The piece of piston then proceeded to bounce around in the combustion chamber, damaging the cylinder head as shown

KNOCK ON STEEL

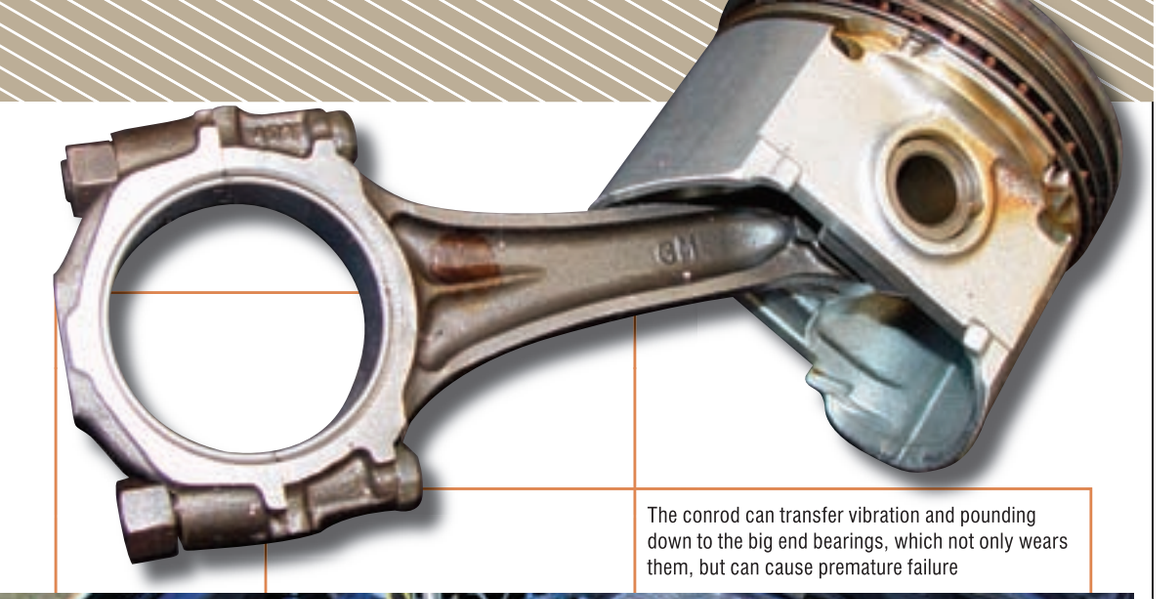
STORY BY FRANK ZAPPIA

The more power we make, the closer to the detonation threshold we get and the more informed we need to be about the causes and effects of this engine-killing phenomena.

Detonation damage, particularly in supercharged and turbocharged engines, is becoming a more regular event now as tuners push the thresholds of both the factory management systems and their pool of forced-induction knowledge.

Understand, though, that detonation takes many shapes and forms, just as its name morphs to describe different kinds of the same event.

Sitting here, without even opening the textbooks, I can think up several different names given to the uncontrolled burning of the engine's air/fuel mixture. Try pinging, knocking, pinking, dieseling, rattling, detonating... The list, if you look hard enough, probably goes on.



The conrod can transfer vibration and pounding down to the big end bearings, which not only wears them, but can cause premature failure

Normally, this type of detonation will be found when winding up the ignition timing to go racing, adding boost pressure or radically changing the volumetrics of the engine in some way (shaved heads, flat-top pistons and so on).

With older engines, particularly those with stock pistons still in them, even the slightest amount of pinging would blast a big chunk out of the cylinder head gasket and cause a complete lack of compression on that cylinder.

Thank poor-quality gasket materials and cylinder head-clamping arrangements that were far from optimum for that. It's all a bit different these days, though…

Now with engines such as the LS1 and LS2, the threshold for pinging is much higher than previously, but when the pressure blasts do, in fact, cause a problem, they will more than likely destroy the piston and still leave the factory head gasket unmarked.

The part of the piston that fails is known as the 'ring land' and is the small, fairly weak piece of metal that separates the stack of piston rings.

The top land cracks, the rings still hold the cracked section in place, but compression falls away on that cylinder. This type of damage is best detected as a misfire at idle combined with excessive crankcase blow-by.

In some cases, the tips of the sparkplugs will also be damaged, with the electrodes literally 'blown' off them.

PINKING

Other than pure octane, an incorrect ignition advance or an overly lean air/fuel mixture can also play its part in uncontrolled combustion.

Lean mixtures love to ignite, which is why some engine tuners live by the saying 'lean is mean'. When these engines run lean and they burn in an uncontrolled fashion, then the detonation damage that occurs is unmistakable.

It's all a bit different to the conventional ping, with the pressure wave of the uncontrolled combustion being combined with massive heat, which literally softens the top of the piston and the valves like a big, angry blowtorch.

The cracking of ring lands then is combined with a molten metal effect. In most of these cases, the sparkplugs have their tips melted away from them.

Because the piston takes such a pounding and suffers such deformation with this type of detonation, the side effects are of an extremely sick engine that in a lot of instances simply won't run.

In the worst pinking cases, where the pink is accompanied with ping, the results are catastrophic. Normally, though, pinking damage isn't instantaneous, with many molten pistons showing evidence of previous injury. Running slightly richer can avoid this problem altogether.

While the detonation event needs to meet several key criteria before occurring, there are all sorts of different theories on, say, the difference between 'knock' and 'ping'. Depending on who you speak to, and what type of background they have, you will receive a different answer.

In fact, it would seem that there is no locked-in-concrete definition for any of these descriptions, so we have decided to create our own. Feel free to let us know if you disagree.

CAUSES AND EFFECTS

In all but one of the detonation instances, the criteria that need to be met are one, fuel and air mixture in the combustion chamber, two, compression stroke achieved, and three, ignition created by firing the sparkplug.

The only variation to this is in the case of 'dieseling', where number three can be deleted, as hot spots in the chamber spontaneously ignite the air/fuel mixture.

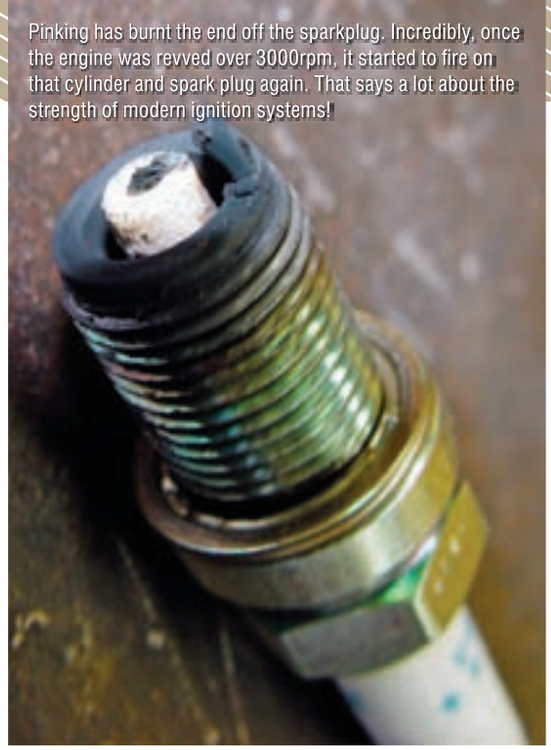
Rather than being a wondrous and mystical event then, detonation in all its forms, though being little understood, is totally controllable providing you have an understanding of the basics.

The event itself is auto-ignition of the air/fuel mixture at the furthest point from the sparkplug once the plug has fired.

The resulting pressure waves as the two flame fronts collide (one lit by the plug and one auto-ignited) hammer the cylinder components and quite literally 'ring' the cylinder block, which is the noise that you can hear.

Controlling detonation comes in the form of changing ignition timing, adding fuel or changing the physical configuration of the engine (such as boost and compression).

With knock-sensing technology being so advanced now, and the factory Holden engine management systems so effective in dealing with all these types of uncontrolled combustion, it's very rare to see stock cars suffer from any of these problems. Highly modified vehicles are another kettle of fish altogether…



Pinking has burnt the end off the sparkplug. Incredibly, once the engine was revved over 3000rpm, it started to fire on that cylinder and spark plug again. That says a lot about the strength of modern ignition systems!

DIESELING

Thankfully, the least seen form of detonation in the new millennium, dieseling generally only plagued nasty, worn-out old engines that had combustion chambers full of grotty carbon deposits.

As the engine ran under load, the carbon deposits would glow, causing the air/fuel mixture to ignite before the sparkplug fired it. In operation, it made the petrol engine much like a traditional diesel engine, with 'glow plugs' to fire the mixture.

Most of the carbon build-up was a by-product of poor tuning (overly rich), bad ring seal (oil), and poor-quality fuel (contaminants). A graphic example, and one that you have probably seen previously in a carby-fed engine, is the engine 'running on' once shut off at the ignition.

Dieseling is not good and over time will destroy an engine, but it's also probably the least damaging of all kinds. A fix 'from the day' was to remove the cylinder head(s) every 50,000km or so and have them cleaned of all these deposits, commonly referred to as 'de-coking'.

PINGING

The familiar favourite of the modified-engine brigade, pinging is best described as the detonation that occurs from having too much ignition advance present in the engine for the given boost and fuel octane. It's extremely audible and highly damaging, and best avoided at all costs.

Pinging with just a touch of 'pink' thrown in. Overly advanced, and then overly lean as this race engine got into stride, the piece of piston crown was first blasted off before its edges were 'cured' by pinking

Tuning big-power Commodores for the track requires the tuner has much experience at controlling detonation. While it may not happen on the dyno, consider the continued load the engine is under by the time it crosses the line and realise that the detonation point drops markedly

Big superchargers on LS1 engines (which are 10:1 compression from the factory) need an experienced hand to tune them for total reliability

Mother of all pinks. Poor fuel supply to number-seven cylinder on an LS1 engine quickly sees this as the first piston to 'pink', and the damage is massive

A genuine detonation event and best described by 'pinging'. Too much ignition timing for too long has sent the ring lands on this piston south. Only a full rebuild will fix it

KNOCKING

Named after the noise it makes, the knocking style of detonation has none of the light rattle of pinking and pinging.

Rather, knock is a solid rap at the bottom end of the engine and is the result of the conrod acting as a tuning fork and quite literally transferring the shock load from the combustion chamber into the big end bearing.

Either pinging or pinking can induce knock in an engine, as the continued pressure shocks work away at the bearing surface until it is that worn that the bearing clearances open and the knock becomes audible.

When this does happen, you have a tiny window of opportunity to correct the situation before the bearing totally fails and the conrod in question ends up through the side of the cylinder block. As you can imagine, the results are catastrophic.

AVOIDANCE

Every single type of detonation described here can be easily avoided if you do your modification homework correctly.

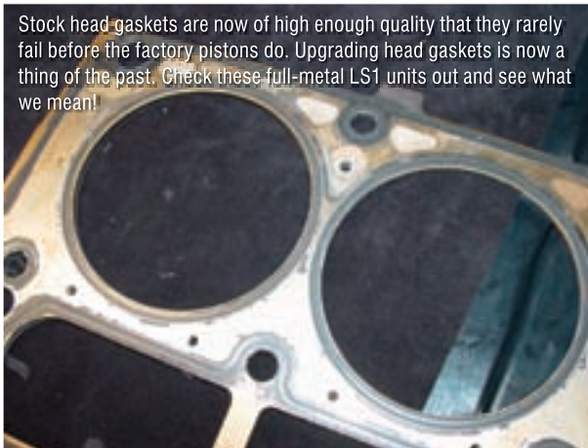
At each and every step of the process, make sure that you check for detonation using simple audible test procedures and, in the case of later-model Commodores, the excellent scanning software that reads live engine data such as HP Tuners or EFI Live Flashcan.

Also ensure that your chosen tuner checks for detonation, particularly when on the dyno.

Run the engine's air/fuel ratio and ignition-advance curve a little more conservatively than first thought possible, particularly if the controls, such as fuel and ignition trim versus air temperature (and similar), haven't received accurate calibration.

The better your mapping and the closer you can run to detonation threshold without actually detonating, the more power you make. SC

The bearing surface gets pounded with all the shock before the bearing itself deforms



Stock head gaskets are now of high enough quality that they rarely fail before the factory pistons do. Upgrading head gaskets is now a thing of the past. Check these full-metal LS1 units out and see what we mean!