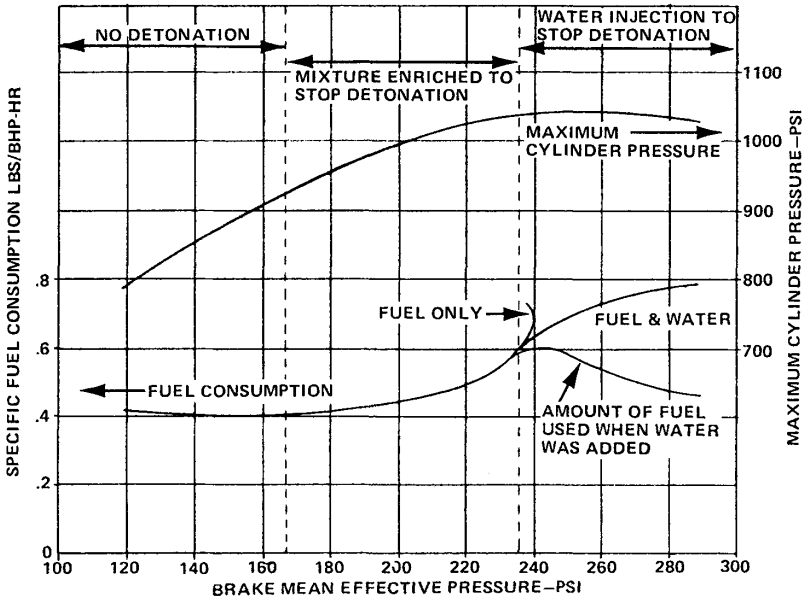
Why Use Gaseous Intercooling™?

Most bolt-on supercharging systems for street use will produce a maximum intake-manifold boost pressure of somewhere between 5 and 8 psig. This amount of boost will not normally require any modification of the engine and it will not detonate on premium fuel when the fuel/air mixture and the ignition curve are set correctly. If modifications are made to the engine to allow boost pressures above 8 psig it is not always possible to prevent detonation, even with a boost activated spark retard module such as the MSD, Crane or Carroll modules. Besides, Gaseous Intercooling™ permits a more aggressive spark curve which always results in more power than retarding the spark.



Enriching the air/fuel ratio is another method of preventing detonation when the engine is in the supercharged condition. This method will work up to a certain limit and beyond that the engine will detonate regardless of how rich the mixture is. At this point either water or water-alcohol injection are required to prevent detonation.

We all have a tendency when we discover such phenomenon and the solution to it, to think we have "invented the wheel." This problem, for one, has been around a long time and Ricardo not only faced it but ran a series of tests in the early 1930's, plotted in the figure above, Reference: *The High-Speed Internal Combustion Engine* by H. Ricardo. To quote Mr. Ricardo, "In this case, running throughout at a speed of 2,500 RPM and with a compression ratio of 7:1, the engine was run on an economical mixture, i.e. about 10% weak, and supercharge applied to the first incidence of detonation, which occurred when the BMEP had reached 168 pounds per square inch. The mixture strength was then increased, step by step, and more supercharge applied until the same intensity of detonation was recorded; this process was continued until a point was reached at which no further enrichment was effective. In fact, after about 60% excess fuel, not only did further enrichment have no effect but there was even some indication that it increased the tendency to detonate. A finely pulverized water spray was then delivered into the induction pipe which served to suppress detonation, in part by the inter-cooling it provided, and in part by the influence of steam as an anti-detonant, and so allow of further supercharging. This was continued progressively, admitting just sufficient water at each stage to ward off detonation until a BMEP of 290 pounds per square inch was reached, which was found to be the limit of the dynamometer. At the same time, it was noted that, with the addition of water, the influence of steam as an anti-knock allowed the fuel/air ratio being much reduced. From this curve as shown in the figure above it will be seen that under these operating conditions a limiting BMEP that could be reached with 87 octane petrol alone at an economical mixture strength was 168 psi. By enriching the mixture to the limit of usefulness, the BMEP could be stepped up to 237 psi. By the introduction of water, it could be further stepped up 290 psi and probably more; at the same time the fuel/air ratio could be reduced once again; in fact with Gaseous Intercooling™, no appreciable advantage was found from the use of an overrich fuel/air mixture. It will be noted that the total specific consumption of liquid, i.e., fuel plus water, is not so very much greater than when running on a very rich mixture of fuel alone."

"The slope of the curve of maximum cylinder pressure is interesting in that after the injection of water, *it no longer rose but even tended very slightly to fall,* and the same applied to the gross heat flow to the cooling water which reached a maximum at a BMEP of about 230 pounds per square inch, and thereafter fell off, until at a BMEP of 290 pounds per square inch it had fallen to the same level as that of 170 pounds without Gaseous Intercooling™."

The result of this kind of test will vary with engine speed, engine size, compression ratio, fuel octane, etc. These variations are not important as far as the principle is concerned. The main thing the curve shows is detonation may be prevented up to a certain point by fuel enrichment, but after that point, water or water-alcohol injection must be used.

Water is usually combined with methanol (methyl-alcohol) in proportions up to 50-50 to increase the volatility of the injected mixture — and therefore its cooling effect — to add part fuel instead of all water for further horsepower increase, and to eliminate the possibility of the water freezing on a cold day. Harry Ricardo, again quoting from his book, *The Higher Speed Internal combustion Engine,* says "Higher percentages of methanol are not desirable because methanol, itself, is prone to pre-ignition."

Tests made in 1971 by Ted Trevor of Crown Manufacturing showed that mixtures containing more than 50% methanol provided no additional HP gains over a 50/50 mixture. Dick Griffin confirmed that 50/50 is practical in his tests which were made several years earlier.

Opinions vary as to the amount of boost pressure which makes water or water/alcohol injection mandatory. Some say any boost over 5 psi should be accompanied by injection. Others claim that 8 psi is where the "borderline" begins. And, we've talked with some racers who felt 15 psi boost was a good place to start using Gaseous Intercooling™. As the saying goes, "Circumstances alter cases." Obviously, a higher compression ratio or advanced spark will require such injection at a lower boost pressure than would a lower c.r. and lesser spark advance. If detonation is occurring at a particular boost pressure and RPM, then Gaseous Intercooling™ should be started prior to the onset of detonation. Should detonation occur, it is essential to back off on the throttle instantly because sustained detonation will destroy the engine very quickly. In any case, water should not be injected at a manifold pressure much below where it is needed. If injection does not take place below 5 lbs. boost, there will usually not be any loss of power due to the cooling effect. It should be noted that engines which are equipped with water-injection will be unusually free from carbon when torn down for inspection or repair. Pistons, combustion chambers and valves all stay remarkably clean with Gaseous Intercooling™. As a side benefit, spark plugs last longer too.

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TURBOCHARGERS
by Hugh MacInnes