THE AEM EMS STANDALONE COMPUTER IS A PLUG 'N' PLAY AFFAIR, OFFERING VAST TUNING OPTIONS

AMS Intake, Head & AEM EMS Install

Bringing on the Power

Story & Photos by Martin Musial of AMS (www.automotosports.com)

THE FIRST PULL AT 19PSI SHOWED 447WHP AND 350 LBS./FT. OF TORQUE. TURNING THE BOOST UP SLOWLY, WE BREATHED ON 500WHP WITH A 497WHP PULL AT 22.5PSI. HAPPILY, WE CRANKED IT TO 25.5PSI AND THEN 27PSI MAKING 533WHP AND 551WHP RESPECTIVELY.

Winter is here and the only racing being done is on the bench. We take this time to develop a power program for the EVO VIII that will take us over 800hp. The first step is going to be looking at the head and

valvetrain. We'll see where improvements are needed and what kind of upgrades will give us the results we're looking for. After we work on the head, we'll install an AEM EMS unit and really discover the capabilities of the EVO VIII.

With the AMS custom spec GT35R turbo kit, we were able to squeeze 525whp out of our EVO VIII while still utilizing the stock ECU and never taking the motor apart. An upgrade path was chosen that eliminated airflow restrictions and choke points - the key to making good usable horsepower. We now look a little deeper, pushing the EVO VIII into super car territory. One of the seemingly obvious restrictions is the turbo right? Big turbo = more power. While this statement is true, it falls under 'the bigger the better' theory. An important tuning secret that I would like to share is: just because something flows more air or is bigger doesn't mean it's

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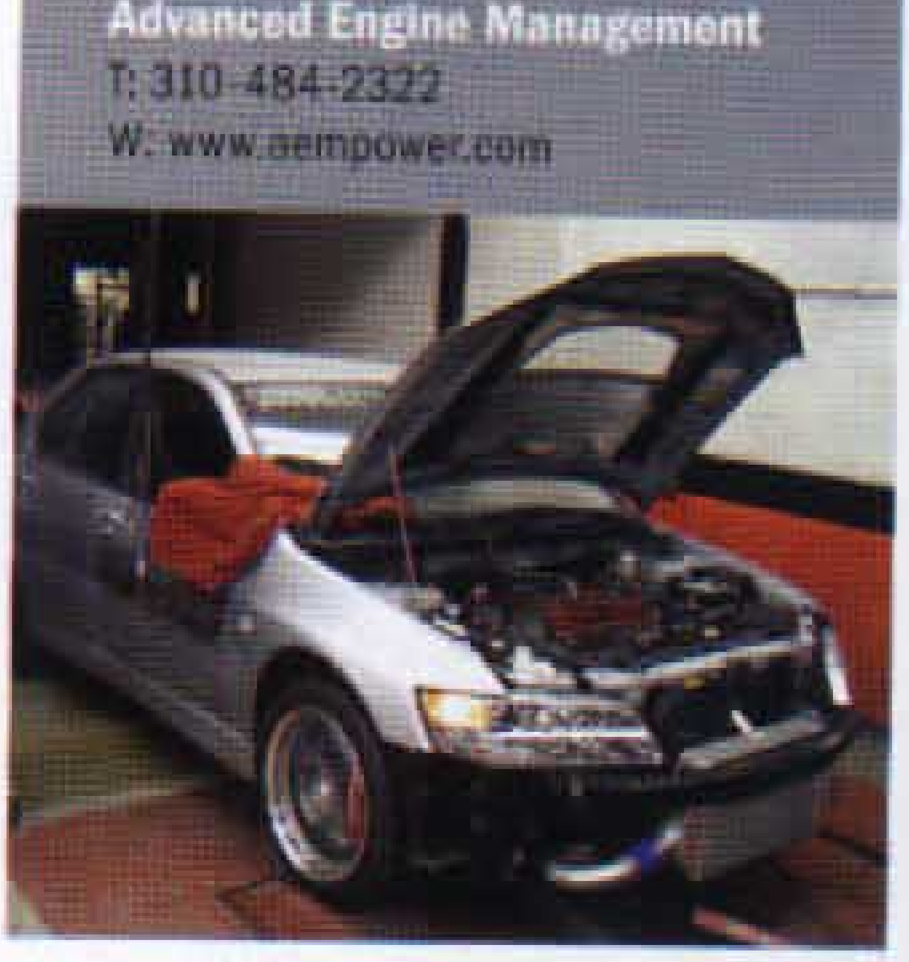

going to make more usable horsepower. As I've mentioned in the earlier articles, components that are not an airflow restriction provide no horsepower benefit if they are upgraded.

Along the same lines, if we install a component that flows more air but shifts our whole power curve to the higher RPMs, all we've done is increase our horsepower bragging rights and created a dyno-queen. Prime examples are FIA rally cars, only 300hp, a bunch of gear twisting torque (over 450 lbs./ft.) and a big fat powerband. Watch an in car video clip and you'll be amazed at the power delivery and how quickly they get up to speed thanks to the power that's available all throughout the RPM range. So why am I rambling about power curves? Because it's a fundamental concept that we'll be applying here to build a car that not only impresses with horsepower numbers, but is incredibly easy to drive and delivers power on demand.

GOOD HEAD

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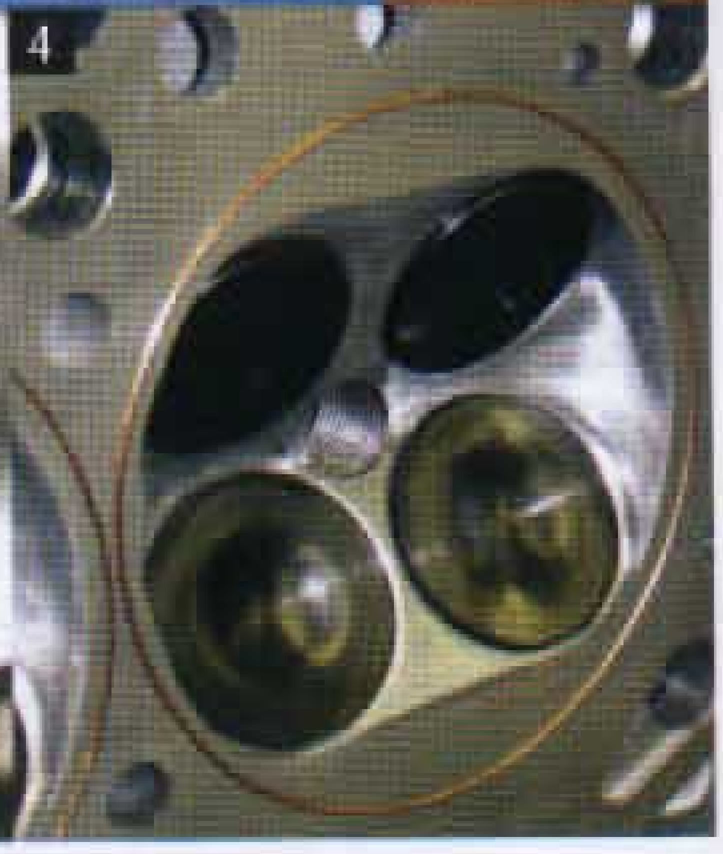


1. EVO VIII head coming off. **2.** Ported, cleaned, & surfaced. **3.** Ported intake port. **4.** Copper O-ring provides extra headgasket sealing.

Headwork to many is considered a mysterious art and unfortunately the 'bigger the better' theory gets used extensively as a selling point. Let's take a look at what Mitsubishi did with their head design for the Evolution VIII and how we can try to improve on it. Starting with the intake manifold we can see that the EVO VIII's manifold has much shorter runners than the 1G or 2G DSM counterparts. Our experience with the DSMs showed that a fabricated intake manifold with shorter runners and a larger plenum design dramatically increases higher RPM horsepower. The downside is that if the runner length is too short, bottom end torque and horsepower suffers. Runner shape is also very important in making good power down low. Working with Dale Forrester of Forrester Racing Heads, we tuned his intake design on the dyno until we reached a design that maintained the bottom end power of the stock manifold but increased top end horsepower considerably. A few key aspects to the design were the shorter runners and a runner design that maintained, for a certain distance, the same shape and size of the intake port as on the head. This had the effect of increasing the velocity of the air-charge right before the injector and allowing for better fuel mixing. Looking at the EVO VIII's short runner manifold shows why we keep making power right up the 7,500 RPM rev limiter.

The intake ports of the head were cleaned up a bit but not opened up because we wanted to keep intake velocity up as the air entered the bowl area and toward the back of the valve.

FRH installed a set of 1mm oversized valves and gave each seat a radiused cut. To help expel combustion gases, Forrester worked over the exhaust tract a little more than the intake side. The bowl area was opened up a bit and the divider wall was necked down. The roof of the port was raised at an angle to meet the top of the exhaust manifold flange. The floors of both ports were left alone as most of the gases hug the long side radius (roof). FRH also cut down part of the valve guides that protruded into the intake tract to increase flow.

The guide boss on the exhaust side was left alone to help pull heat out of the exhaust valve. The combustion chamber was cleaned up and the valves where unshrouded near the edge of the chamber to let more airflow squeeze through. The porting may seem mild compared to some heads that have the ports hogged out and opened way up. The end result will be a powerband that keeps the bottom end horsepower and torque of the stock head and increases high RPM power. With the new head installed and the cams dialed in we saw nice solid gains. An average of 30-35whp was made at upper RPMs and low-end power was maintained. Turning the boost to 22.5psi made us 482whp and another bump to 24psi turned up 500whp. With the headwork a success we moved on to the ECU.

ENGINE MANAGEMENT

1. AEM EMS & Stock ECU. **2.** 3.5 bar MAP sensor, pulse dampener, & wiring into factory harness.

With the MAS (mass airflow sensor) reading so much air at this point, the ECU is unwilling to give us the timing advance we need to make more torque and horsepower. With our larger injectors, 780cc, we already reduced our MAS reading with the A'PEXi S-AFC to allow for more ignition timing. This worked for our higher RPM range as we had to reduce the MAS reading so much that it gave us plenty of ignition timing (20+ deg). The problem was with the torque, even with the S-AFC reducing the MAS signal the ECU still only provided 2-4 degrees of ignition advance. AEM stepped in with a solution. Their plug and play EMS units are a natural choice for ease of installation and tuning. After removing the glove-box and taking out the stock ECU, the harness is unplugged from the stock computer and the EMS unit plugs right in. The EMS will run in mass-air mode utilizing the factory MAS or in speed-density mode, which needs a MAP (manifold absolute pressure) sensor and eliminates the factory MAS.

Speed density has the benefit of removing the stock mass air meter, which imposes an intake restriction at higher horsepower levels.

We installed an AEM 3.5bar MAP sensor along with a vacuum canister to help smooth out the pressure pulses and provide a smooth signal to the MAP sensor. Since the factory pressure differential sensor is no longer used we can cut the harness and wire the new MAP sensor directly into it. The MAP sensor has three wires, ground, a 5V reference, and the signal wire. The factory pressure differential sensor has the same wiring and referencing the AEM EVO VIII wiring diagram shows us the yellow wire is the signal wire. Using a digital volt meter we trace the other two and confirm ground and the 5V reference. After some soldering and heat-shrinking we have an install that looks like it came from the factory.

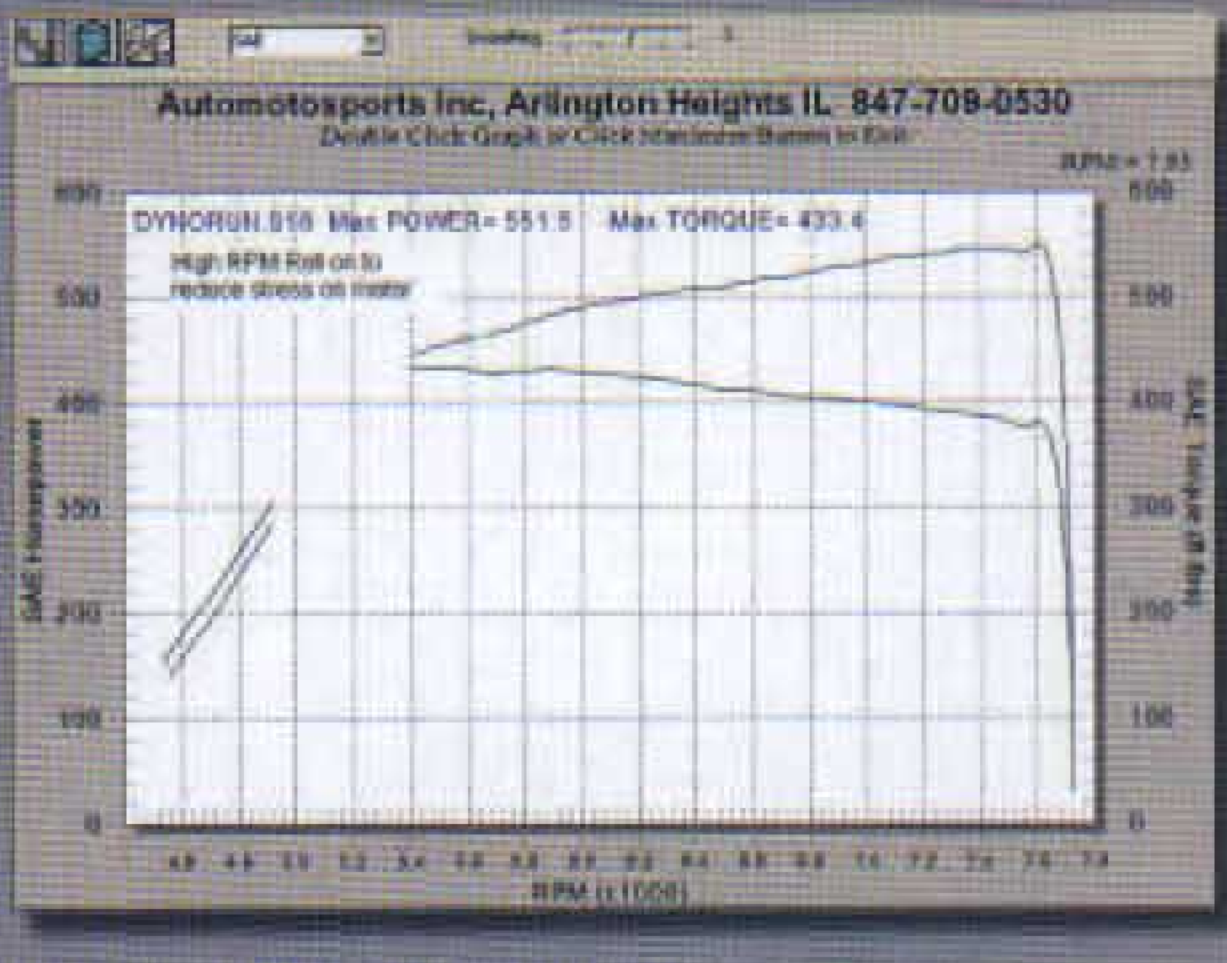
Removing the stock MAS also requires the install of a GM-style intake air temperature sensor. The signal wire of this sensor gets wired to the red/blue wire that is in the MAS harness plug (#72 on the ECU pinout) and the ground wire to chassis ground. That's all there is to it and we can now prepare to start the EVO VIII. The base MAP sensor calibration is loaded and the throttle position sensor is configured. The base map provided is for stock sized injectors but with our EVO running 780cc injectors, I edited the fuel map and engine start settings so we didn't flood her out. A few seconds of cranking brought the engine to life and I waited for the wideband oxygen sensor to get up to operating temperature. Like most cars with aggressive cams they like to idle smoothly in the 13:1 A/F range and sometimes even dip into the 12:1's.

An important step with any engine management system is to ensure crank and ECU ignition synchronization. To check this we set a certain area of the ignition map to 10 degrees advance and made sure all other ignition trims are turned off as to not affect our ignition timing. With a timing light we verify the ignition at the crank and if needed adjust the timing synchronization with the EMS's ignition setup. With the EVO being waste spark, use a simple timing light without dial advance otherwise you might wind up with incorrect ignition timing. A few minutes of fuel and idle tuning and she's purring like a kitten. Gone is the rough and erratic idle we had with the stock ECU. Now you can barely tell that we are running aggressive cams at all. Strapped to the dyno, we start making partial pulls to fine-tune the fuel curve under boost. With race gas, the air fuel ratio can be in the 13-14:1 range in the low boost region during boost transition and hit mid 12:1 as we reach our target pressure level. If we were using 93 octane pump gas we'd want to be about a point lower in our A/F ratio to artificially cool the charge down and to help keep from detonation. Timing was set to about 12-13 deg advance at 19psi and ramped up to 20 deg advance as RPMs hit the 7,900rpm limiter. The first pull at 19psi showed 447whp and 350 lbs./ft. of torque. Turning the boost up slowly, we breathed on 500whp with a 497whp pull at 22.5psi. Happily, we cranked it to 25.5psi and then 27psi making 533whp and 551whp respectively.

With torque crossing over the 450 lbs./ft. mark for the last run, I backed off the ignition timing as the stock rods were being pummeled with stress. Converted back to AWD for street use, only a touch up on the fuel map is needed to make the EVO drive like it came off the showroom floor.

At this point we're making more horsepower and torque at 25.5psi than we did before at 29psi (533whp & 413 lbs./ft. vs. 525 & 398 lbs./ft.). With well thought out head-work and an engine management system, we increased horsepower and broadened our powerband, a win-win situation. Good luck to any Viper or turbo Porsche chasing this 4-door down! Before we get silly and turn the boost up higher we need to address engine internals. At close to 650 crank horsepower, we've more than doubled the stock output of the EVO VIII and we can't expect the stock rods and pistons to take much more punishment. To reach our 800hp goal, we're going to be upgrading the internals, turning up the boost and experimenting with new parts for the extra ponies.

Stock vs. Forrester
At 22.5psi the difference between the stock head and ECU versus the ported Forrester Racing Head with the AEM EMS standalone is substantial, a 56.4whp gain!



On Dyno
551 whp at 27psi. Going WOT at higher RPM's avoids peak torque and doesn't beat up the stock rods as bad.