PINPOINTING PISTON PROBLEMS

Experts explain that it's the little clues that count when diagnosing damaged pistons.

By **Dan Anderson**

Whether you're collecting shrapnel after a catastrophic engine failure or checking pistons during an engine rebuild, it's good to play detective.

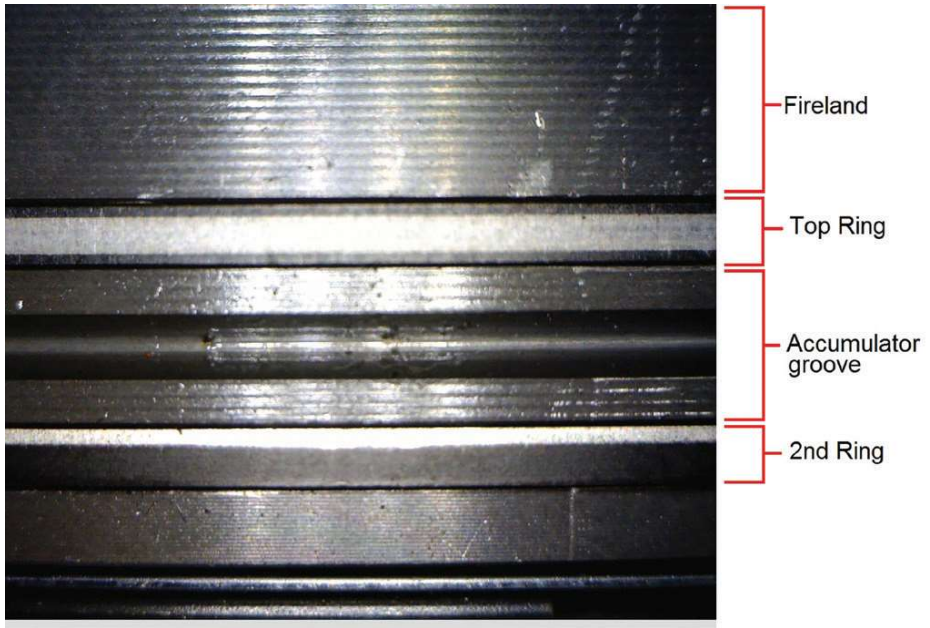
The folks at Mahle Motorsports routinely receive boxes with damaged pistons, piston pins, piston rings, and associated parts. They're experts at examining the debris, sometimes under a microscope, to determine what caused the damage. Here are examples of some of the common problems they see, and suggestions on how to prevent carnage.

Faulty combustion due to detonation, incorrect fuel octane, lean air/fuel ratio, or over-advanced ignition timing produces similar damage. Faulty combustion led to the side of this piston's intake pocket peeling away. That failure was preceded by the pitting and erosion evident just to the right of the valve pockets.

"That light gray area without soot, where it looks like it's been sandblasted, is an early warning of faulty combustion," says Zach Jones, engineer with Mahle Pistons. "If you know what to look for during a rebuild you can check for piston tops that look like they've been sandblasted, figure out what's causing the faulty cobustion, and prevent catastrophic problems."

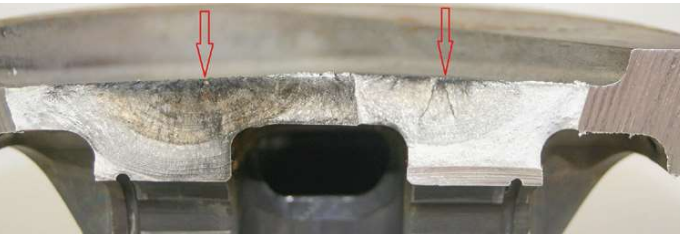
Ring Land Erosion. Vertical scoring/erosion above a piston's top ring groove is another symptom of faulty combustion, specifically detonation.

"Detonation happens after main combustion occurs, when residual fuel in the combustion chamber self-ignites, causing an explosion that erodes the aluminum around the edges of the piston crown," says Jones. "Pistons that look like this indicate problems with detonation due to incorrect fuel/air mixture, wrong fuel octane, over-advanced timing or even incorrect spark plug heat range. This sort of damage is actually more common than the sandblasted top in the previous photo. It's good to look for this sort of thing during engine re-builds."



Engine assembly mistakes. This is a close-up look at the top two rings on a piston from an engine that was smoking, indicating excessive oil consumption.

"The shiny, silver strip along the top third of the second ring shows where that ring has worn against the cylinder [wall,]" says Jones. "On a correctly installed second ring, that shiny strip should be on the bottom of that ring. The second ring has a tapered edge, and should be installed so the wide part of the taper is toward the bottom of the piston. This ring was installed upside down, so the wide part was at the top. Instead of scraping oil on the cylinder wall down toward the crankcase, it was scraping it up into the combustion chamber, causing the engine to smoke and possibly causing abnormal combustion because the oil was throwing off the fuel/air ratio. The way the second ring was installed is the first place we look when we're dealing with an engine that starts smoking soon after a rebuild."



Piston temperature-related. There are two ways extreme temperature can harm pistons: excessive *piston* temperature and excessive *engine* temperature. These photos show the results of excessive piston temperature.

"The red boxes in this photo of a cross-sectioned piston show where the cracks started, and how they propagated across the top," says Jones. "The cracks usually start in a valve pocket, often because of a lean fuel/air mix or too much ignition advance that causes elevated piston temperature. When the cracks first develop the engine still runs fine, and runs fine for another 10 or so races, but the cracks are propagating during that time. Eventually the excess heat of combustion can torch and wear away the edges of the cracks, and you've got a holed piston. That's why you should always check for hairline cracks in the tops of pistons during any rebuild or repairs."

Excess engine temperature. In this situation the engine cooling system is the culprit, though the piston initially appears to be to blame.

"This piston is from a 410 sprint car," says Jones. "The main clue here is that the damage is to the piston skirt, not the top of the piston, and that the damage started on the edges of the skirt in front of the skirt struts due to uneven expansion of the piston. We'll see this if an engine runs low on coolant, if there are air pockets in the cooling system, or other cooling problems. [The racer] sent all the pistons from this engine, and not all of them had this much damage, so we were eventually able to determine that the engine had cooling issues that created hot spots in the block."

Circlip ejection. Never underestimate the damage a piston pin circlip can unleash.

"We see three common problems related to circlips," says Jones. "Failure to fully seat a circlip during installation, circlips bent or damaged during installation, and using the wrong circlip or re-using a circlip during a rebuild. All three problems have the same symptoms—quick and catastrophic engine damage. Because the damage is so extreme, it's sometimes hard to determine that something as simple as a circlip started the chain reaction that ended up so ugly. That's why it's so important to examine every little piece of debris out of the engine and crankcase.

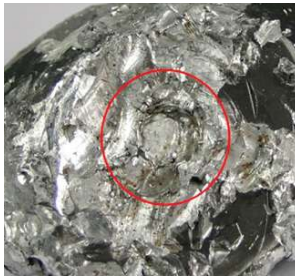
"The close-up photos of the ends of the circlip from that piston, which the owner found in the crankcase, show what happened. A properly-sized, properly installed circlip will have polished sides all the way around. This one had polished areas only on the ends, which means that only the ends were in the groove, so that circlip came loose and led to a lot of damage."

Contamination ingress. Contamination that enters an engine through its air intake system tends to score piston skirts from top toward the bottom. Contamination that's in the engine's oil tends to score skirts from the bottom toward the top.

"We tend to see indications of contamination in the oil in engines that weren't well cleaned after honing and boring," says Jones. "Residual grit and filings get distributed by the lubrication system throughout the entire engine and end up doing a lot of damage."

Over-revved/dropped valve. When a valve has dropped there's no question about the cause of the carnage.

"Most of the damage in this photo is general," says Jones, "but the small circle outlined in red is from the valve stem. That suggests the piston was intact after the valve head broke, for the valve stem to puncture the piston like that. The other photo shows where a valve hammered the top of a piston but the piston remained intact. Either way, it's not hard to diagnose."



Puzzle solving. These photos demonstrate how important it is to look at the "big picture" when diagnosing piston-related engine problems.

"It's easy to look at a handful of piston pieces and think the piston failed," says Jones. "But usually there was a reason that piston came apart, and the only way to figure out the actual cause is to get *all* the pieces and put them back together so you can see if there's a starting point. In this case, reassembling the piston identified that the problem started with scuffing on the piston skirt. We were able to work backward and determine how to prevent that from re-occurring in the future."