COBB™ TUNING

Technical Documentation

How Mazda's MS3 Factory Boost Control System Works v1.00

This document is intended to assist you with the understanding of how turbo boost pressure is controlled on a turbo-charged MAZDASPEED 3. This document is intended to show you details about how the stock boost control system has been set-up. This document is broken down into four chapters; Hardware, Plumbing, Hardware Function, & Mechanical Calibration. Please read the following thoroughly before you attempt to modify your MAZDASPEED3 with the AccessPORT™ hand-held ECU programmer. In the AccessTUNER PROfessional™ or AccessTUNER RACER™ software, table descriptions and tuning tips for most of the tables are provided and can be accessed by pressing the "F1" key while that table is highlighted in the Table List.

We would like to go into further detail about the safeguards and advanced tuning features that are available through the AccessTUNER software. The boost control system uses a closed-loop targeting system which does everything it can to make the boost control system consistent. By employing this closed-loop boost control system the electronic control unit (ECU) can use its speed to bring down boost in overboost situations and raise the wastegate duty cycles (WGDC) for underboost situations. The stock boost control system is much faster than any human analysis and input; we highly suggest you use it to your advantage. Once the stock boost control system is fully understood you will find it easy to tune on internally or externally wastegated turbos.

Chapter 1 – Hardware

Turbo - An exhaust driven air compressor which consists of four basic sections or components. The compressor section consists of the compressor housing and the compressor wheel. This section acts as the inlet or intake for the turbo, compressing the intake charge and generating relative pressure (boost). Generally speaking the inlet is always in a vacuum, sucking air in and the outlet is pressurized with the intake charge. Next is the center section which contains the bearings,

shaft, and the oil and anti-freeze passage ways; the compressor and turbine wheels are also attached to the shaft in this section. The third section is the turbine section which consists of the turbine wheel and turbine housing. This section also contains a machined by-pass for the wastegate valve to seat against. The last component of a turbo charger is the wastegate valve and wastegate actuator which control the wastegate valve's movement. We highly recommend that you use a turbocharger which has both an oil and water cooled center section; turbocharger longevity is compromised when only oil is used to cool the turbocharger center housing.

Wastegate Actuator - A spring/diaphragm based mechanism which controls the movement of the wastegate valve. A turbo wastegate is normally closed, forced shut by a compressed spring inside the actuator canister. As air pressure is applied to the canister, the wastegate shaft moves away from the actuator, swinging open the wastegate valve.

Wastegate Solenoid Valve - An electromagnetic solenoid which controls the air flow from the wastegate actuator to the turbo inlet. This device is normally closed when no voltage is applied. When 12V direct current (DC) voltage is applied, from the drivers in the electronic control module (ECM), to the wastegate solenoid valve, it fully opens allowing air to pass through the device.

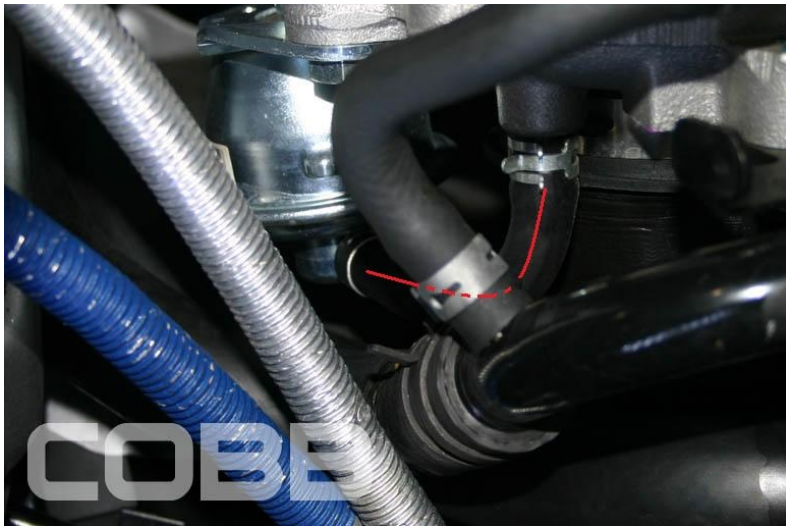
Vacuum Lines - Rubberized or silicone tubes attached to various components in the engine assembly. For this article we will be concerned with the six attachment points and the three sections of vacuum line plumbing and adapters which we will cover in Chapter 2.

Primary Restrictor Pill - A small pill made of brass which contains a precision machined lengthwise hole in the center. The stock restrictor pill is pressed inside the compressor outlet nipple, see below picture. This pill restricts the amount of air coming from the compressor outlet nipple.

ECU - Also known as an ECM, PCM, EEC, EMS. The Engine Control Unit contains the processors, drivers, and logic which is calibrated to control the boost load via wastegate solenoid duty cycle.

Chapter 2 – Plumbing

We will break down the plumbing of the factory boost control system into 3 sections of vacuum line, and 6 attachment points. Please look at the following picture where we have the three basic lengths of vacuum line and the 6 attachment points labeled. Three of these lines are pressurized while the vehicle is under load and the one vacuum line which goes to the turbo inlet tube is under a vacuum which is created by the turbo sucking in air.



Line 1 which can only be seen from under the chassis plumbs the nipple on compressor outlet to the larger, bottom nipple on the wastegate acutator. This line contains the brass restrictor pill, which is actually pressed inside the compressor housing nipple. This is a view from the bottom of the turbocharger.

Line 2 plumbs the smaller, top nipple on the wastegate actuator to the wastegate solenoid valve. This is a view from the top of the turbocharger.

Line 3 plumbs the other nipple of the wastegate solenoid valve to the turbo-inlet pipe. This view is from the top of the turbocharger.

Chapter 3 – Hardware Function

Turbo - The function of a turbo is to compress the intake charge, creating a greater volumetric efficiency for the internal combustion engine.

Wastegate Actuator & Wastegate Valve - A wastegate actuator's function is to control the wastegate valve. The wastegate valve manages the exhaust energy being directed into or by-passing the turbine housing. If the wastegate valve is fully closed, more exhaust energy is directed into the turbine housing causing the shaft speed of the turbo charger to increase and the relative pressure (boost) to increase, all within the efficiency range of the turbo and the restrictions of the intake and exhaust systems. If the wastegate valve is opened the exhaust energy by-passes the turbine wheel and goes into the downpipe so that the turbo shaft speed decreases or remains constant. Opening the wastegate valve will generally lower relative pressure (boost) produced by the turbo.

NOTE: The MORE boost you run, the LESS wastegate you need/use. So unless you want to run less pressure than stock and/or have un-tunable boost problems, we suggest that you do not port your wastegate by hand. We suggest you leave your wastegate, the area around it, the turbine housing, etc. alone and tune your boost curve through the proper means.

Wastegate Solenoid Valve - The function of this device is to control the amount of air pressure being bled away from the wastegate actuator. A 0% Wastegate Duty Cycle (WGDC) setting will allow the solenoid to stay fully closed; which will force the turbo boost pressure to push open the wastegate valve and the engine will run mechanical boost pressure, which can be anything from 7-10psiG. A 100% WGDC setting will bleed off the air from the WG actuator through the solenoid valve attempting to keep the WG valve shut; which will force the turbo to run maximum boost pressure. This valve is considered to be normally closed when no power is applied to the valve.

Primary Restrictor Pill - This component limits the amount of pressurized air flowing from the compressor housing nipple. The primary restrictor pill restricts the air flow so the wastegate solenoid valve and wastegate actuator are not overdriven, which would force the wastegate valve to open prematurely.

Vacuum Lines - Vacuum lines plumb pressurized air to the proper components so the Mazda boost control system works properly.

ECU - This is the master device which controls the wastegate solenoid valve, the slave device, so that the targeted boost load is obtained.

The factory boost control system bleeds air pressure through the wastegate actuator to the intake or turbo inlet pipe. With this device set at 0% wastegate duty cycle through the ECM calibration, all of the air pressure generated at the compressor housing will be applied to the wastegate actuator forcing the wastegate valve to fully open. When the wastegate actuator is fully open, the vehicle will run mechanical boost pressure which can be anything from 7-10psiG on original equipment manufacturer (OEM) turbochargers. When this device is programmed to 100% wastegate duty cycle through the ECM calibration, all of the air pressure generated at the compressor housing will be allowed to pass through the wastegate actuator

allowing the wastegate valve to close. The flow is limited by the size of the hole in the restrictor pill located in the compressor housing nipple. The wastegate valve will only close as much as it can (taking into consideration that the exhaust gas pressure between the exhaust port and the turbocharger is generally greater than the manifold pressure the turbo is generating) with the exhaust gas pressure pushing on the wastegate valve.

NOTE: If you run a turbocharger beyond it's compressor efficiency range, it will turn into a flame thrower.

Chapter 4 – Mechanical Calibration; Mechanical Tuning and Boost Control System Calibration Using the AccessTUNER PROfessional or RACER Software.

Mechanical Tuning

You can mechanically tune the boost control system by changing the size of the center hole in the restrictor pill; since this restrictor pill is actually pressed inside the compressor housing nipple, we highely suggest you leave the stock restictor pill in tact). The middle of this restrictor pill has a lengthwise hole precisely machined to a certain specification so that it works with the factory wastegate actuator and the wastegate duty cycle settings in the stock ECU. The size of this center hole can be changed in order to mechanically assist boost control.

A smaller diameter hole in the center of the brass restrictor pill will have a higher tendency to create boost spike in the system and require less wastegate duty cycle to run higher boost. The larger the diameter hole in the center of the restrictor pill, the less chance the boost control system will boost spike and the greater wastegate duty cycle you will need to run in order to produce higher boost. If you have a stock turbo and are running an AccessPORT map, you have no reason to modify your restrictor pill. If you have installed a new turbocharger and you are using the stock boost control system to tune boost, please verify that the vacuum line coming off the compressor housing contains a restrictor pill with a hole machined in the center of the pill.

The stock boost control system most commonly uses a restrictor pill with a center hole size of 0.0415" +/- 0.003"

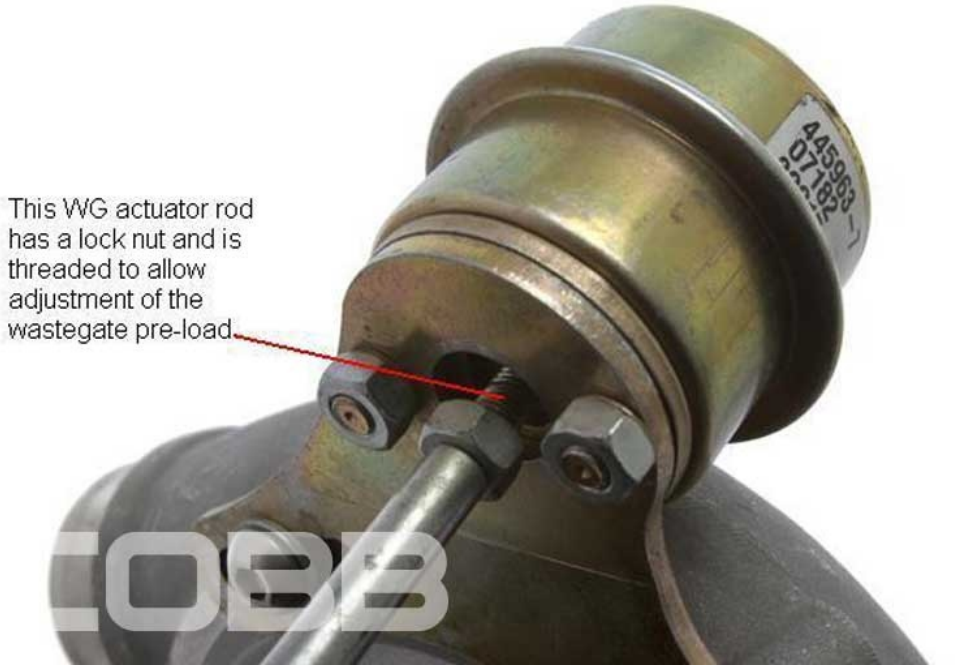
For larger-than-stock turbochargers or turbochargers with a stronger mechanical spring in the wastegate actuator you will need to use a restrictor with a larger center hole, something along the size of 0.042"-0.060" +/- 0.001"

For similar-to-stock-sized turbochargers with a weaker mechanical spring in the wastegate actuator you will need to use a restrictor with a smaller center hole, something along 0.028"-0.040" +/- 0.001". Be very careful when using a restrictor with

a center hole of this size, there is a higher tendency for the system to boost spike and you will need less wastegate duty cycle to run higher boost.

NOTE: The hole in the restrictor pill can always be machined to a larger diameter. Be sure to make very small increases in the diameter of the hole. If the center hole is machined too large you will not be able to hit your boost targets…even with 100% wastegate duty cycle.

The location of the threads can be located at either end of the wastegate actuator rod, see the below picture where it demonstrates the threaded section is closest to the WG actuator diaphragm.



You can mechanically tune the boost control system by pre-loading the wastegate actuator arm; adjustment of the wastegate actuator rod (if the rod length is not fixed and adjustments can be made) will allow proper calibration and some additional mechanical tuning. All Mitsubishi Heavy Industries (MHI) turbochargers have an adjustable wastegate actuator rod, all IHI turbochargers do not. If the rod coming out of the wastegate actuator is shortened it will pre-load the spring inside the wastegate actuator increasing the pressure level at which the actuator will allow the wastegate valve to open and the total boost pressure that turbo can generate will increase (as long as the turbo is still within its efficiency range and has no restrictions, intake or exhaust wise). This pre-load will also limit how far the wastegate valve can open. Pre-loading (shortening) the wastegate actuator rod too much CAN POTENTIALLY CREATE A MECHANICAL BOOST CREEP ISSUE THAT CANNOT BE TUNED OUT! If the wastegate actuator rod is lengthened the actuator will decrease the load on the spring and decrease the pressure level at which the actuator will open and total boost pressure the turbo can generate will decrease. If the wastegate actuator rod does not put enough pre-load on the wastegate valve then you could see boost fluctuations of + or – 3psi even when the wastegate solenoid duty cycles are constant. If you have a stock turbocharger then you should not have to adjust the wastegate rod length. From what we have seen, the factory MS3 wastegate actuator is pretensioned to 7-9psi. When I have run the vehicle on 0% WGDC the turbo produces around 7-10psiG.

NOTE: The larger diameter (or greater surface area) wastegate valve a turbo has the more difficult it is to stabilize boost pressure as the valve initially opens. This is also true for greater exhaust gas back pressures created by a smaller A/R on the turbine housing.

Electronic Tuning Through ECU Calibration

COMING SOON.

COBB Tuning, Inc.
3362 West 1820 South
Salt Lake City, UT 84104
Phone (801) 713-0035
Fax (801) 478-0925
www.cobbtuning.com
www.cobbforums.com

v1.00