Issue: 239 Section: Technical Features

Shooting the Overboost

Flattening the mid-range boost spike that's common to many late-model turbocars equipped with breathing enhancements...

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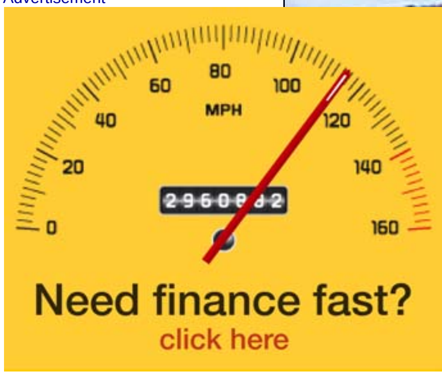


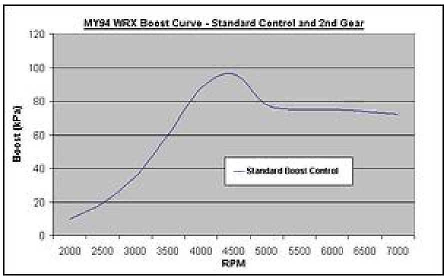
Boost pressure is the natural friend of car enthusiasts who like to drive fast - but, believe us, the 'more is better' philosophy is not always best. In this story we won't be showing how to force more induction air through your engine; in fact, we'll be doing the exact *opposite*!

Like many late-model turbocars with factory electronic boost control, the AutoSpeed MY94 Subaru WRX has realised an unintentional (and uncontrolled!) increase in mid-range boost after the fitment of its high-flow intake and exhaust. This boost overshoot occurs immediately after the spool-up period and, given its relatively narrow rpm band, we're inclined to categorise it as a boost spike. Whatever you want to call it, though, it's not something we set out to achieve...

Similar to many turbocars of its era, the '94 WRX factory boost control system incorporates a hose connecting the turbo compressor outlet to the internal wastegate actuator; this hose is fitted with an inline airflow restriction (as seen here) as well as a 3-port wastegate solenoid. In the WRX's case, the top solenoid port is the air inlet (which accepts pressure from the turbo compressor), the middle port is the outlet (which sends a portion of pressure to the wastegate actuator) and the lowest port is the vent (which sends bled pressure back to the pre-turbo intake system).

The factory ECU pulses the boost control solenoid to bleed a given amount of pressure from the wastage hose; although specific details of the ECU operation are scarce, we're told the boost control circuitry onboard the MY94 computer is pretty 'old school'. This lack of sophistication makes sense considering the wild boost spikes we have been seeing...

In the case of our WRX - and many other similar turbocars we can only assume - the factory ECU aims to bring boost up comparatively quickly. In order to reduce wastegate creep, the wastegate solenoid is therefore called upon to bleed a substantial amount of pressure from the wastegate hose until the turbocharger is up to near maximum boost (around 70 - 75 kPa on this particular model WRX). The problem is, though, the ECU doesn't appear to realise that the turbocharger is now able to spool-up quicker thanks to our breathing mods; by continuing to bleed off considerable wastegate pressure it ramps the turbo up *very* swiftly and, before it knows what's going on, boost pressure has dramatically overshot (not far away from the factory boost cut, in fact). Following the overshoot, boost control is quickly regained and manifold pressure settles back to around 70 - 75 kPa toward the rev limiter.



So how much of a boost spike are we talking in the case of our WRX? Well, on cold nights we've seen up to 1.05 Bar momentarily; that's nearly *40 percent* more boost than the factory setting...

Why would you want to eliminate a mid-range boost spike?

We know what you're thinking. A boost spike - intentional or not - makes a car accelerate faster, so why on Earth would we want to get rid of it?

The answer is quite simple in the case of the WRX - driveline strength. The standard clutch and gearbox can only handle so much torque before either the clutch slips and/or the gearbox ends up with toothless gears. Note that many other constant AWD turbocars (such as the Laser TX3, Celica GT4 and Lancer GSR) are also in the same boat to a greater or less degree.

In the case of a front or rear-wheel-drive turbocar, however - let's say either a Mazda MX-6 or Nissan 200SX - the main motivation for ironing out a boost spike is related to traction. A boost overshoot in a 2WD can quite easily cause a loss of traction, which slows acceleration and reduces driver control. Further to this - as any race driver will tell you - a nice, linear torque delivery gives better chassis composure through any given series of corners.

Okay, that's the why out of the way - now let's move onto the how...

How to flatten a boost spike - for around $30AUD!

There are few possible approaches to solve the boost spike problem. We considered fitting a 'pop off' pressure relief valve to the intercooler plumbing and we very nearly went ahead and tested a system that employs an adjustable pressure relief valve in the turbo control hosing.

The approach we ran with, though - as suggested by AutoSpeed's Julian Edgar - is completely fail-safe, cheap and incredibly simple. All you need to do is fit a bypass hose and variable restrictor valve parallel to the factory boost control solenoid.

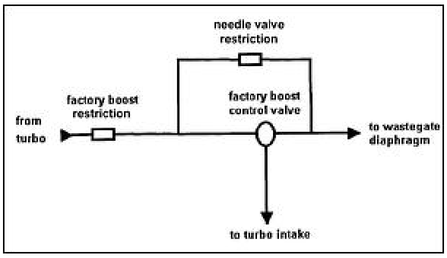
So how does it work?

Well, solely by fitting a bypass hose around the factory boost control solenoid, the wastegate actuator feels a lot more pressure than usual; as a result, boost is slow to rise and peaks only at the value determined by the wastegate spring.

Then - by adding an adjustable restrictor valve to the bypass hose - you can vary the amount of extra pressure felt by the actuator. Once adjusted, the bypass and restrictor valve arrangement allows *just* enough extra pressure to be felt by the actuator to avoid spiking immediately after the spool-up period. From thereon, held boost pressure will remain virtually as standard - it appears that the factory inline boost restriction gives enough control over wastegate hose flow that the solenoid is able to bleed enough air to deliver the factory set manifold pressure.

The adjustable restrictor we elected to use our in WRX is none other than the ¼-inch brass needle valve used as part of ["Project EXA - Part 3 - DIY Boost Control"]; in that article, however, the valve was used to *lift* boost... The brass needle valve offers very good durability and is wonderfully cheap - complete with a pair of barbed fittings to suit ¼-inch hose, the valve will set you back around $30 AUD.

Note - the needle valve we bought offers only four full turns of adjustment from fully closed to fully open. For better set-up accuracy we recommend using a needle valve with a greater number of turns across its range.



This diagram shows how the solenoid bypass and variable restrictor valve is integrated into the WRX's factory boost control system.

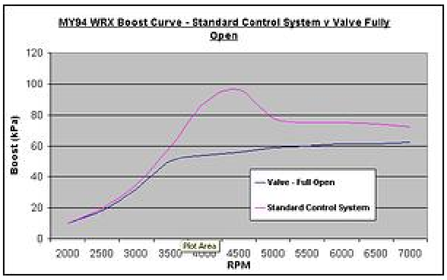
As you can see, you need to make only two connections into the factory boost control system - insert a T-piece in the hose in between the factory inline restriction and boost control solenoid, and another in the hose between the solenoid and the wastegate actuator. We used ¼-inch T-pieces and, of course, a number of hose clamps to keep everything securely connected.

With the two T-pieces installed the next step is to find an out-of-the-way position to mount the needle valve; you *can* have it suspended only by its connected hoses, but make sure its adjustment knob won't be in a place where it will get moved inadvertently. With the needle valve in a safe position, connect two lengths of ¼-inch hose between each T-piece and the barbed fittings on the valve. Take care not to kink any of the hoses and note that the needle valve is optimised for airflow in one particular direction - make sure the arrow on the valve body points in the direction of the wastegate actuator.

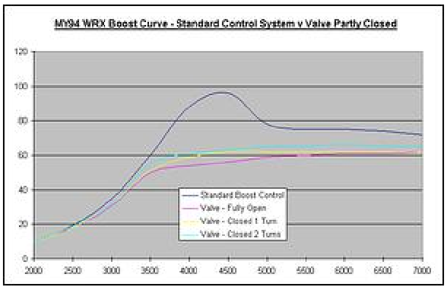
With the valve connected we can now 'tune' it to flatten out that boost spike...

In order to preserve your vehicle during set-up, we advise you start testing with the valve set near its fully *open* position. With the valve open, boost pressure will be significantly reduced so you can 'tune upward' until you reach your desired boost curve. Inevitably, you'll need to perform a few full-throttle runs from low rpm to see where you're going with your valve adjustment. On the WRX we did our comparative testing in second gear and, once we found our desired boost curve, we checked for consistency across the remaining gears.

Interestingly, on our WRX, the fully open needle valve made the factory boost control solenoid redundant - we achieved exactly the same boost curve as we have previously with the solenoid removed from the equation.



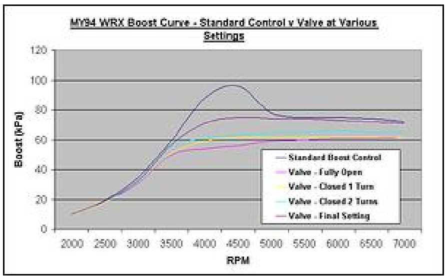
Compared to the standard control system there's quite a contrast. Boost is very slow to rise and gradually winds out to a maximum of just 62 kPa. Obviously, this is a long way off where we want to be, but you can clearly see the effect that the needle valve is capable of; that boost spike certainly looks a long way off at this particular setting...



With the needle valve now closed by one turn of the knob (out of a maximum of four), our WRX showed a slight increase in boost from 3500 rpm up, but it still nosed over at 62 kPa as previously. Some more adjustment was obviously required...

With another full turn on the adjustment knob (so the valve was now set at its mid point) we saw the TD05H turbo come up on boost a bit harder to hold a constant pressure a few kPa higher than previously. Definitely on-track, but still not quite enough...

Another full turn was then added (the valve now three-quarter closed) and - whoops! - that was a bit too much. The boost curve was now virtually a carbon copy of the curve using the standard boost control system. Oh well, at least we now had the target adjustment point narrowed down...



With some very fine-tuning in just 1/8-turn increments (as mentioned, a needle valve with a greater number of turns across its range would provide better resolution) we arrived at a boost curve that suits us. Let's have a look at it...

The rate of boost increase at low rpm is virtually identical to the standard control system; it's only above about 3500 rpm where the new settings begin to fall behind the rocketing-out-of-control standard boost curve. Looking at these curves, though, it's obvious the new boost system give a *much* more linear pressure delivery; we set it to give a very slight overshoot (only about 2 or 3 kPa) knowing that we wouldn't be trading off too much - if any - boost response at low rpm. As you can see, top-end boost now remains virtually line-ball with the standard system.

With a satisfactory boost curve in second gear, we then sampled the boost curves in the other gears; each curve was spike-free and maintained an identical held pressure. Perfect!

The Verdict

If your lightly modified late-model turbocar has a boost spike that causes some concern, you might be tempted to buy an expensive aftermarket boost control system to iron things out. If a deliberate boost increase isn't in your plans, though, all we can say is "DON'T DO IT!" We've proven it's possible to completely eliminate that boost spike with an outlay of only around $30 AUD and a couple of hours work.

This is what DIY is all about!