KEEP COOL WITH VOLVO

An intercooler kit can turn your turbo into a TURBO

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INTERCOOLERS ARE IN these days for getting the most out of turbo engines. In fact, they're standard equipment in almost all 1984 Volvo GLTs; almost all, we say, because some early cars will sneak out of the factory without them. And, for those of you already bitten by Volvo's turbo bug, the company has a retrofit kit that can bring the benefits of intercooling to your Volvo Turbo. John Lamm recently went this route with his 1982 Wagon and his experiences as Mr Mediocrewrench accompany this report. Here, we'll focus on a little theory, then share some before-and-after testing experiences with another GLT. (No fool, John; he pretended not to hear us when we asked whether we could instrument his car.)

First, you should recognize that an intercooler is a heat exchanger, snagging the intake air before it reaches the manifold and allowing it to give off some of its heat to another medium. With an air-to-air intercooler, such as Volvo's, this other medium is (you guessed it) another flow of air. Now guess the medium with an air-to-water intercooler. Nope, it's usually a glycol solution, sort of an engine's radiator working both sides of the street. The relatively hot intake air gives off heat to the liquid that, in turn, transfers it to the ambient airflow passing through the device.

By the way, an intercooler isn't a theoretical free ride: True, it lowers temperature of the intake charge, but the rerouting of intake airflow through its plumbing can't help but reduce pressure as well. The trick is to optimize the reduction in temperature (a Good Thing) versus the loss of pressure (a Bad Thing) to get a beneficial gain in density.

Pressure, temperature, density? This is getting complicated and why does the intake air get so hot anyway? I'm glad you asked, and I'm heartened by your interest up to this point. It gets hot because of that old physics formula, $PV=nRT$, where P is pressure, V is volume and T is temperature of a given gaseous substance. This is called the Ideal Gas Law, and I quite agree. Now, ignore n and R (they would only confuse matters and, besides, they're constants); instead, concentrate on P, V and T. You can see that if a gas's volume stays the same and its pressure increases, then its temperature will have to increase as well. Next, think about what happens in an automotive turbocharger: Ambient air is compressed on its way into the intake manifold. In fact, the conditions for increased temperature are met and exceeded, what with the turbo deriving its spin from the engine's exhaust and being hot as the hinges of hell because of this. So it's no wonder that what began as nice, normal ambient air can exit the compressor of an automotive turbo at a temperature of 300 degrees Fahrenheit.

So who cares if the intake air is hot? Yes, you in the back; you are a smart one, aren't you? The engine cares, and for several reasons. First, a hotter intake charge puts heavier heat load on the entire engine; its exhaust is hotter, its valves have a harder life, its coolant and lubricant have more heat to dissipate. Second, as its temperature rises, the density of air diminishes, and fewer little molecules of oxygen are around to combine with fuel to do their combustion routine. If fewer guys take part, there's less power produced. Third, a hotter intake charge is more likely to detonate; that is, to ignite in an uncontrolled manner in some relatively far-off reaches of the combustion chamber.

What's more (there's always something, isn't there?), turbocharged engines go through life believing they have a higher effective compression ratio when they're on boost, so detonation protection takes on even greater importance. It's not uncommon for turbo engines to have ignition retardation, fuel enrichment or other means of sidestepping harmful knock. And the choice of maximum boost, controlled by the wastegate calibration, is typically detonation-limited.

So what's a turbo engine specialist to do? Yes, that's getting to the point now, isn't it? If he's working for Volvo, he'll design an air-to-air intercooler that lowers the intake charge temperature by as much as 100 degrees. And think of all the benefits: a cooler engine, a denser charge and less tendency toward detonation. These can be exploited in several ways, jointly or independently. You can bump the engine's compression ratio

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you can devise a more aggressive ignition timing or, certainly the most straightforward approach, you can reset the wastegate to give more boost. Volvo opted for this last route exclusively, increasing maximum boost from the non-intercooled 6.5 to 10.5 psi. Output of its turbo engine jumps from 127 bhp at 5400 rpm to 162 at 5100; torque rises from 150 lb-ft at 3750 to 181 at 3900.

What a neat idea, you say, and so simple. Well, more or less, but not exactly. For one thing, engines have characteristic sensitivities to detonation, and these depend on more than simply the octane level of the fuel. With Volvo's, there's an rpm window between 2000 and 3200 in which the higher boost would cause knock, even in intercooled form. To avoid this, Volvo's revised wastegate actuator is actually calibrated for 8.5-psi maximum boost. But what about the 10.5 psi, you ask. My, you are paying attention. There's a solenoid valve in the wastegate plumbing connected to an rpm sensor that's part of the standard engine electronics. This solenoid stays closed during that critical rpm, but it opens above 3700 bleeding just enough pressure back into the system to trick the wastegate into allowing the full 10.5 psi. Clever, eh?

How much quicker is it? Yes, you with the beady eyes; you would ask that. In a word, much. We instrumented a Volvo GLT 2-door in non-intercooled form and did 0–60 mph in 10.5 seconds; the quarter mile came in 17.6 sec at 77.0 mph. Off to Volvo for installation of the intercooler kit, back to the track and we recorded 0–60 in 8.5 sec, the quarter mile in 16.4 sec at 83.0 mph and, as icing on the intercooled cake, reached 100 mph in less time than it took the baseline car to get to 90.

What does it cost, how does it affect the Volvo warranty and is it legal? This had best be the last question, because we're running out of space. The kit costs $595 and is directly applicable to any manual-gearbox Volvo Turbo, 1981 through those early 1984s that won't have it regularly fitted. As the accompanying article shows, it can be do-it-yourself or, if dealer installed, add the cost of three hours' labor. There's no voiding of factory warranty provided your dealer checks the wastegate and seals it against boy-racer tampering. Otherwise, you could see as much as 17 psi, but perhaps not for long. And, yes, the entire package is street-legal.

If, however, your Volvo Turbo has an automatic transmission, things are a bit more complicated. First, there's a supplementary kit, costing $35.80 plus installation, that consists of recalibrated springs for the automatic's internal valving. Second, with some 1982 and all 1983 Volvo Turbo automatics, it's recommended that the rear axle be swapped for one with more robust gears. Knowing Volvo's penchant for engineering conservatism, we'd guess this is based on absolutely worst-case testing, a stoplight GP pulling a trailer up a steep hill or some such. In any event, it's required for warranty coverage and Volvo has an exchange price of $400 for this axle swap.

Thanks for your kind attention. Now perhaps you'd like to read about John Lamm's experiences with his do-it-yourself project. If you get a chance, ask him why he didn't want us to use his car.

DO IT YOURSELF

THERE'S NEVER BEEN any danger of my being named Mr Goodwrench of southern California, so I approached this project with some trepidation. Here I had a perfectly good 1982 Volvo Turbo Wagon that did all the things I asked of it and I was about to change it. I am a great believer in the adage, "If it works don't fix it," but lured by the prospect of 35 extra horsepower, I opened my toolbox and the car's hood.

You begin by having the engine steam cleaned, and then you remove the radiator, its overflow tank and all their hoses. Next take out all the plumbing for the induction system from the fuel meter up to the intake manifold. The oil cooler needs to be repositioned and the most difficult-to-get-at-if-you-don't-have-a-lift piece, the wastegate actuator, has to be replaced with one that will allow the higher 10.5-psi boost limit. There's a new relay to be added, along with a boost pressure control valve. The inlet pipe to the turbo gets reinforced, as does the bellows that fits over the fuel meter. And then it's time to start putting the pieces back in.

Fit the intercooler in front of the radiator, then add the radiator and old hoses, which are cut down to fit. Install the new expansion tank (I had to reinstall mine at the very end, thanks either to me or a floppy drilling template for the new mounting holes) and then the intercooler intake plumbing. Next, hook up a small wiring harness to give the new system happy electrics and another for air-conditioned cars to shut that system down under full throttle.

I've simplified things, of course, but installing the intercooler isn't much more difficult than that. And I love one of the last instructions, which is to disconnect the overboost light. Then in with the coolant and—nervous, nervous—start the engine.

It worked. I still had to have my local Volvo dealer check to make certain the boost pressure was correct, but the engine ran, and as soon as the coolant temperature was up I nailed the throttle. And all those scraped knuckles were certainly worth it.

One reason the intercooler installation works so nicely is the way Volvo has organized it. The larger parts are obvious, and all the small ones are grouped in numbered bags by use. The instructions are clear and easy to follow, though Volvo has put together some supplementary notes that change the order of things somewhat for the sake of convenience. And I strongly recommend reading through the material at least twice before starting.

Reading those instructions will also help you determine what tools you need. I am also not Mr Quickwrench, partially because I always seem to have lost the present job's socket when I last used it. (During my trips to Sears I spent several minutes lusting after that $1000 tool kit.) Volvo says it takes three hours to install the intercooler and I suppose a factory mechanic could do it in that, but I was at it for about nine hours. So read the instructions, have the proper tools and don't rush. And these are the only cautionary comments I have to make about installing the intercooler kit.

I should add, however, that I have a manual-gearbox Turbo, and if you have an automatic version you should plan on having the transmission and rear-end work done by the dealer.

Is it worth the trouble and cost? For 35 horsepower, you bet.—*John Lamm*