When Do You Dig Deeper

Sometimes circumstances just erase all doubts: the engine drips oil from the stump of a connecting rod hanging out of a gaping hole in the block; the spark plugs you pull out are covered with recently-molten aluminum; a sample of oil from the crankcase twinkles with tiny shards of journal and bearing metal, grit rubbing sharply between your fingers. But usually the question of whether to open the engine for inspection is somewhat more in doubt: perhaps the most common question—after a timing belt has broken or stripped—did the valves bend? Or there are mechanical noises inside, noises that could be lifters or wrist pins or piston slap, but you're not sure. Or there is an oil or coolant leak with no obvious source, or a regular cylinder miss unexplained by fuel, spark or compression loss. What about those cases where coolant leaks into the oil, causing unknown damage to the oil pump, bearings and rings?

The first thing to keep in mind is your role in the assessment. The customer pays you for your best, most reasonable diagnosis, the one that will most probably identify and fix the problem without unnecessary work and without leaving something undone. What went wrong with the engine is not something you're responsible for. Whether there was insufficient maintenance or a manufacturing defect or merely so many miles and consequent wear, this is not something you answer for. The customer, not you, must undertake the risks involved.

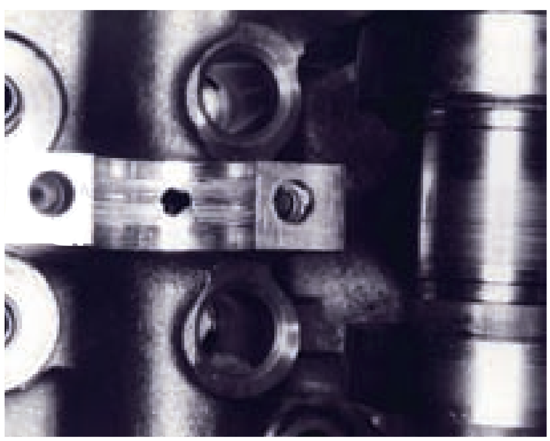
Doctors, insurance companies, banks and everyone else undertaking a financial risk gets paid for it and calculate the odds in their favor. So should you. There is absolutely no reason for a shop to accept such a risk free. If you reasonably assess what might be going on and base your surgery recommendations on that, it is not your loss if the assessment turns out wrong, but the customers. You provide him or her with your best judgment of what to do; he or she decides whether to do the job or not based on that.

If the customer is uneasy with your advice, let them take the question up with another good shop. Even if you tell them, based on your tests, that you're 90 percent sure they've spun a bearing, but it turns out to be something else, that's not work you should have to cover, assuming you've done a thorough job of considering the possibilities, based on your knowledge and experience. Running a shop does not commit you to being right every time, and the customer should know that up front. He should also know that the exploratory work is not free, even if he decides later not to have the repairs done.

A sensible customer will base the decision on the numbers. How much is the exploratory work likely to cost? How much of it will be absorbed by the repair bill if the diagnosis is correct? Is the rest of the car worth it once the engine is repaired? This is not the time to float rosy scenarios. For each of the possibilities you think of, tell the customer what you think the chances are (more or less probable is about all you can really say) and a realistic price you would anticipate for the necessary repairs. Most shops consistently underestimate the price of major repairs, except in those localities where laws compel you to stay within a certain percent of the price quoted (and most shops in such localities consistently overestimate prices, quite reasonably). Then leave the decision, and the responsibility, up to the motorist.

Now to some of the typical cases.

If you find silvery particles in the engine oil, its not pixie dust but bearing and journal metal, such as from this cam and tower. At this point, you can be sure you will find substantial major work and parts replacement necessary.



Broken or Stripped Timing Belt

Everyone knows about interference and non-interference engines, surely? An interference engine has valves that open far enough that, under some circumstances, the cam-and-crankshaft geometry can allow the piston to strike the open valve and bend or break it. A non-interference engine does not open its valves that much or has fly-cuts in the face of the piston to provide clearance. In general, the higher the compression of the engine, the less room there is for an open valve. Thus, all automotive diesel engines with their 19: to 21:1 compression ratios are interference: break a chain or belt on them and the parts will collide (most likely breaking the cam and towers as well). In general, the newer an engine design is, the more likely it is to be high compression and interference.

There is a book, however, which can resolve most of your doubts on broken belt questions. Appropriately titled *Timing Belts,* it includes the latest information for all toothed-belt engines from 1974 on, with updates every year. Besides a listing of which engines are and which are not interference-types, it includes valuable sections on inspection, replacement techniques and timing marks (not all of them are obvious!) for all the engines it covers.

I can't imagine running a shop that does timing belts without this book, which is available from Autodata Publications (**Circle No. 130**).

If a belt breaks, even on an interference engine, that doesn't necessarily mean the valves and pistons will collide, just that it is more likely. Sometimes that can happen even with a non-interference engine if there's enough carbon on the pistons, clogging the

Engine noises come in all notes and frequencies. It's good practice to keep your stethoscope handy whenever you work on an engine that's new to you. Listen to the fuel injectors as here as well as to other components to learn that engine's peculiarities and to tell what's normal from what's not when you get one in that's not working properly. Some fuel injection systems are banked, some are sequential and some use various other pulse strategies depending on load and temperature.

flycuts, perhaps. Most often a belt breaks just at engine startup because that's when it's most stressed. Over a period of a second or two, the starter accelerates the engine from a standstill to perhaps 200 rpm. But with the first power stroke, the crankshaft spins up to nearly fully idle speed in half a revolution, less than a hundredth of a second, with all the inertia of the valvetrain.

This startup failure actually decreases the odds of serious damage because the engine stops immediately unless the motorist keeps cranking. When a belt breaks at cruise speed, the engine will keep turning longer, doing more and more energetic damage. In any case, with an interference engine you have to consider the likelihood that the head will have to come off, valves will have to be replaced and possibly there will be a damaged piston or two. Any time a head is off, of course, its only sensible to ship it off to the machine shop for valve machining.

Leaks and Seeps

These can be real killers. With the tight quarters in most engine compartments, it's really hard to find most leaks without a blacklight and the fluorescent additive. Those using a brighter blacklight make the job somewhat easier at least if the shop is flooded with sunlight. Finding out where the coolant or oil seeps out, however, doesn't always tell you what the cause is. Often, particularly if the engine has a block made of Detroit Wonder Metal and a head made of aluminum, the heat cycling changes of size will scrub away the head gasket and allow a leak.

In the easiest cases, this shows up as clouds of steam in the exhaust and empty space in the radiator/overflow bottle. The temptation in such a case is to quote a simple head gasket job, but keep in mind that sometimes coolant leaking into the head can do more damage than a gasket replacement can fix. While two hundred degrees seems very hot to us, it is a serious thermal shock to an exhaust valve face at as much as 1000 degrees. Alert your customer to the possibility, however small, that such damage might have occurred; and once you have things opened up, carefully examine the valve and piston surfaces for metal fatigue, cracking or flaking. These things don't grow back, of course.

More complicated, more expensive and rarer sources of such leaks come with cracks in the castings, either block or head, and porosity seepage through the metal. Porosity seepage occurs more frequently than we are used to thinking. While today's casting technology is far superior to that ten or twenty years ago, the castings are also much lighter and thinner, so any casting porosity is more likely to sweat coolant or oil than the engineers sometimes predict. The casting improvements may be a wash as far as seepage is concerned.

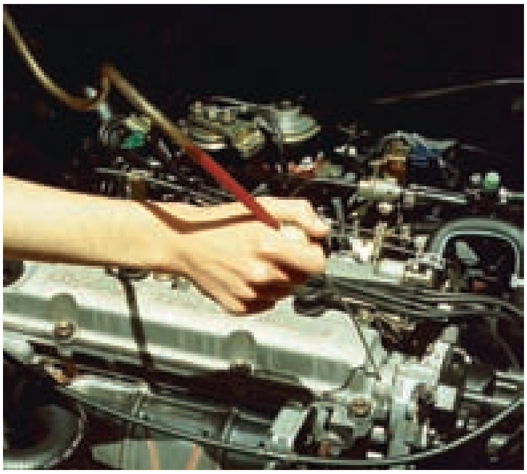
Listening to cylinder head noises along the length can tell you whether the valves, lifters and cam lobes are all playing the same tune. Individual variations may show a poorly adjusted valve, collapsed lifter or valve that doesn't seal — all of them reasons to pop the cap.

Sometimes this can be repaired by a machine shop that is very good at aluminum welding, but more often it calls for replacement of the head or block. If you quoted the customer a simple gasket job, this could come as quite a shock. Lowball estimates also don't leave you room to do such sensible things as routine oil changes or timing belt replacement under these circumstances. You may lose a job occasionally if you estimate too high, but you'll never lose a customer by coming in a hundred dollars under.

Clanks and Pranks

These can really drive you crazy. The motorist reports a disturbing sound from the engine, hoping it will be something insignificant and cheap. The first step, of course, is to determine whether the sound (if you can hear it at all) does come from the engine. Most civilians just suppose anything they hear is an engine sound, but it could come from any moving part of the car.

I can even recall one customer whose pickup made an intermittent banging sound which worried him considerably. After a test ride with him at the wheel, it was apparent that the bed of the pickup had broken loose from some of the holddown stove bolts, allowing the floor to oil can when he hit just the right sort of pavement undulations. Other people will mistake the sound of a loose heat shield or even of a flat tire for something in the engine. You're the one with the educated ear: if you don't hear it, don't take anything apart.



The joint between the distributor and the camshaft is often a source of unnerving sounds. Since there's little load at that point, the circulation of oil is not as much as in other places, and it's about as far from the oil pump as the galley gets. If you can avoid opening an engine because you know the problem is merely a distributor bushing, you'll be the hero (in the case of this mechanic, heroine) for that customer.

The first test is to determine whether the noise is in the engine or somewhere else in the drivetrain. Engines do not turn at wheelspeed, and while in RWD cars they turn at driveshaft speed in high you can put the car in neutral or some lower gear to distinguish the frequency. Sometimes you have to put it up on a lift to listen more carefully still, and sometimes the noise does come from the engine but is caused by a split seam or crack in the exhaust system (keep in mind that the exhaust system starts with the manifold gasket, and a crack there can sound just like a collapsed lifter!). You really need two kinds of stethoscope, the regular mechanic's version with a metal acoustic probe and one consisting only of tubes you can move to places you wouldn't want to put your ear. Often, you can just pull off the metal probe and replace it with a length of vacuum tube.

So let's suppose you've eliminated the causes outside the engine, even those possibly from a broken element in a clutch pressure plate or a cracked flange in a flex plate. The next step is to determine whether the noise is crankshaft-speed relative or camspeed relative. This is not always as easy as it sounds, since some engine-speed sounds, like piston slap, can occur every other cycle if the piston needs compression to make noise. Of course, your stethoscope is an invaluable aid in locating the position where the sound is loudest, likely to be the source (though the internal acoustics of an engine can be very strange —there are lots of noises going on we don't hear from the outside). Don't forget there are some sounds, like timing chains tapping against tensioner shoes, that don't correspond directly to either the cam or the crankshaft rotational speed, and there are others caused by cylinder misses that correspond but can mislead you.

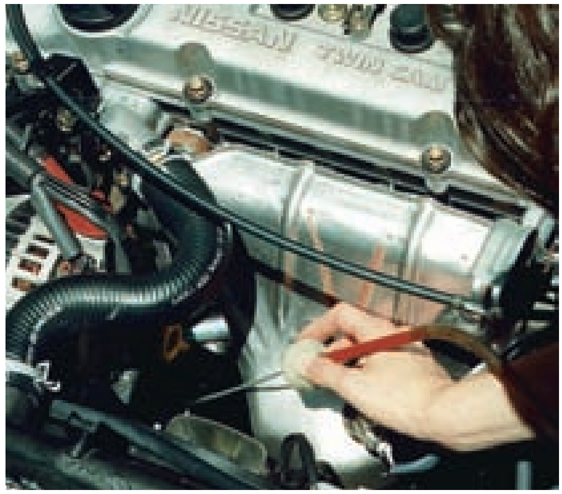
An alternator can also fool you into thinking something is amiss in the engine. Not only can the bearings make the typical sound of a rotating shaft that's lost any lubrication, a bad set of diodes can make the same squeal under some circumstances. Use your slack time to build your inventory of what different parts of different engines should sound like; then when something unusual comes along, you won't be tempted to say, "they all do that."

There are two kinds of piston slap, one more common than the other. Classical piston slap occurs because the piston is loose inside the cylinder, and the sound of the piston rocking to and fro as it moves is the slap. On some high performance engines, this is a designed-in feature: the pistons are elliptical when cold but expand to be circular when hot. Of course, this will be more evident when cold. On more ordinary engines the symptoms will be the same, but may not go away with operating temperature.

A second kind of piston slap occurs with high-compression engines that have begun to form carbon deposits on the roof of the combustion chamber, just around the circumference. There is not much clearance here on most engines these days, and sometimes the piston will tap against the carbon deposit until the engine warms and the cylinders grow lengthwise. This type of piston slap goes away with operating temperature, of course. There is virtually no acoustic way to tell these conditions apart, but if you have a borescope you can resolve the question quickly. Obviously, its much cheaper and quicker to remove carbon than to fit a larger piston, so this is a significant difference.

Bearing noise sounds about the same as wrist pin noise, except from the lower part of the engine instead of the top. Wrist pins bores are much less likely to wear, but when they do the diagnosis can be tricky since you can't be sure whether you're hearing the noise at the top or the bottom of the piston travel. If you're lucky, it will rattle at each extreme, giving you a sound at just double the crankshaft speed. A timing light, by the way, is an excellent tool for providing an exact measurement of engine speed to compare to a sound.

Main bearings, however, seldom make much noise unless all of them are worn, in which case you can frequently tell by prying



An air conditioner compressor can cause engine-like noises, even with the clutch disengaged. While many of them, as on this Nissan, are fairly hard to reach for work, there's always room for the stethoscope probe. Another way to use the stethoscope is to remove the probe altogether and move the plastic tube to places like the mating surface between the cylinder head and the exhaust manifold. A failed gasket there may cause a noise in a place where you'd rather not stick your head.

the crankshaft back and forth. If you find excessive clearance in the thrust bearing, you can be confident there is excessive clearance in all of them.

Oil pumps rarely make noise, but if they do you can be confident you have to go in and take a look. Unfortunately, you have to know the engine pretty well to know the ratio of oil pump speed to the crankshaft. Classic American V8s, of course, turned it at the bottom end of the distributor shaft; many imported cars use a gerotor pump turning on the crankshaft; others use a chain or gear drive at some other ratio. Oil pressure checks are essential if you expect to diagnose this problem correctly, using a real tool, not the frequently inaccurate gauge on the dashboard.

Bottom end sounds are typically heavier than those indicating problems in the cylinder head. Rod knock is distinctive enough that even amateurs can identify it; but a spun main bearing may make no sound at all, appearing instead as low oil pressure at idle. Piston slap and slop in the wrist pin are rarer, but not unheard of. Hints on how to distinguish them are in the text.

The mere fact that there is oil pressure is not a guarantee that things are going well with the pump, however. For example, if the pressure relief piston sticks at one point partially open, you'll find low pressure at idle and high pressure at cruise. Oil pressure is not one of those things that fall under the rule "if some's good, more's better." Excessive oil pressure will spray too much oil on the cylinder walls, consuming oil, fouling plugs and coating the oxygen sensor and cat with carbon. It can also lead to blown seals in various places on the engine and can damage hydraulic lifters.

Collapsed lifters themselves are most easily found using a cylinder balance test: when the noise goes away, you found the cylinder with the bad one. Sometimes, however, the noise doesn't go away.

Exploratory surgery is never good news for the patient, but by using your knowledge and experience, you can assure your customer that nothing is being done that's unnecessary and that the repairs will be just the right ones. ■

—By Joe Woods

If there's one secure rule of thumb about engine noise diagnosis it's this: never open an engine up chasing a bad sound until you've removed all the accessory belts and run the engine (briefly! The water pump is not turning!) without it. If the noise went away, reconsider your plans; the problem's not inside.