Over the last year or so, there has been quite a lot of talk about the effect unleaded petrol would have on our motor cycles, so when the following article was sent to me by Bruce Metcalf, I felt sure you would all find it interesting. It is reprinted by courtesy of American Motorcyclist magazine, the monthly publication of the American Motorcyclist Association, PO Box 6114, Westerville, Ohio, USA 43081-06114 - Ed.

You've seen it on cars for the past 10 years - on the fuel gauge and next to the gas tank filler opening - just a small decal reading: "Unleaded fuel only." Unfortunately, car owners by the thousands have been ignoring that message and dumping leaded fuel into their cars anyway to save a few cents per gallon. In the process, they've destroyed the emissions control systems on those cars, and the Environmental Protection Agency doesn't like that.

What's this got to do with motorcycles? Plenty. The EPA has come up with a plan to stop this "misfuelling" of cars. And that plan means you may soon see signs reading "Unleaded fuel only" posted at every gas station instead of just on cars. By July 1 of this year, the federal agency in charge of vehicle emissions will have cut the level of lead allowed in gasoline to one half gram per gallon, down from two to three grams per gallon back in the '60s, and 1.1 grams per gallon earlier this year. And, starting on January 1, 1986, that level will be cut again, to one-tenth gram. Finally, the EPA is considering a total ban on leaded gasoline, perhaps as early as 1988.

Lead has been used as a fuel additive for decades. Tetraethyl lead - Pb(C₂H₅)₄ - for the technically inclined - was originally designed to boost the octane rating of fuel for high-powered engines. If you're old enough, you may remember when high-octane fuel was known as Ethyl because of this ingredient. But no matter what name it goes by, the Pb in that chemical equation still stands for plumbus, or ordinary metallic lead. As in bullets. As in lead poisoning. As in anemia, kidney damage, hypertension and behavior disorders in children, and perhaps high blood pressure in adult men.

There's no question that lead is unhealthy stuff. The controversy concerns the scope of the problem. C.A. Hall, associate director of air conservation for the Ethyl Corporation, one of the few, manufacturers of tetraethyl lead in this country, says that lead usage in motor vehicles is down about 80 per cent since the peak year of 1970, when more than 400 million pounds of lead was used in motor fuels. The one-tenth gram per gallon standard that goes into effect January 1 will reduce the motor-fuel lead content to a mere 1 per cent of that peak year, says Hall. And he says that's an acceptable level that eliminates health hazards.

The funny thing is that lead isn't even particularly good for an engine. When leaded gasoline is burned, corrosive byproducts are left behind as a coating on the piston, head, spark plug and exhaust system. These lead salts can also get into your oil, where they attack the bearings of the engine and transmission. That's one reason why newer cars, running on unleaded fuel, can go farther between oil changes, tune-ups and exhaust systems.

In spite of all those drawbacks, lead has two redeeming values. First, it's the cheapest way to increase a fuel's octane rating, and that's important in high-performance motorcycles and cars. But even more important is that the lead deposits which are such a problem elsewhere in the motor may be just what the engineer ordered for prolonging the life of the valve system in four-stroke engines.
The exhaust valve of a four-stroke engine operates at particularly high temperatures. When it's open (see diagrams above and right), it's surrounded by just-burned gases being pumped out of the cylinder. Then the valve is slammed shut against its seat by the valve spring. The temperatures at that point can become hot enough to melt iron, and the valve can actually weld itself to the seat. When the valve opens again, it may carry with it a "wart," a small glob of metal from the seat. In the process of opening and closing, the valve rotates slightly, so that the next time it shuts it will slam the wart into a new place on the seat. Over a period of time, this action wears away at the valve seat, driving the valve farther and farther into the cylinder head. However, as Hall points out, lead can eliminate this welding and wearing and greatly reduce valve-seat wear. "The lead compounds lay down a fine coating on the valve seat and valve head that prevents these two pieces from coming into intimate contact with each other," he says. "Instead, the lead coating cushions the blow."

It's entirely possible to build four-stroke engines to run on unleaded fuel. The major car companies have been doing it since 1971. William Giles, now vice-president of engineering for the Valve Division of TRW, a major manufacturer of valve components, was one of the engineers studying that problem in 1970. "In the '50s and '60s most engines used cast-iron heads with the valve seats machined into that surface," Giles says. "No attempt was made to harden the seats because lead oxide and lead sulfates acted as a solid lubricant. But with unleaded gas we had a poor wearing surface. "We did a number of tests to figure out what was necessary to improve that situation. Installing valve-seat inserts of hardened material or induction hardening the cast-iron seats worked very satisfactorily. Today we see only an occasional wear problem in a heavily loaded engine - like a small, four-cylinder car pulling a trailer."

The Japanese motorcycle manufacturers, familiar with the lead-free gasoline used at home, also began planning for unleaded fuel at an early stage. Honda, which has the longest experience with four-stroke engines, has made all of its motorcycles to unleaded specifications since 1969. "In fact, says Fred Wing, who trains Honda service-department personnel, "we see more problems when the owners don't run unleaded."

The other Japanese manufacturers concentrated most of their attention on two-stroke engines in the '60s, but all said that their four-stroke engines built since 1970 will handle unleaded gas.

That leaves American and European makes. Leaded gasoline has remained an option in this country and, with the exception of its new Evolution-engine models, Harley-Davidson has continued to build motorcycles designed for leaded gas. Similarly, the English bike manufacturers never included unleaded fuel in their plans. BMW began building bikes compatible with unleaded fuel in 1981, while Moto Guzzi phased in the switch from 1979 to 1981. If you have any doubts about where your motorcycle fits into this picture, you may want to consult your dealer, manufacturer or importer. Owners manuals, since they were written at a time when leaded fuel was readily available, may not have given enough consideration to unleaded gas. If you find that your dealer has the same uncertainties about lead that you do, you can find an address and telephone number for the manufacturer or importer in AM's Cycle Connection, which you received with your March 1985 issue.
Since you've followed along in the story this far, it's likely that you own a motorcycle that wasn't made for unleaded fuel and you're wondering what problems you'll face as a result of the EPA ruling. The first thing you should know is that the lead standard that takes effect July 1, specifying no more than one-half gram per gallon, shouldn't pose a problem for any engine. The much higher levels of lead used by refiners in the past were simply shortcuts to higher octane and offered no additional lubricating benefits. Mark Tuttle, engine designer for Harley-Davidson, says his company's tests indicate that at any lead level about three-tenths of a gram per gallon Harley engines going back decades do not suffer from unusual valve-seat wear.

However, when the maximum lead content drops to one-tenth gram next January, and particularly if the EPA goes ahead with its total lead ban, some engines may develop problems. How widespread and how severe those problems will be is uncertain simply because no definitive test has been conducted of motorcycles using unleaded fuel. The EPA claims that the Army studied the use of unleaded fuels in motorcycles at some bases in the '70s, but a check by the AMA's Government Relations Department revealed that the study offered no usable data. The next best information available comes from studies like the one performed by TRW in 1970 using automobile engines. The results of those studies vary, but they seem to indicate that engines used in light-duty use, around town and without heavy loads, showed little or no excess valve-seat wear. Engines used at high rpm and under high loads, however, showed as much as 10 times faster valve-seat wear in some cases.

One of the key factors affecting valve-seat life in those engines was rpm, that may mean that motorcycles will face greater problems with unleaded fuel than the car engines in the test. Then again, many of the motorcycles at risk from unleaded fuel - the Harleys, BMWs and Moto Guzzis, for example - are comparatively low-revving engines that may tolerate unleaded fuel as well as or better than the automobiles tested.

What all this theoretical discussion boils down to is the simple fact that you may soon be a part of an actual-use experiment to determine the effects of unleaded gas on your engine. The EPA has shown little inclination to give the subject of motorcycle engines any more consideration, and chances are that someday soon you won't have a leaded option when you pull up at the gas pumps.

What can you do? Well, the simplest thing would be to add your own lead to the fuel. Surprisingly, the EPA doesn't have any problems with that notion. The proposed EPA rule would ban the sale of leaded gas at the pump, but it wouldn't prohibit the sale of lead as a gasoline additive.

Harley's Tuttle says the Milwaukee company is considering marketing such an additive through its dealers. Because tetraethyl lead in its pure form is highly toxic, Tuttle says the company probably would sell it premixed with gasoline in relatively high concentrations packaged in, say, quart bottles. Dump the bottle into your tank, then fill the tank the rest of the way with unleaded fuel and you'd have normal leaded gas again. That solution may be particularly attractive to owners of older high-compression bikes, since the additional lead would tend to raise the octane rating of the fuel into which it was mixed. It may also be the perfect solution for owners of antique bikes which get only limited use. But if you ride a 1984 Harley Sportster or a 1980 BMW for daily transportation, you may not want to mix fuel every time you fill up.

Fortunately, the automobile tests conducted 15 years ago indicate that the layer of lead, once it builds up on the valve and valve seat, takes about 10 hours of hard running on unleaded fuel to completely disappear. That means you may be able to use an additive only once every three or four tankfuls without losing the lubricating properties of the lead. It also means you shouldn't panic if you need gas and can't find a source of leaded fuel. The major factor in keeping leaded-fuel bikes running in the unleaded age will undoubtedly be vigilance on the part of the owner. The dangers associated with excessive valve-seat wear have cutout symptoms, and by watching for those symptoms you can minimise any problems.

One of the standard maintenance procedures on almost any motorcycle is adjusting the valves. The manufacturer specifies a gap between the top of the valve and the rocker arm or camshaft or cam follower, whichever part actually pushes the valve open. This gap is vital to proper engine operation, since it ensures that the valve closes completely. If this gap disappears, the valve will hang open slightly during the entire combustion cycle. The result can be a burned valve and an expensive top-end overhaul. On a typical new engine, this gap may change rather quickly during the break-in period, and then settle into a pattern of very slow change, requiring adjustments only at widely spaced intervals. However, valve-seat wear may be accelerated in a leaded-fuel engine running on unleaded, causing this gap to disappear more rapidly. Therefore, by monitoring your valve clearances, you can get an accurate picture of how well your engine tolerates unleaded fuel.

"Our owners manuals have been telling Harley owners to check their valve clearances every 2,500 miles" says Tuttle, "but many owners have found that when they check them that frequently, they never have to adjust anything. So they've gotten into the habit of checking the valves only once a season. However, as the rate of valve-seat wear increases, that means the valve gap is going to disappear much more quickly, so people may have to start checking their valves every couple of thousand miles."
All that's necessary to check the valve gap on most engines is to remove the valve covers, rotate the engine to a position prescribed in your owner's manual or a service manual for your machine, and slip a feeler gauge between the top of the valve and the valve-actuating piece. The main area of concern with unleaded fuel is wear on the exhaust valve seat, but while you're checking clearances you may as well check the intake side too. How do you know if you've got excessive valve-seat wear? Let's say you check the valve clearance at the factory-recommended intervals. Perhaps the gap designated for your engine is eight thousandths of an inch (0.008in), and instead you find that it's seven thousandths or six thousandths - that's normal. If, on the other hand, you find a gap measuring three thousandths or two thousandths, you should recheck your work and make sure you've accurately followed the manufacturer's instructions for engine position. If that reading still stands up, you've caught the excessive wear just in time and you'd better shorten the period between valve adjustments.

Even if you do find some additional wear, Tuttle says you shouldn't worry that your engine is useless. "As long as you stay ahead of it and keep adjusting the valves you can tolerate a certain amount of wear and still have a good engine," he says. "It's not like losing a couple of thousandths of an inch of valve clearance means you'll have to do a valve job immediately." In fact, Haley engineers have determined that an engine with a high rate of valve-seat wear can, with frequent valve adjustments, last up to three-quarters of the mileage between valve jobs as a normal engine. Tuttle says you should begin this more frequent maintenance program next year, since the one-tenth gram per gallon standard that goes into effect on January 1 may not be enough lead for all engines under all operating conditions. Besides, he notes that the one-tenth gram standard is the maximum set by the EPA, and some refiners may actually have less lead in what they sell as leaded fuel.

The first time you switch over to unleaded with an engine used to running on leaded gas, you'll begin cleaning off the layer of lead that's formed on the valve seat and elsewhere in the engine. Honda's Fred Wing says some riders discover that their engine runs a little rough during this period and blame that on the fuel. Instead, he says, it's a result of cleaning the lead impurities out of the cylinder. He also notes that as the layer of lead disappears from the valve seat, the valve will fit more closely into the seat, taking up a slight amount of the valve gap. Therefore, when you make your first valve adjustment after switching to unleaded, you can assume that a tiny bit of that change was due to cleaning out the lead deposits and not to unusual valve-seat wear.

Everything we've said so far about valve adjustments applies to motorcycles with solid lifters, which is the most common method of opening valves. However, the 1,340cc "shovelhead" Harley engine (and the 1,200cc models from years past) use hydraulic lifter like those in most automobile engines. Hydraulic lifters automatically compensate for valve-seat wear over a certain range of adjustment and, therefore, may mask some of the symptoms of increased engine wear. If you own a motorcycle with one of these engines, it should not require maintenance until the entire range of adjustment is used up. By following Tuttle's recommendations for more frequent valve-clearance inspections, you can probably adopt a "wait and see" attitude towards low-lead and unleaded fuel, determining for yourself whether your engine can tolerate the change. But if you'd rather not take any chances, or if you find that your engine is suffering from the use of pump gas, it may be possible for you to update that engine to unleaded-fuel specifications.

The first thing to determine is whether your engine has a cast-iron head or a head made out of aluminium alloy. The "Harley Sportster line of engines has always used a cast-iron head, while the bigger Harley engines, and nearly all European engines, have been made of alloy. If you have any doubts about the composition of the head on your bike, test it with a magnet. If the magnet sticks, it's cast iron. The cast-iron engines probably have the valve seat machined right out of the material of the head and can't be easily converted to unleaded specs. Your best bet with these engines is to closely monitor the valve clearances and use a lead additive if you discover unusual wear.

But engines with aluminium-alloy heads use valve-seat inserts, a ring made of a stronger metal, to protect the aluminium from the impact of the valve. Engines made to run on unleaded fuel have similar inserts, except that they're made even harder as protection against the welding and warping process that leads to excessive valve-seat wear. Since the valve-seat material is the only difference between your old leaded-fuel engine and the newer unleaded version, all you have to do is pop the old seats out and hammer new ones into place, right? Well, it isn't quite that simple.

Replacing valve seats is an intricate job calling for extreme precision and close tolerances. The only thing holding that seat in place is a carefully engineered interference fit between it and the head casting. As a result, replacing valve seats probably isn't a job that you can undertake at home. In fact, it's not even the kind of job that most motorcycle dealers can tackle. However, Harley-Davidson is considering a program whereby owners of its big-engine models (the aluminium-head 1,200cc and 1,340cc models) may be able to send in their existing heads and have them updated with unleaded-style valve seats at the factory. A similar program might be worked out by the importers of some European bikes, with the update being done by some reputable machine-shop service in this country. These programs are just in the planning stages now, since the manufacturers, like many motorcyclists, are just beginning to study the problems of unleaded fuel. We'll keep you up to date on further developments as they occur.

Even if your factory doesn't decide to offer an update program, there may be a way for you to bring your own bike into the unleaded age. Brian Slack, tech editor for Norton News, the publication of the US Norton Owners Association, says he's had good luck installing modified automotive valve seats into Norton heads. If you think you'd like to undertake such a project,
make sure you get competent help. You might want to start by talking to the people at local automotive speed shops, since they may have some experience in fitting new valve seats into high-performance car engines.

There's no question that the changeover to low-lead and unleaded fuels will require some adaptations for the owners of motorcycles designed for a different grade of fuel. But with the help of the manufacturers, with some creative thinking and with diligent attention to the condition of your engine, you may find that you can survive without lead. We hope so; we'd hate to see a wide range of great motorcycles disappear from the streets.