the pipe. The oxygen sensor may get a whiff of this unburned fuel and lean the mixture even further.

Converter Diagnosis

There are several tests that can be used to give you a good indication of the general health of the catalytic converter. You will find pictorial coverage of vacuum gauge and back pressure testing of the exhaust system later in this article. We're going to cover back pressure testing as well as two other testing methods on a step by step basis here.

Make sure that the engine is running properly before you begin any of these tests. If it's not, you're putting the cart in front of the horse. The converter is really the last in line and only responds to what gets sent down the pipe from the engine.

Back Pressure Testing

Correct back pressure specifications can be hard to come by. Each of the back pressure gauges used in this article suggested a different range of acceptable exhaust back pressure readings. Your best bet is to consult a service manual to determine the normal range for the vehicle you're working on. If a manual isn't available, run a test on a known good car so that you have a base line figure to work with.

As a rule of thumb, most back pressure readings taken at the oxygen sensor port should run in the 0-3 PSI range. If you're getting readings way above that, it's safe to assume that there's a restriction in the exhaust system. You might have to do a little digging to make sure that the converter, and not another part of the exhaust system, is the source of your restriction.

Four Gas Analyzer Testing

• Insert the exhaust probe and

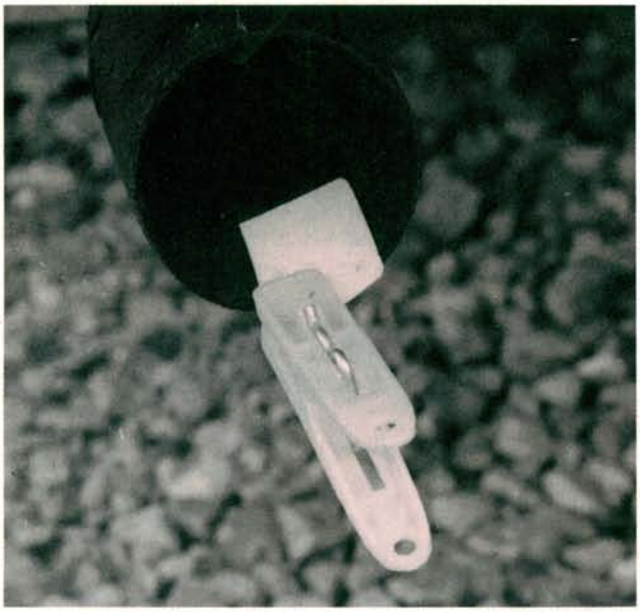
bring the engine and the analyzer up to operating temperature.
• Note the CO and HC readings. If they're higher than specs, disconnect the air supply to the converter.
• If the readings climb even higher but return to normal when the air supply is reconnected, your problem isn't in the converter.
• Increase engine speed and observe the O_2 and CO readings.
• A properly functioning converter's O_2 reading should be higher than its CO reading.

Exhaust Temperature Testing

Converters make heat, and lots of it, when they're doing their job. You can use this heat to get a better idea of what's going on inside the converter by using a digital thermometer or pyrometer to take the converter's temperature.

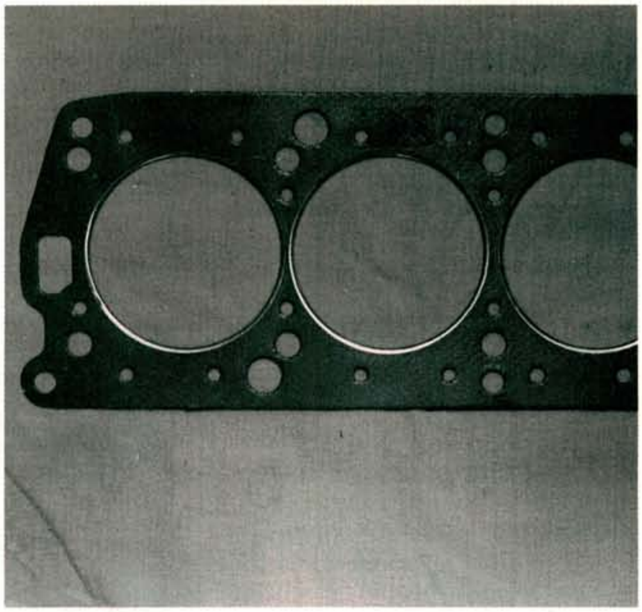
The exhaust gases coming into the converter are already pretty hot, but the catalytic reactions inside the converter should make these gases even hotter.

Here's a quick test using a pyrometer or digital thermometer to measure converter operating efficiency:
• Clean the rust and scale off the exhaust pipe at points before and after the catalytic converter.
• Attach the thermometer or pyrometer sensing probe to the cleaned spot on the inlet pipe of the converter with a radiator hose clamp.
• If you have a dual range thermometer, attach the other probe to the cleaned spot on the outlet side of the converter. This will let you compare inlet and outlet temperatures at the same time.
• A properly functioning converter should have at least a 100 degree hotter converter outlet than inlet temperature.
• If the outlet temperature is the same or cooler, the converter is either being starved for extra oxygen from the air pump or it isn't working properly.
• An outlet temperature that shows a huge increase over the inlet temperature can indicate a couple different problems. Either an over-rich fuel mixture is overheating the converter, or the converter is already damaged and the increased back pressure is generating extra heat.

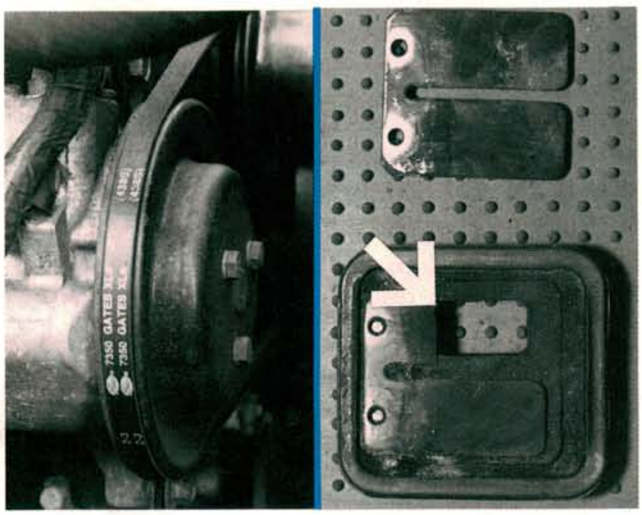


An engine that's burning oil can really shorten the life of the catalytic converter. Phosphorus in engine oil builds up on the surface of the catalyst and reduces its ability to process exhaust pollutants. Unfortunately, there is some oil vapor in all exhaust gas, even if the engine isn't a crop duster. The gradual buildup of phosphorus cuts the effectiveness of the converter over time. Phosphorus buildup is a leading cause of converter death.

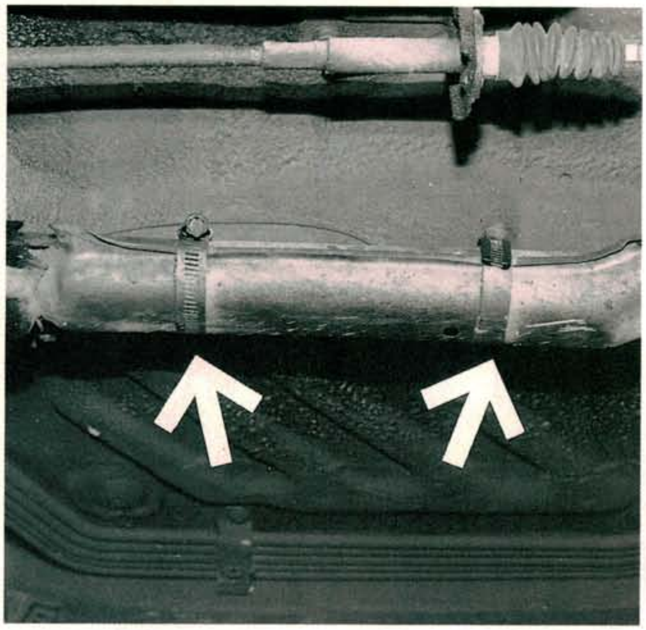
The ultimate converter no-no is leaded fuel. It only takes one or two tanks of leaded fuel to deposit enough lead on the catalyst to deactivate it. Lead poisoning affects the converter's ability to oxidize hydrocarbons first. As lead poisoning gets worse, the converter has trouble dealing with CO and NO_x emissions too. The lead interacts with the palladium, platinum, and rhodium and turns them into an inactive metal compound. Lead poisoning can't be reversed. The only cure is converter replacement.



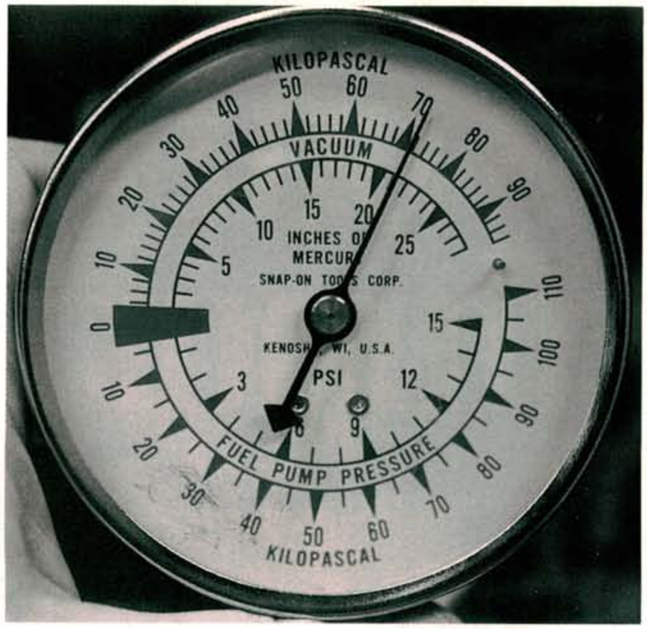
A blown head gasket can dump a lot of antifreeze into the exhaust system. The exhaust may stop steaming after the gasket is replaced, but the damage is already done. Few converters regain their old form after a good soaking. The antifreeze reacts with, and bonds to the catalyst's surface. The restriction caused by this buildup increases backpressure. Like a dog chasing his tail, this restriction makes more heat, which causes more restriction, until the converter self-destructs.



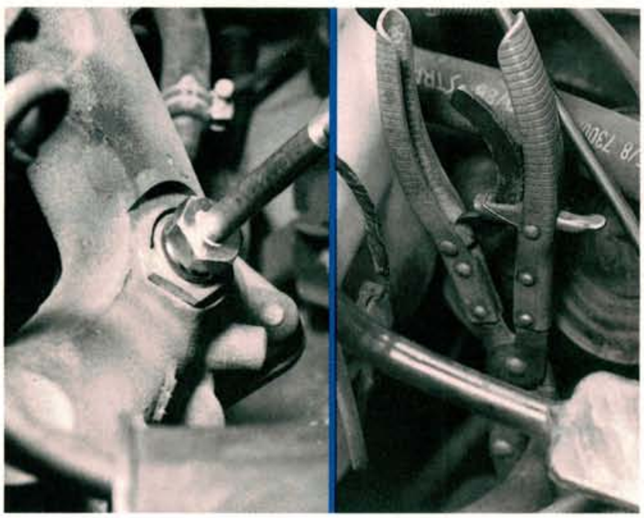
A loose air pump belt (left photo) keeps the air pump from delivering enough air to a three-way oxidizing converter. Manufacturers using pulsed air systems can also run into their share of problems. Pulsed air systems don't have the horsepower drain of an air pump, but damaged reed valves (right photo) in an air suction valve will allow exhaust gases to sneak back to the air cleaner, and reduce air flow to the converter at the same time.



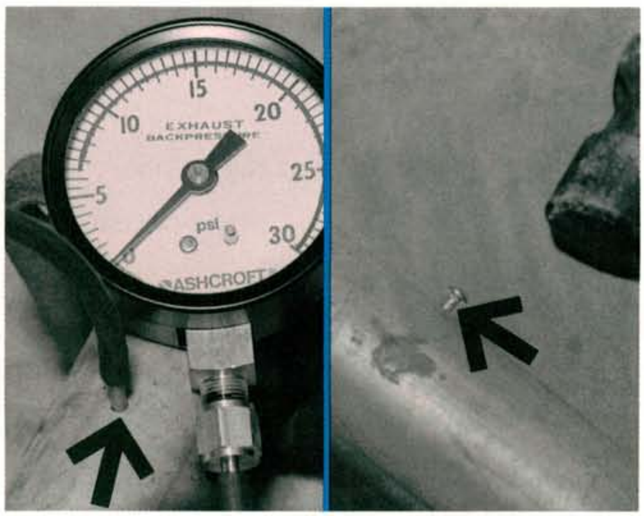
Since converters get hot, the addition of numerous heat shields have given new meaning to the word rattle. Shields like these on first generation Nissan Sentras and Pulsars are notorious for rusting loose and rattling. There's a pre-converter ahead of this pipe so it gets pretty hot too. The hose clamp, band aid approach is a popular fix, although welding or replacement of tattered shields is a better way to go. Resist the temptation to remove and discard any heat shield.



Here's a quick test for a converter restriction. Disconnect and plug the vacuum line to the EGR valve. Dig your trusty vacuum gauge out of your tool box and attach it to a manifold vacuum port. Rev the engine to 1500-2000 RPM. Vacuum should hold steady at 14-22 inches of mercury. Repeat the test at the same RPM with the brakes applied and the transmission in gear. If the vacuum reading drops steadily or the car stalls during either test, check for an exhaust or converter restriction.



On vehicles equipped with an oxygen sensor, you can screw your exhaust back pressure gauge right into the threaded sensor hole. Remove the oxygen sensor and install the 18 mm test adapter (left photo). Don't overtighten the adapter or you'll strip some threads. This Borroughs gauge adapter uses the threaded end of an oxygen sensor. If the converter has air injection, block off the air supply (right photo) to the converter before beginning your test.



The absence of an oxygen sensor on some cars means you'll need a back pressure tester like this one from Forrest Manufacturing. Drill a hole in the exhaust ahead of the converter using the drill bit supplied with the tester. Insert the back pressure gauge adapter (left photo) and measure back pressure at that point. Drilling extra holes lets you locate the exact location of the restriction. After testing, install a self-locking plug (right photo) to reseal the exhaust.