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Technical Note: Engine Ticks and Their Relationship to Engine Temperature

1. Background

We discuss the ways automotive engines make percussive sounds, methods by which these can be positively identified, and triage criteria for determining whether the noise warrants concern at all.

2. Causes of Engine Tick at Cold Start

Internal combustion engines are a complex assembly of moving parts, most of which move at high speeds and under great force. The clearance between these parts is tightly controlled by engineers- too small of a clearance causes excessive friction and does not allow adequate oil flow, thereby causing heat buildup and, potentially, galling. Too large of a clearance causes noise, and allows too much oil to flow past, reducing the pressure of the oil. Because heat flows through different parts at different rates, in most cases engineers design the clearances to be the correct size when the engine is at operating temperature. Due to the varying scale of different parts and the variance in how much heat flows through them in operation, it is not possible to design the clearances between the parts such that the clearances will remain the ideal size when the engine is "cold"- that is, at any natural temperature, before the heat of engine operation warms the parts to their design temperature.

As a result, most engines make significantly more noise when first started. The most common is a valve lash noise. This noise may affect all cylinders or may affect only one. At idle speeds of 600-1200 RPM, the noise from each cylinder will be heard 5-10 times per second (that is, 5Hz - 10Hz), and is a light, high-pitched metallic click noise, much like a small hammer makes when striking a hard surface. These noises are caused by air pockets in the hydraulic lifters (in OHV engines), or hydraulic lash adjusters (in OHC engines), both of which are constructed similarly despite the difference in their function. The device in question is filled with pressurized engine oil, which exerts an outward force on a piston at the end of the device, thereby taking up any free slack in whichever part of the valvetrain the device is installed in. The device is made without seals, relying on controlled leakage of oil through the clearances between the piston and cylinder, so some oil will leak out after the engine is shut off. When it is started again, it can take some time for the flow of pressurized oil to flush out the air bubbles. Valvetrain noises of this type rarely get better or worse with mileage, and usually go away when the engine reaches operating temperature. They can be corrected but do not usually need to be.

A second common cause of engine noise at cold start-up is a piston slap. Pistons in mass-produced engines are aluminum, which has a coefficient of thermal expansion much different than that of iron. Since the piston is exposed to intense heat and will expand greatly in operation, the piston is designed to be significantly smaller than the bore it slides in when cold. Many engines exhibit a slight "piston slap" when cold. This sound is a slightly "richer" sound than a valvetrain noise, since generally it will excite at least two different frequency bands (the piston itself, the block, and sometimes the rod and pin). A piston slap generally goes away much faster than a valvetrain noise, because the piston is heated by direct contact with flame, and is cooled only by oil; whereas valvetrain components have no direct contact with flame and are separated from flame by a liquid cooling jacket that takes several minutes to reach operating temperature. Another distinguishing characteristic of piston slap is that it tends to consistently affect all cylinders equally, whereas valvetrain noises tend to affect anywhere from 0 cylinders up to all cylinders according to random chance.

Neither of the noise types above is cause for great concern, provided the sound level or nature does not change consistently over mileage, and that the noise stops when the engine reaches operating temperature. However, some noises that are exhibited when cold will get worse as the engine warms or as mileage is accumulated. These types of noises, which we discuss below, usually *are* cause for concern.

3. Noises heard at operating temperature or which get worse with time

A common cause of percussive noises that get worse with rising temperature, is loose spark plugs. We recommend looking for this problem first, because, compared to the other sounds we discuss here, it is by far the easiest to find and the easiest to repair. On engines equipped with on-plug coils, while the engine is running, loosen the pack mounting screw 1-2 turns, then place a finger on the top of the coil and apply light pressure. If the sound changes significantly as a result of applying finger pressure, or if the spark plug can be felt to bounce up and down, a loose spark plug is indicated. In many cases simply tightening the plug to specification will correct the problem. In others it may be necessary to cut a new seat, to install a thread repair insert, or to replace the cylinder head. Try the easiest solution first.

Another class of percussive sound heard when warm, and which is inexpensive to diagnose and repair, is exhaust leaks. By ear, these are extremely difficult for most people to distinguish from valvetrain noises (which we discuss later). It is possible to use sophisticated audio analysis techniques to positively differentiate these sounds from those of valvetrain problems, contact us if you would like to use that approach. Another way to positively identify an exhaust leak is to spray soapy water around the exhaust manifold when the engine is stone-cold and before it is started, then look for bubbles once

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the engine starts. With a good, strong flashlight, carefully examine the manifold, the surfaces it mates with, and the flange joint at the end for signs of exhaust leakage (faint black stains) or heat distortion of nearby components (blue spots in heat shields, rippled surface of any nearby plastic components).

After the easy, cheap problems are eliminated, we start to look for more serious ones. Most of these are caused by mechanical problems with the rotating assembly, also known as the "short block" or "bottom end". Repairing the cause of these sounds is expensive and generally requires a full engine rebuild, so be sure to eliminate other causes first. Also be aware these problems are likely to co-exist with other mechanical problems like piston slap or a valve tick, so the presence of a "cheap" problem does not mean there is not a problem with the rotating assembly. At idle speeds of 600-1200 RPM, these sounds will occur 10-20 times per second. Testing under load is often a good next step if these noises are suspected. Usually, if the noise gets louder as load is applied, the issue is a worn main bearing, if it gets quieter with load, the issue is a worn rod bearing or wrist pin. Bronze shavings in the oil filter are circumstantial evidence of this type of failure. To positively confirm it, remove the oil pan and shake the rod ends. Failed rod bearings will be evident from play in the rod. Main bearings must be inspected visually to positively confirm damage, which requires them to be disassembled.

What if applying load causes no change at all in the noise amplitude? In that case, the component causing it is a valve component. Worn camshaft lobes are the most common reason for this mode of failure. Other components can cause it too. The good news is valvetrain problems are usually feasible to address "in-frame"- with the engine still in the vehicle- and do not require any work on the heavy, expensive components in the bottom of the engine. Finding steel shavings in the oil pan is circumstantial evidence of this type of problem; to positively confirm it, the valvetrain must be visually examined.

4. Final notes

In our experience, over 95% of instances in which an engine makes a percussive sound *only when cold* are not cause for any further action. Absent any perceptible change in the noise either over time or over less than 100,000 miles, the risk of the noise warranting further concern is small enough that the most rational path is to simply ignore it.

If the noise *does* prove worthy of concern, we hope the information in this note can help you narrow down where to look for it and to choose a course of action.