

# COBB™ TUNING

## AccessTUNER Software Calibration & Tuning Guides for MAZDASPEEDs **AccessTUNER™ PRO** and **AccessTUNER™ RACE**

This document is intended to assist you with the calibration and tuning of your Mazda 2.3L DISI engine using the Cobb Tuning **AccessTUNER** software. This document has broken down the process into 8 basic steps. Please read through this guide before you attempt to tune your Mazda 2.3L DISI engine with the **AccessTUNER** software. This document will break down the calibration and tuning process into what tables you will be tuning in each section, what engine variables you will want to datalog to tune each section, and what adjustments should be made to your calibration. We have also written Table Descriptions and Tuning Tips for most tables in the software, you can access these help documents by pressing the “F1” key while that table is highlighted in the Table List using the **AccessTUNER** Professional or **AccessTUNER** Race software.

We highly suggest you log the following parameters for the tuning process:

Accel. Ped. Pos. (% , % , % )  
**Actual AFR (Lambda, AFR, AFR) \***  
**Boost (kPA, PSI, kPA) \***  
Boost Air Temp. (C, F, C)  
Coolant Temp. (C, F, C)  
**Fuel Press. Sens. (kPA, PSI, kPA) \***  
Intake Temp. (C, F, C)  
**Knock Retard (degrees, degrees, degrees) \***  
Long Term FT1 (% , % , % )  
**Mass Airflow (g/s, g/s, g/s) \***  
**Rel Throttle Pos. (% , % , %) \***  
**RPM (RPM, RPM, RPM) \***  
Short Term FT1 (% , % , % )  
**Spark Adv. (degrees, degrees, degrees) \***  
**Vehicle Speed (kph, mph, kph) \***  
**Wastegate Duty (% , % , %) \***

\* The variables that are in bold are the default 10 datalog list for the AccessPORT.

Now we are going to walk you through establishing your initial calibrations for your base map. Establishing calibrations are different from tuning. Please read through this document and establish proper calibrations for your vehicle before you begin to tune for power. You want to determine and establish calibrations without creating excessive stress or damaging your engine assembly. These 7 steps have been put in this particular order to assist you with establishing a safe calibration for your vehicle without over stressing the engine.

During your tuning session please make sure that your Intake Air Temperature (IAT) and Engine Coolant Temperature (ECT) values are stabilized prior to your power runs. This will make tuning much easier for you if these two values are always the same when you start your power run. Otherwise, you can chase your tail trying to tune boost or ignition advance if your ECU is in a different compensatory tables due to the change in either of these temperatures. You can also turn the engine off (then cycle the key back to the “ON” position so you do not lose the connection to your ECU) for a short period of time with a fan blowing on the vehicle. Shortly after you start your vehicle, free rev the engine from ~3500 to ~5500 RPM six to eight times; this will spin the water pump pulling the hot coolant out of the block and replacing it with the colder coolant from the radiator.

**1<sup>st</sup> – Please update your AccessPORT firmware, review some helpful documents, and start with the appropriate base map.** Please start with a standard base map that best fits the hardware installed on your vehicle. You can read the long description of the base map to see what hardware the map was designed for.

MS3 Base Maps = <http://www.accessecu.com/accessport/mazda/AP-MAZ-02/MS3Maps.html>

MS6 Base Maps = <http://www.accessecu.com/accessport/mazda/AP-MAZ-02/MS6Maps.html>

Please be sure to update the firmware on your AccessPORT to the latest firmware by following these instructions = <http://www.cobbtuning.com/info/?ID=4106>

Please review the [MS3-MS6 Service Bulletin](#). This document contains Technical Service Bulletin (TSB) information from Mazda, Operating Experiences from MAZDASPEED owners, and other suggestions about what services should be performed prior to dyno tuning.

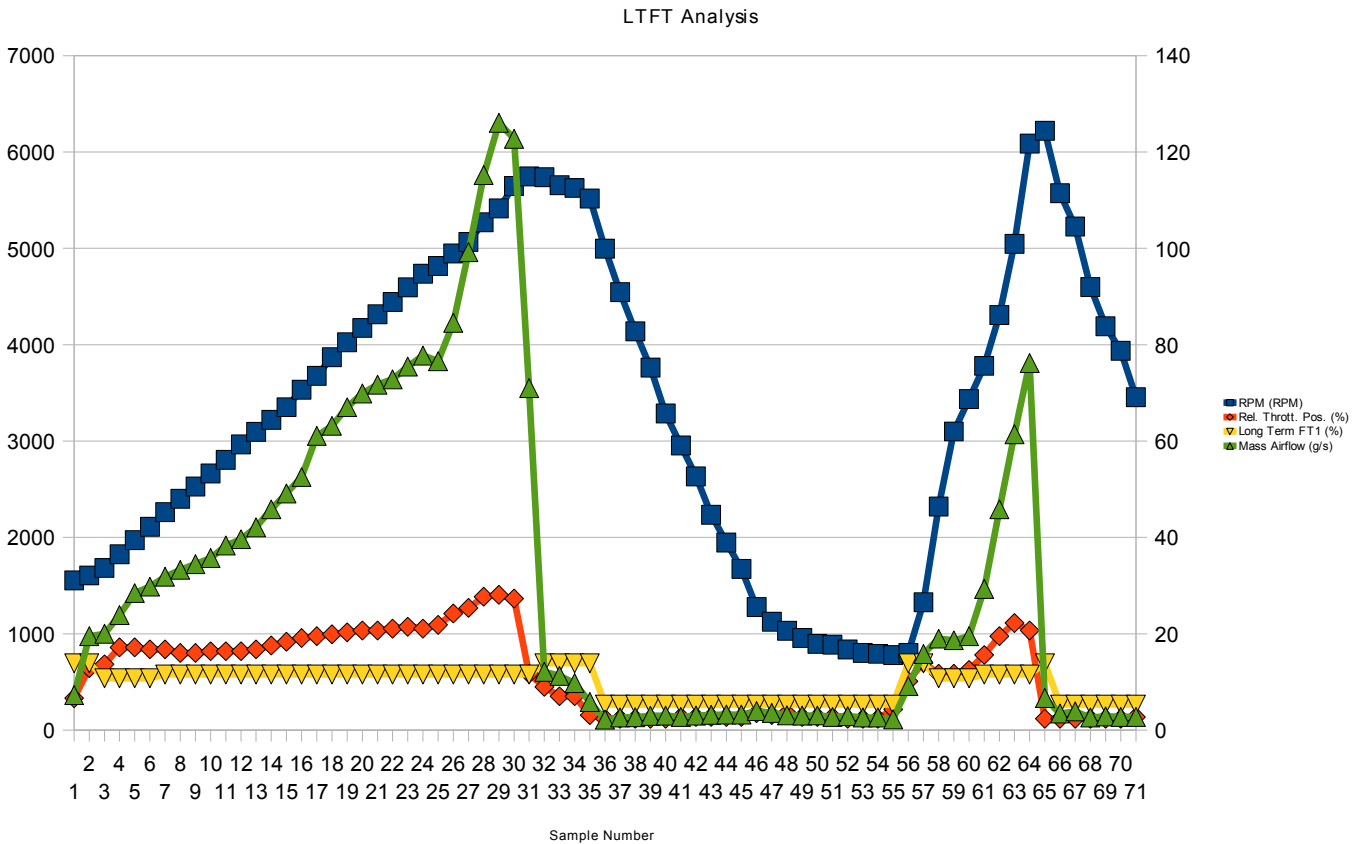
We have also included a MAZDASPEED HelpFile that you can access by pressing the F1 key while the software is open. We have written a detailed description for all tables and tuning tips for most tables. Please take into consideration that the engineers who established these calibrations did so in a very scientific manner and most of these calibrations are optimal already.

**2<sup>nd</sup> – Datalog and establish or verify the proper *part throttle* and *WOT* MAF calibration settings for the fuel intake system and other hardware that will be used for calibrating the engine.** To capture this data please follow the below directions:

**This test should be done carefully. Allow the vehicle to idle for a few minutes, then drive for about 50 city miles at light throttle.** Please make sure the ECU has not been reset or the battery disconnected for these 50 miles. Set the AccessPORT or AccessTUNER software up to datalog the standard 10 AccessPORT variables along with Long Term FT1 ( LTFT ), Mass Airflow, and Short-Term Fuel Trim (STFT). Be sure to have MAF Flow

displayed on the screen as you prepare to log. Start in 2nd gear at 1500 RPM then **very slowly** modulate throttle from there over the next 20 seconds, please be sure to accelerate at a steady rate until you exceed 100 grams/sec airflow. After you have completed this test up to 100 grams/sec, please put the car in neutral and allow the car to idle for a few seconds. Then steadily open the throttle while the car is in neutral until you exceed 30 grams/sec, then stop the datalog. This will allow us to see what type of learning the stock ECU is doing to compensate for the intake system that is installed on this car. Ideally, you want your LTFT values to be closer to zero. Anything +/- 8% is acceptable, but closer to 0 LTFT is ideal.

The objective is to observe the various adjustment that have been saved by the ECU at various breakpoints along the MAF curve. These breakpoints are based on grams/second airflow values.



By analyzing the datalog recorded above, you can see what changes the ECU is making to compensate for the various hardware installed on the vehicle. You should only need to apply these adjustments once prior to continuing the tuning process. One objective is to calibrate the MAF sensor for part throttle conditions. The other objective is to calibrate the MAF sensor so the WOT fuel tables can be accurate. From what we have seen with these vehicles, the MAZDASPEED3 (MS3) and MAZDASPEED6 (MS6) have different learning breakpoints for the LTFT corrections.

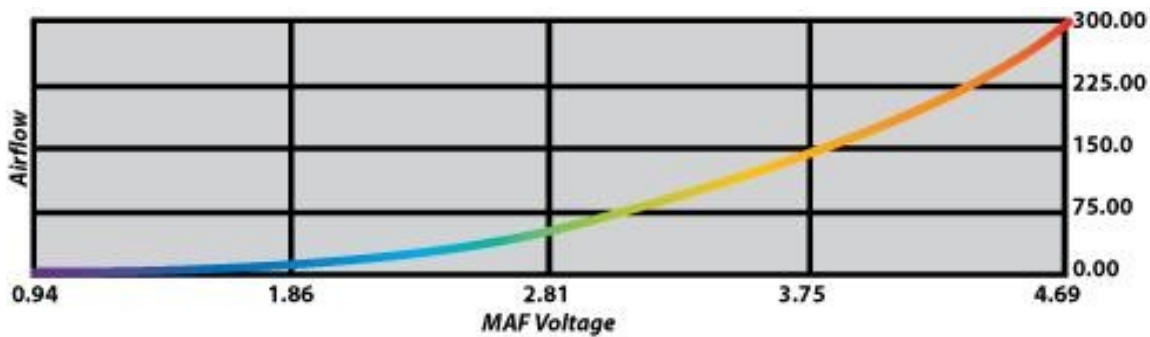
The MS3 uses five different LTFT Breakpoints from;

- 0 – ~5 grams/sec
- ~5.01 – ~16 grams/sec
- ~16.01 – ~28 grams/sec
- ~28.01 – ~77 grams/sec
- ~77 grams/sec – full sensor range

The MS6 uses five different LTFT Breakpoints from;

- 0 – ~5 grams/sec
- ~5.01 – ~18 grams/sec
- ~18.01 – ~31 grams/sec
- ~31.01 – ~69 grams/sec
- ~69.01 grams/sec – full sensor range

If you are operating the engine with an intake system which has a larger diameter than the stock intake system then you will want to use the global multiplier value calculated from the “Intake Calibrations” tab located in the “AccessTUNER Calibration & Tuning Guide Worksheet for MAZDASPEEDs.” This multiplier should be applied to the entire MAF Calibration curve.



The following steps can be followed if you do not use historical learned LTFT data for making a proper MAF calibration.

**The MAF Calibration** table contains values that tell the ECU the MASS of air entering the engine for the given MAF voltage. These values allow the ECU to properly calculate the mass of the fuel it needs to inject into the engine to get the air/fuel value dictated in the Primary Fuel table or by the closed loop control targets, 1 Lambda. The factory ECU airflow adjustments table is based on MAF Voltage. The data in this table is represented in grams per second; this is the only table that exists for the sole purpose of adjusting MAF transfer (or MAF calibration) values. Under closed loop conditions the ECU is always going to try and hit 1 Lambda or the stoichiometry of the fuel you are running. You will be most familiar with the associated petrol air/fuel ratio of 14.68:1 A/F, which is an air mass of 14.68 to every 1 fuel mass.

This paragraph has been composed to give you a better understanding about how fuel trims work for this vehicle. If you follow the above steps and capture a datalog, you will not need to follow the steps in this paragraph. Start the vehicle, let it idle, and come to temperature...it may not perfectly idle, but just deal with it until it comes to temperature, 180-190 F. Use the dashboard to pull up your STFT, LTFT, MAF Voltage, and Coolant Temp. After the vehicle has come to temperature, watch your MAF voltage and A/F trims. You want the combination of your A/F trims to be as close to 0 as possible. EX = If your STFT is +5% and LTFT is 0, then simply look up the MAF Voltage, which should be close to 1.2-1.28 volts at idle, on the MAF Calibration table and adjust the grams/sec value for that voltage up (+) until your combined fuel trims are 0 or close to zero. These adjustments can be made very easily by looking at the combined % correction of the STFT & LTFT. If that total is +6% then you can highlight the MAF Calibration cell for that particular MAF voltage and hit the "M" key, you will then be prompted to enter a floating point value. The correct value for this particular situation would be 1.06. This adjustment will now tell your ECU for that particular MAF voltage you now have a 6% greater MASS of air entering the engine so 6% more mass of fuel should be injected. After this adjustment is made and your ECU flashed with the map, your A/F Trims should be close to zero. (If that total is -6% then you can highlight the MAF Calibration cell for that particular MAF voltage and hit the "M" key, you will then be prompted to enter a floating point value. The correct value for this particular situation would be 0.94; this adjustment will now tell your ECU for that particular MAF voltage you now have 6% less MASS of air entering the engine so 6% less mass of fuel should be injected, bringing your fuel trims close to zero.) We suggest you shoot for a LTFT value of +/- 8% max. You may have to re-set your ECU throughout this process with the **AccessTUNER** software to remove any learned trims. To re-set your ECU while live data logging, close down any tracing or dashboard, then you can go to the "ECU" drop down menu and select the Reset ECU option. You will be prompted to turn your vehicle fully off and back on again.

Complete these calculations along the MAF Calibration table up to 2.6 volts or so ON A LOAD-BASED CHASSIS DYNO at part-throttle. Be sure to run the vehicle with the A/C on as well to make sure your calibrations are consistent. If you have a properly designed intake system, the MAF Calibrations should look very similar to your stock MAF Calibration graph under the table data. Be sure to keep your throttle movement as steady as possible during this process. Rapid movements of the throttle may employ adjustments from the tip-in enrichment conditions and may skew your fuel trims.

Your trim values will always adjust back and forth (+/-); let them, that is what they are supposed to do. Do not beat yourself up trying to get them at exactly 0...it is impossible (temperature, weather, gasoline, etc. changes will not keep anything constant while you are tuning).

If your idle RPM or AFR at idle has a slight fluctuation then you may need to modify your MAF calibration table settings around the MAF voltage the vehicle idles. We have found that the stock calibration settings at idle can be too far apart and they may need to be adjusted so they are closer together at the MAF voltage where the vehicle idles. For this example we will say that the vehicle is idling around 1.29 MAF volts.

If you are seeing plateaus, spikes, dips, or flat spots in the graph for the MAF Calibration table then you know something is wrong...replace the intake system with a properly designed one.

**NOTE: CHANGING THE MAF CALIBRATION TABLE WILL CHANGE YOUR CALCULATED LOAD.** If all other variables remain constant, the less airflow you calibrate in the ECU for a given MAF voltage; the less engine load will be calculated. This is particularly difficult to deal with because this also changes the torque calculations completed by the ECU. This is why we suggest you use historical LTFT data to make one major revision to your MAF calibration. Once you verify that your LTFT does not go beyond +/-8% at idle and part throttle, and your Actual AFR matches the values in your WOT fuel tables, then should not need to address the MAF calibration again. If you see your LTFT values suddenly change, this may mean something mechanical has changed with the engine. Please mechanically check all vacuum, intake, charge pipe, and intercooler connections to make sure they are properly sealed.

#### **What all of the above 2<sup>nd</sup> step means to you:**

- It takes significantly less time and is much easier to calibrate the MAF sensor based on historical data. We highly suggest you allow the vehicle to run on a calibration for at least 10 miles of street driving and a few key cycles so the ECU is allowed to learn and show you what has been saved for LTFT values.
- Fuel trims are different based on whether or not the vehicle has an upgraded Camshaft Driven Fuel Pump (CDFP).
- Fuel trims affect torque calculations. Vehicles with the same map and same or different parts will perform differently based on the LTFT value the ECU has learned.
- The MS3 and MS6 have the same MAF housing, but different MAF Sensor calibrations.

### **3<sup>rd</sup> – Establish proper boost targets, boost limits table values, and absolute load limit table values.**

Several tables exist within the ECU that control when the engine cuts fuel and closes the throttle plate if the engine exceeds a determined safety limit. We have found it helpful to establish proper boost targets in the Boost Targets tables in order establish these various safety limit values. The ECU does

not use the Boost Targets table under normal Wide Open Throttle (WOT) conditions. However, we have set up a worksheet that calculates proper Boost Limits - Fuel Cut and Boost Limits - Throttle Close table values based on the values on the Boost Targets table. The Boost Limits table will cut fuel to the engine if the boost values in this table are exceeded, so it makes sense to set these values above your Boost Targets values. The Boost Limits - Throttle Close table will close the throttle after the boost values in this table are exceeded. Setting these values slightly under the Boost Limits - Fuel Cut table values is an appropriate strategy to help use the throttle control system in order to prevent an over boost situation. By basing the Boost Limits - Fuel Cut and Boost Limits - Throttle Close table values off the Boost Targets table values, one can establish proper protective values to help protect the engine from exceeding various boost limits.

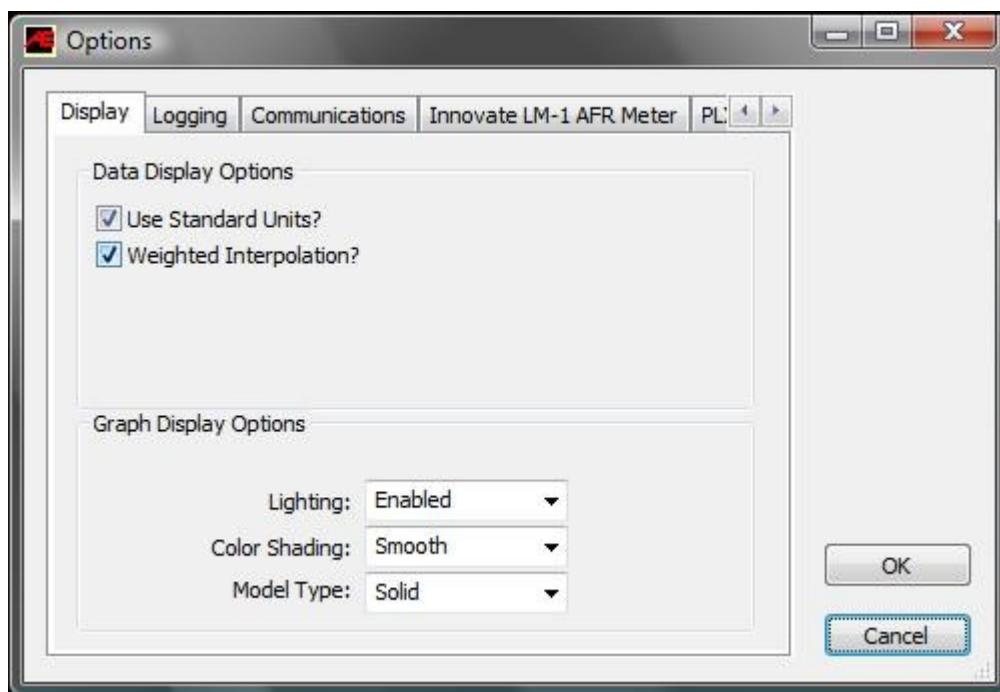
The Abs Load Limits – Fuel Cut table is another table that will cut fueling to the engine if the engine exceeds the load values in this table. We can speculate that this table was used to establish the fueling limitations of the stock CDFP. If the ECU calculates that engine load is exceeding these values, then fueling is temporarily cut to the engine until the calculated engine load falls below these values.

#### ***What all of the above 3<sup>rd</sup> step means to you:***

- Please be sure to verify that your fueling capacity is capable of keeping up with fueling demand. If you see your DI Fuel Pressure drop below 1200psi while at WOT, then we highly suggest you upgrade your CDFP. The stock CDFP usually hold DI Fuel Pressure at ~1500-1600psi, most high-flow CDFP usually hold DI Fuel Pressure at 1600-1800psi. We highly suggest you verify fueling supply is capable of fueling demand and that you set various limit tables appropriately.

#### **4<sup>th</sup> – Establish proper safe fuel curves.**

Please make sure that the Weighted Interpolation box has been checked. This setting is found in the Display tab of the Configure Options menu, which can be accessed in the software by pressing CTRL+F key.



The fuel targets at idle and at part throttle will and should always be 1 Lambda (or 14.68 AFR with petrol), for this is a Closed Loop (CL) fueling target. When you increase your engine load from idle or part throttle you should always see a smooth transition from 1 Lambda (14.68 AFR) to your Open Loop (OL) fuel targets. These dictated fuel targets are in the Fuel OL/WOT Commanded EQ (No Knock) table. If steps 1, 2, and 3 have been properly performed then you should not need to modify much of your part throttle fuel targets because the transition will always go from ~1 Lambda down to the desired Lambda or AFR for WOT. This transition will only happen after any closed-loop delays have taken place.

**Fuel OL/WOT Commanded EQ (No Knock) calibration.** We suggest you start off with excess fuel and run the engine richer than you want for your final tune, something around 0.68 Lambda (lower 10.X:1 AFR Petrol). Leaning the engine out from a richer fuel curve is a much safer approach to tuning your fuel curve. Once all of the above tables have been calibrated, you will want to datalog your AFR Actual and compare it to your dictated Lambda (AFR) in your Fuel OL/WOT Commanded EQ (No Knock) table; you can make your adjustments to your MAF Calibration from there. We highly advise that you start your WOT pulls by focusing on the mid RPM ranges then working your way up to just before redline. EX: Start your pulls on the dyno from 3200 RPM and go to 4200 RPM. Check the values dictated in your Fuel OL/WOT Commanded EQ (No Knock) table against the Actual AFR as measured in the exhaust stream.

This comparison only relates if you have an intake system that is other than stock; if your dictated A/F is 11.0 and you measure 12.0 in the exhaust stream, then you will want to add (+) grams/sec for the MAF voltage that corresponds for that RPM and load point. The specific adjustment for the above situation should be multiplying the corresponding MAF flow grams/sec by 1.0909 = 12/11. You should be measuring very close to the same Lambda (A/F Ratio) in your exhaust stream that you have dictated in your Fuel OL/WOT Commanded EQ (No Knock) table. Your trim values will always adjust back and forth (+/-); let them, that is what they are supposed to do. You should not have to modify the MAF Calibration table if you have a stock vehicle. We highly suggest you do not spend excessive time tuning your MAF Calibration table just so the A/F output matches exactly what is dictated in the

Primary Fuel table. You will chase your tail getting it spot on...then you will fill up at a different gas station that will have a different quality fuel and the targets may be slightly off.

For the next pulls you can go from 3200 RPM to 5200 RPM, then 3200 RPM to 6200 RPM, until you can safely make pulls from 3200 RPM to just before redline. Again verify that what you measure with the Actual AFR matches what you have in the Fuel Table WOT.

NOTE: IF ANY REPORTS OF KNOCK RETARD (KR) ARE PRESENT DURING THE PULL, THE ECU WILL INJECT ADDITIONAL FUEL TO HELP PREVENT REPORTS OF KR. The higher the reports of KR, the more fuel (in addition to the fuel dictated in the Fuel OL/WOT Commanded EQ (No Knock) table) the ECU will inject. In order to verify the MAF Calibration is set up properly, you will need to make sure that KR is not reported for the entire pull. This may require that you run a lower than desired boost levels in order to datalog a clean dyno run that has no reports of KR.

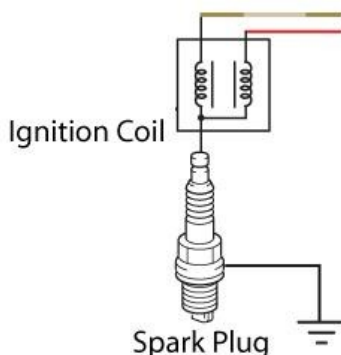
If you notice that the ECU's closed-loop delays are longer than desired, then you can modify the various Closed Loop tables. Please use caution when doing so for this will change when and how the car transitions from closed-loop to open-loop operations which can greatly affect driveability.

***What all of the above 4<sup>th</sup> step means to you:***

- Please be sure to verify that your fueling capacity is capable of keeping up with fueling demand. If you see your DI Fuel Pressure drop below 1200psi while at WOT, then we highly suggest you upgrade your CDFP. The stock CDFP usually hold DI Fuel Pressure at ~1500-1600psi, most high-flow CDFP usually hold DI Fuel Pressure at 1600-1800psi.

- The ECU switches logic and blends fueling strategies in different modes. Fueling can go from stratified to homogeneous, and back. Torque targeting can go from boost targeting to load targeting. Closed-Loop (CL) to Open-Loop (OL) transitions may not be smooth on a vehicle where the turbo spools very quickly.

- Fueling strategies change with reports of Knock Retard. For each 1 count of KR, you will see the ECU adds a proportion of fuel.



## **5<sup>th</sup> – Establish proper ignition advance table settings**

First, you need to recognize that it is impossible for any engine to never detonate under all conditions. Too many variables are constantly changing during engine operation and it is impossible to avoid detonation under every condition. The objective of ignition advance tuning is calibrating the ignition advance tables to MBT, Minimum spark advance for Best Torque output. This is a state where you have calibrated the ECM to the maximum power available, or the maximum power that the engine can produce under the given conditions (engine hardware, fuel quality, atmospheric conditions, etc.). Adding less ignition advance will usually lose power (and increase Exhaust Gas Temperature (EGT)); adding more ignition advance will usually lose power, decrease EGT, and bring the motor closer to the detonation threshold. You want to start off with less total ignition advance than you are going to run for your final tune. Too much ignition advance for any given RPM and calculated engine load can destroy an engine very quickly. Again, the objective is to run as little ignition advance as possible while making the greatest amount of torque.

Finding MBT can only be safely completed with a good load based chassis dynamometer that has the ability to load the vehicle and measure the torque output at the same time. Chassis dynos such as Mustang Dynamometer, Bosch, and Dyno Dynamics have this ability. You can start off in the higher gears (lower engine RPM) and have the chassis dyno hold the vehicle and give you the torque output of the vehicle at a RPM breakpoint on your ECU calibration. You can start out at very light (low TPS) loads holding the vehicle at one specific load for the ignition table(s) and slowly add ignition advance in different maps until the vehicle does not make any more torque or gets close to the knock threshold for the engine. One suggestion is that you increase ignition advance for each particular cell until you see that torque no longer increases with the additional ignition advance. Now back off 2-3 degrees of ignition advance to keep the calibration on the safe side. Once you find where the engine produces the maximum amount of torque with the least amount of ignition advance, this is MBT. Tuning for MBT will take a very, very long time and is not suggested unless you are very experienced with the particular chassis dyno you are using and the engine you are tuning.

Another option is to tune the ignition advance curve for part throttle by identifying which ignition table(s) your ECU is using for part throttle conditions. You will need to datalog the following variables: RPM, Engine Load, Spark Adv. (°), Knock Retard (°), Rel. Thrott. Pos. (%), and Actual AFR (AFR) to help you identify which table(s) the ECU is looking-up for Closed-Loop (CL) ignition calculations. The MS ECU will usually switch between ignition tables based on whether or not the ECU is recognizing Knock Retard (KR). If no KR is reported, then the ECU will use one table or set of tables, if KR is reported then the ECU will use another table or set of tables. Generally speaking, the ECU will try to run as much ignition advance as possible during part-throttle conditions in order to determine MBT. This is done through advanced detonation detection measures using the knock sensor. *When the ECU calculates reports of KR while at WOT, the ECU will remove ignition advance and add fuel to help protect the engine.* If the ECU does not run excessive ignition advance, then it cannot determine the detonation threshold of the engine for the given conditions. If you are to run less ignition advance, then the engine will be less efficient, generating greater emissions, achieving lesser fuel economy...and the engine will still detonate (and the ECU will report KR) under some conditions.

For tuning of your ignition advance curves at WOT or Open-Loop (OL), we suggest you begin with less total ignition advance than is optimal, that way you can work your way up from there. Generally speaking, a turbo-charged Direct Injection Spark Ignited (DISI) Mazda engine will run the least



amount of ignition advance near peak torque and ignition advance will generally rise with RPM in order to keep up with the increasing piston speed. This trend is normal for most internal combustion spark ignition engines; as VE (Volumetric Efficiency) increases the amount of ignition advance an engine needs will decrease. During part-throttle driving, a turbo-charged engine's VE will not be the highest because the turbo is not producing much boost under cruise conditions and ignition advance will usually be higher. As VE increases at WOT (when the turbo is producing boost) ignition advance will go down to its lowest point by peak torque then it will slowly increase during the torque plateau. This is not due to decreasing VE, but is done in order to keep up with the increasing piston speeds. Once torque begins to fall off you will see ignition advance increase at higher rates. This is due to the decreasing VE or torque and is also done in order to keep up with the increasing piston speeds; you have to start the burn earlier so that the pressure wave expansion occurs at the optimal time. Ultimately, you will always want the combustion pressure wave occurring inside the combustion chamber to exert maximum force so the piston/connecting rod assembly pushes on the crankshaft at the same timing after-top-dead-center (ATDC). This optimal position is usually between 9-16 degrees ATDC.

We have found that one must have a chassis dyno to help find the thresholds for maximum ignition advance for a particular engine and the fuel that is being used. The objective of ignition tuning is very simple. You are trying to start the flame front, BEFORE TDC (or after on a DISI engine), so that the peak of the combustion chamber pressure wave pushes down on the piston at the same time AFTER TDC. This is why values in the ignition advance tables are in degrees of ignition advance *before* (positive values) and *after* (negative values) TDC.

With the above said, what you will be trying to do is to get the total ignition advance curve as close to optimal for your engine and the fuel you are using. If your ECU and engine are happy with your calibration you will generally see that the ECU will seldom report KR above 1 while at WOT.

You should be satisfied with the ignition advance curve if while at WOT for several runs, hot ones even, the KR does not go above 2 across the RPM range and the ignition is a smooth predictable curve. This is not the only way to tune, just one perspective. You can carefully run more ignition advance so that the ECU will show you if the engine wants more ignition timing. You can increase total ignition advance in small increments, .5 - 1 degree of ignition advance. Once you are able to find the optimal ignition advance curve your engine wants for the particular fuel you are using you should see that your total ignition advance curve is consistent from run to run.

Generally speaking, ignition advance is used to increase the volumetric efficiency (VE) of an engine where the efficiency does not naturally exist. With this said, peak VE is found at peak torque so the engine will need the least amount of ignition advance under these conditions. After the engine's torque peak, you will typically need to increase ignition advance in order to keep up with the increasing piston speeds the engine will see as RPM increase. Please take into account that once you exceed MBT (Minimum spark advance for Best Torque output); it is possible to make less power with more ignition advance and this additional ignition advance beyond MBT has the ability to damage an engine. This is when tuning on a load based chassis dyno can be very beneficial.

The MS ECUs have been programmed with ignition advance curves that are very aggressive for part throttle conditions. This has been done to allow the ECU to determine MBT for varying conditions. Once the ECU detects that ignition advance is too aggressive for the given conditions, by using feedback from the knock sensor, the ECU will report KR and remove the excessive ignition advance...THIS IS NORMAL. Please understand that detonation at light engine loads is not as much of a concern as KR while at WOT. The cylinder pressures at part throttle are not significant enough to damage the engine as to where the cylinder pressure at WOT can damage an engine if detonation is sustained. This allows the ECU to run the engine on various different fuel qualities that are available across the United States. Reports of KR may not be present while running 93 octane, but KR may report at part throttle while running 91 octane.

The ECU has two pairs of main ignition advance look-up tables. As you have the software open, you can press the CTRL+K keys then you will be prompted if you want to revert the ECU back to stock values. By doing this you can see how the factory settings are the same for two pairs of main ignition advance look-up tables. Being that these tables are set the same from the factory, you will likely want to set these pair of tables the same unless you have determined a better strategy.

#### ***What all of the above 5<sup>th</sup> step means to you:***

- Ignition strategies change with reports of Knock Retard.
- The stock vehicle has several compromises that need to be dealt with prior to tuning. Poor spark plug quality and compressed coil spring tension are two minor pieces of hardware that may need to be replaced or inspected prior to tuning.



#### **6<sup>th</sup> – Modify the Throttle – Req. Load – X Gear (Norm BAT) torque targeting tables, Boost Dynamics, and Load Dynamics tables in order to achieve the boost control characteristics that you would like.**

You will need to datalog the following variables: Actual AFR, Boost, Boost Air Temp., Fuel Press. Sens., Knock Retard, Rel. Thrott. Pos., RPM, Vehicle Speed, Wastegate Duty to help you identify which table(s) the ECU is looking-up for open-loop torque targeting. The MS ECU will also usually switch between the Norm BAT and High BAT Throttle – Req. Load tables based on the Boost Air Temp values. The objective is to keep the intercooler efficiency high enough and turbo boost low enough to keep the BAT values consistent and within the heat exchanging abilities of the hardware installed on the vehicle.

First we would like to review some of the stock MS ECU logic. The ECU will use the lowest torque target from one of the three groups of tables:

Throttle – Req. Load – X Gear (Norm or High BAT)  
Throttle – Requested Load : Baro v. RPM  
Throttle – Requested Load

This logic allows several different strategies to be used to calibrate these ECUs. One can set two of the tables to higher values; this would force the ECU to allow torque to be tuned by the one table (or group of tables) with the lowest torque target values. This would allow the Throttle – Requested Load : Baro v. RPM table or the Throttle – Requested Load table to be used to tune torque for all gears. On the other hand, one can set the above two requested load tables to higher values and then the torque targeting tables associated with each gear can be used. This is what we have chosen to do with our OTS maps so we can try to map boost differently in each gear based on the differing load conditions for each gear. If you increase the desired torque values in these tables, the ECU will do what it can to make additional torque. If you decrease the desired torque values in these tables, the ECU will do what it can to make less torque.

Being that this engine is turbocharged makes the tuning process fairly straight forward. The turbocharger boost levels are the main variable used to create torque. When you increase your torque targets for a particular gear, you will see the ECU uses more Wastegate Duty (%) in order to achieve the higher torque (boost) levels. If you see that you are overshooting boost levels, you can simply decrease your torque targets for that particular gear.

If you are increasing or holding wastegate duty cycles steady and boost is dropping then you have most likely reached the threshold of the mechanical efficiency of the turbo or your exhaust gas back pressure prior to the turbo is too high and is forcing the wastegate valve to open.

If you are having a small boost spike you may need to decrease the Target Load a few hundred RPM prior to the over boosting event to allow the exhaust energy to be released past the turbine wheel.

The Boost Dynamics and Load Dynamics are used to fine tune boost or torque control characteristics. These tables give the ECU authority to remove WGDC when an over boost or over load condition occurs, and add WGDC when an under boost or under load condition occurs. These tables are used to help correct boost and torque targeting values when an over boost (or over load) or under boost (or under load) condition occurs. These tables are calibrated to help control the smaller stock turbo, if you have changed your turbocharger we suggest you modify these table settings in order to fine tune the boost control characteristics.

NOTE: With porting a wastegate, you are trying to make the wastegate valve function work better which means that your turbo is going to lower boost super fast when the wastegate door/valve opens or not run as much boost as it was engineered to run. If you make your wastegate react quicker then boost will be very difficult to stabilize and reach peak #s at an earlier RPM. If you make the wastegate flow better, then the exhaust energy your turbo needs to make and maintain boost will have less opportunity to flow across the turbine wheel. Generally speaking, air/pressure/exhaust gases will always flow along the path of least resistance. Not bashing, just trying to give you a different perspective.

Generally speaking, the stock turbo can experience an uncontrollable overrun condition if a high-flow exhaust manifold is installed in conjunction with a high flow intake and catless exhaust system. You can modify the boost control system by changing the size of the orifice in the restrictor pill. Although, installing a properly designed stainless steel substrate high-flow catalytic converter will significantly assist with controlling turbo overrun conditions and will have a nominal effect on power output.

***What all of the above 6th step means to you:***

- Fuel trims affect torque calculations so one car with the same map, same or different parts, will perform differently based on the LTFT value the ECU has learned.
- Torque targeting strategies change with changes in Boost Air Temp (BAT) values.
- The ECU can be tuned several different ways depending on how you have established various table settings. You can have one table for all torque targets, or you can target torque per gear.
- The ECU may switch between boost targeting and torque targeting for closed-loop and open-loop operations.

**7<sup>th</sup> – Modification of throttle table settings for part throttle and WOT throttle controls. Advanced calibrations.**

If you choose to establish calibrations for these tables yourself, you will need to datalog the following variables: Accel. Ped. Pos. (APP), Actual AFR, Fuel Press. Sens., Knock Retard, Rel. Thrott. Pos., RPM, Vehicle Speed, and Wastegate Duty to help you identify which table(s) the ECU is looking-up for closed-loop or open-loop boost and torque targeting.

The APP Translation tables represent how the Accelerator Pedal Position (APP) values are reported to the ECU on a per gear basis. The x-axis values in these tables are APP read-only values and the cell data is the reported APP values that are used by the ECU for throttle controls. These tables use read-only APP values to look up a APP value that is reported to the ECU for throttle controls. The stock values work very well. Although, if you are to modify these values, we highly suggest you drive the vehicle and datalog APP and TPS values to get a better idea about how this vehicle drives with the various changes. These vehicles tend to use switching and blending functions for closed-loop to open-loop transitions. Please be aware of this as you start to modify any closed-loop functionality.

The DBW Throttle tables define the throttle duty cycles indicated under three separate conditions as a function of calculated engine load, and thus requested torque. The table is referenced by the Engine RPM on the x-axis and by the calculated engine load on the y-axis. Table values are the relative throttle duty cycle the torque targeting system will drive the electronic throttle body in an attempt to target the associated torque. Higher values mean more duty cycle, lower values mean less duty cycle. The factory ECU settings use these table values to control the torque produced by the MZR engine. These tables most directly effect how the throttle system works during part throttle and WOT conditions. The requested torque values on the y-axis indicate how much or little to duty cycle to drive the electronic throttle body with. A value of 80% throttle duty cycle represents the maximum amount the electronic throttle body can be driven. The OTS map settings are very effective and we suggest you start there.

***What all of the above 7<sup>th</sup> step means to you:***

- As was done with the factory calibrations, throttle controls can be effectively used to help manage the torque output of the engine or for protective measures to help prevent overrun (over rev) conditions.

**8<sup>th</sup> – Advanced calibration, Idle Speeds, Speed Limiter, VVT Intake Cam Adv., etc.** We have written a detailed description for all tables and tuning tips for most tables. You can access this information by pressing the “F1” key while the particular table you want to learn about is highlighted in the table list located on the left hand side of the software. Please take into consideration that the engineers who established these calibrations did so in a very scientific manner and most of these calibrations are optimal already.

When running a balance shaft delete kit, we have found it has been helpful to maintain an Idle Speed which is 100-400 RPM higher than the factory calibration. At idle, the vehicle is in closed-loop operation trying to maintain 1 Lambda or an AFR Petrol of 14.68:1 and the ECU might modify the injector pulse width (IPW) to a point where the ECU will not allow a fuel injector to fully open and close due to the short pulse width is running in order to hit this fuel target. Larger fuel injectors need a minimum injector pulse width in order to fully open and close; if the engine is idling too low then the pulse width is too short to allow the injector to work properly and an occasional miss-fire can occur.

In order to assist you with the calibration of your ECU using the **AccessTUNER** software, we have uploaded all of our base calibrations for you to start with. These calibrations can be found below for the various vehicles from this link = <http://www.cobb tuning.com/info/?ID=4332>

We also have a General **AccessTUNER** thread on our forums where you can ask us and other **AccessTUNER** users questions about how to use the software, what hardware has performed best, and other tuning tips. Here is a link to that thread = <http://www.cobbforums.com/forums/forumdisplay.php?f=27>

We hope this **AccessTUNER** Tuning Guide has been helpful. Please e-mail any criticism or comments to [christian.krahenbuhl@cobb tuning.com](mailto:christian.krahenbuhl@cobb tuning.com) so we can here back from you about how the material is presented, if the material is helpful, etc. We want to make constant improvement to our services and products and we need your feedback in order to achieve this.



Addendum 1  
How Mazda's 2.3L DISI Turbo 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, MAZDASPEED 6, or CX-7. 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 over boost situations and raise the wastegate duty cycles (WGDC) for under boost 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. These vehicles are a bit unique in that they do not target boost for WOT conditions, they simply target torque.

## 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 top of 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. This device is actuated on a percentage basis, 0% wastegate duty cycle (WGDC) equals fully closed and allows all turbo boost pressure to push open the wastegate valve, and 100% WGDC equals fully open and allows all turbo boost pressure to bleed away from the wastegate actuator.

*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 air into the compressor housing.



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 actuator. 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. The stock 2.3L DISI restrictor pill orifice measures at approximately 0.0415" +/- 0.003"

*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 its compressor efficiency range, it will turn into a flame thrower.

### Chapter 4 – Mechanical Calibration; Mechanical Tuning and Boost Control System Calibration Using the **AccessTUNER PRO** or **RACE** 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 highly suggest you leave the stock restrictor 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  $0.0415'' \pm 0.003''$

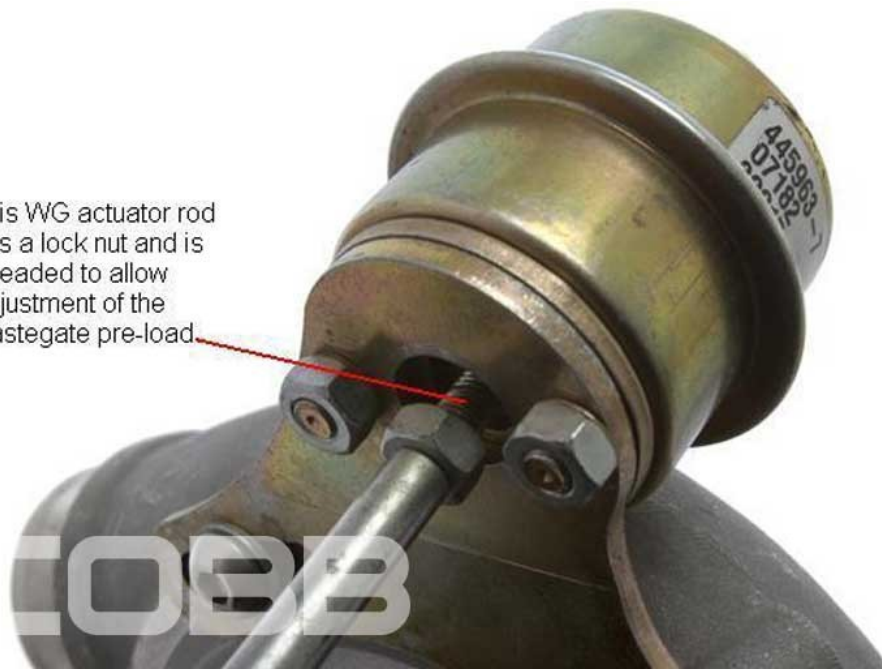
For larger-than-stock turbochargers or turbochargers with a stronger mechanical spring in the wastegate actuator you will need to use a restrictor with a larger center hole, something along the size of  $0.042''\text{--}0.060'' \pm 0.001''$

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  $0.028''\text{--}0.040'' \pm 0.001''$ . 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.

This WG actuator rod has a lock nut and is threaded to allow adjustment of the wastegate pre-load.



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 we 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.

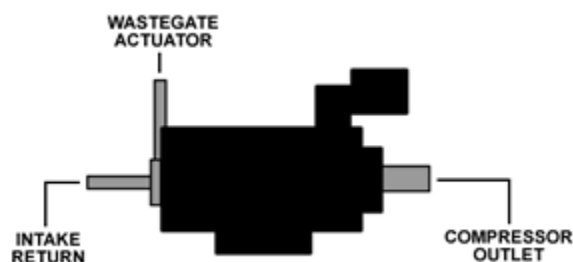




### *Electronic Tuning Through ECU Calibration*

The stock boost control system can be used to control boost on properly designed internal and external wastegated systems. If you have a turbocharger with a properly designed internal wastegate valve/actuator that has been properly calibrated using the correct size restrictor pill and wastegate pre-load you will be able to use the factory boost control solenoid.

NOTE: If you are tuning with an external wastegate, we have found that the Prodrive electronic boost control solenoid (EBCS) works perfectly with the stock compensatory wastegate calibrations (coolant, intake air temperature, etc.). This solenoid is a replacement for the stock EBCS and plugs in to the factory wiring harness. Tuning external wastegates with the factory boost control system (ECU) has worked very well as long as you use the Prodrive EBCS. Please refer to the below picture so you know how the plumbing of the Prodrive EBCS should be set-up. With the Prodrive EBCS you WILL NOT NEED TO USE ANY RESTRICTOR PILL!



The above diagram is only for internally wastegated turbos

You must be made aware that tuning the boost control system is the most difficult tuning you will perform on your Subaru. TUNING THE BOOST CONTROL SYSTEM IS ALSO GOING TO TAKE THE LONGEST TIME TO COMPLETE. Although, once you are finished tuning your boost control system you will be very appreciative of the complexity and capability of the OEM boost control system. The OEM boost control system is much faster than any human input so we highly suggest you start with lower wastegate duty cycles than you may need and work your way up from there. The boost curve and the stability of the boost curve must be established in order to allow you to properly tune all other tables from this point on. The MAF signal has a major influence on the ignition advance and fuel curve as this signal is the major component used by the ECU to calculate engine load (and in turn the fueling and ignition calculations).

The OEM Subaru boost control system employs a closed-loop, targeting system for tuning boost. You must first establish your boost targets in the Boost Targets table. The values in the Boost Targets table are in relative pressure, Bar or Psi. Running these boost targets is going to be the primary goal

for the ECU. The ECU will start off with using the wastegate duty cycles established in the Wastegate Duty Cycles (Low & High) table(s). Some Subaru ECUs use a single Wastegate Duty Cycles table and some use two, Wastegate Duty Cycles Low and Wastegate Duty Cycles High. If your ECU uses the Low and High Wastegate Duty Cycles tables we suggest you set your Wastegate Duty Cycles Low table ~8% lower than the Wastegate Duty Cycles High table for the corresponding Throttle Position and RPM cells. We have composed a worksheet called the "[AccessTUNER Calibration & Tuning Guide Worksheet for MAZDASPEEDs v1.XX](#)" which has various tabs set up to assist you with the Low and High WGDC calculations. The ECU will then use the Turbo Dynamics tables to adjust the wastegate solenoid duty cycle in order to achieve the dictated boost target. Other compensatory boost and wastegate tables are also used by the ECU to fine tune boost for environmental changes, temperature, barometric pressure, etc. Although, these tables should not need to be modified when using the stock boost control solenoid. If the wastegate duty cycle values are too low, you will not achieve your target boost pressure. If the wastegate duty cycle values are too high, you will overshoot your boost targets and potentially damage the engine. We do not suggest you run a wastegate duty cycle of more than 95% to prevent overheating or lock-up of the wastegate solenoid, and to promote the longevity of the wastegate solenoid.

While tuning the boost control system you will want to datalog and/or view your RPM, Throttle Position, Wastegate Duty Cycle (WGDC), Relative Pressure, and Turbo Dynamics values so you can see what your ECU is actually doing to achieve its boost targets. The further your turbo dynamics value is from zero, negative or positive, the further away your engine is from achieving the dictated boost targets. Your boost targets are either too high or too low for that particular RPM and TPS point to achieve your boost target or your wastegate duty cycles are not close enough to where they need to be in order to achieve your boost targets. We suggest you tune so that your turbo dynamics value is a small positive number (8 or less for the DBC 2.0L vehicles, 100 or less for the DBW 2.5L vehicles) across the RPM range. We suggest you tune your boost control tables in this manner so that if you accidentally overload the engine (with additional passengers, going uphill, towing, flooring the car in higher gears at lower RPM, etc.) you have some protection against over-boosting.

If your datalogged turbo dynamics value is a negative value then your ECU will remove wastegate duty cycles to hit your boost targets because the engine is over-boosting; the pressure measured at your intake manifold is higher than what is dictated in the Boost Targets table for the given RPM and TPS values. If your boost is surging up and down or then your boost control is searching because it is grossly overshooting its target. If your datalog shows a negative value for turbo dynamics then the ECU will use the additional authority in the negative portion of the Turbo Dynamics tables to lower WGDC until the target boost is achieved.

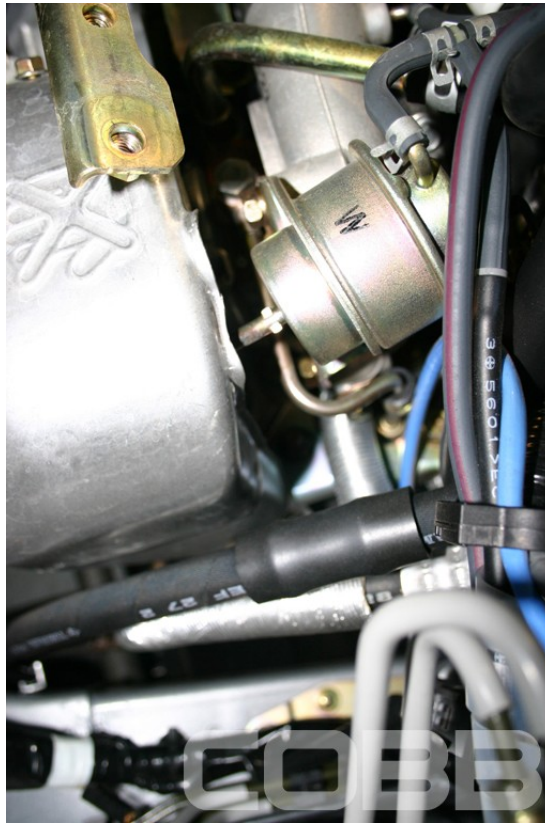
If your datalogged turbo dynamics value is positive value then your ECU will add wastegate duty cycles to hit your boost targets because the engine is under-boosting; the pressure measured at your intake manifold is lower than what is dictated in the Boost Targets table for the given RPM and TPS values. If your boost is lower than what is dictated in your Boost Targets table then you will need to increase your WGDC for the given RPM and TPS values. If your datalog shows a positive value for turbo dynamics then the ECU will use the additional authority in the positive portion of the Turbo Dynamics tables to increase WGDC until the target boosts are achieved.

If you are increasing or holding wastegate duty cycles steady and boost is dropping then you have most likely reached the threshold of the mechanical efficiency of the turbo or your exhaust gas back pressure prior to the turbo is too high and is forcing the wastegate valve to open.

If you are having a small boost spike you may need to decrease the WGDC percentage a few hundred RPM prior to the over boosting event to allow the exhaust energy to be released past the turbine wheel.

NOTE: With porting a wastegate, you are trying and make the wastegate valve function potentially work better which means that your turbo is going to lower boost super fast when the wastegate door/valve opens or not run as much boost as it was engineered to. If you make your wastegate react quicker then boost will be very difficult to stabilize and reach peak #s at an earlier RPM. If you make the wastegate flow better, then the exhaust energy your turbo needs to make and maintain boost will have less opportunity to flow across the turbine wheel. Generally speaking, air/pressure/exhaust gases will always flow along the path of least resistance. Not bashing, just trying to give you a different perspective.

The remainder of this document is intended to demonstrate how to measure the wastegate pre-tension using a vacuum pump. Your WG actuator arm may need to be adjusted (shortened for more pre-tension and lengthened for less pre-tension) in order to achieve proper wastegate actuator movement. These measurements are all static measurements which do not take into account the effects that exhaust gas back pressure prior to the turbo (temperature, exhaust restrictions, etc.) will have on the movement of the wastegate valve.



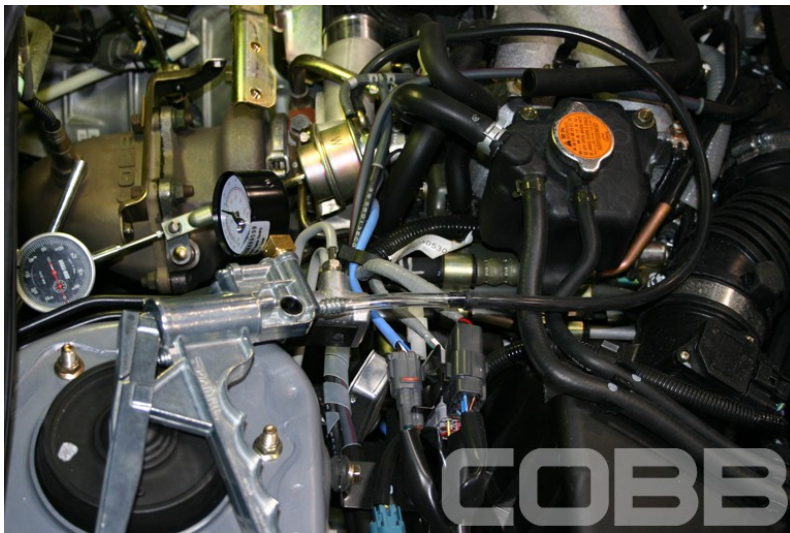
The wastegate actuator is the bronze item with the “W” stamped on it in the above picture.

While the turbo installed on the vehicle, we suggest you expose the wastegate actuator rod so you can easily see wastegate rod movement. Now you will need to remove the stock vacuum line which attached to the WG actuator. Replace this line with the vacuum line from your vacuum/pressure pump.

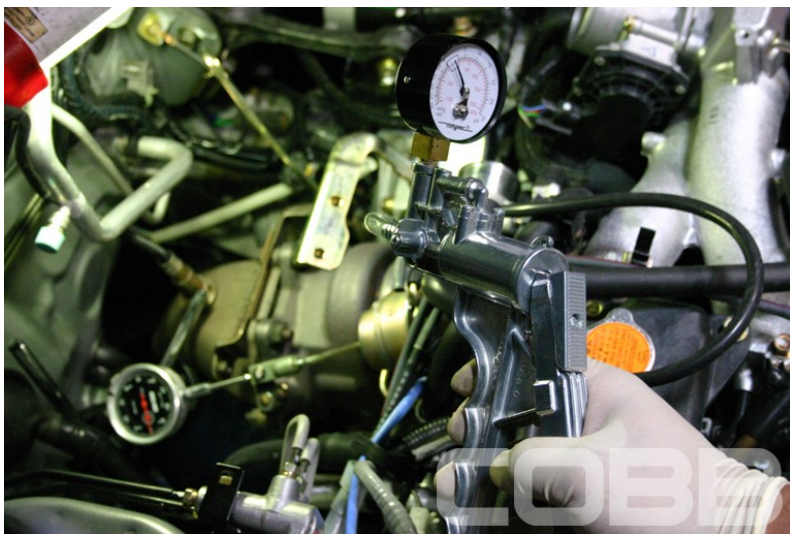


A standard Mityvac™ vacuum/pressure pump can be used.





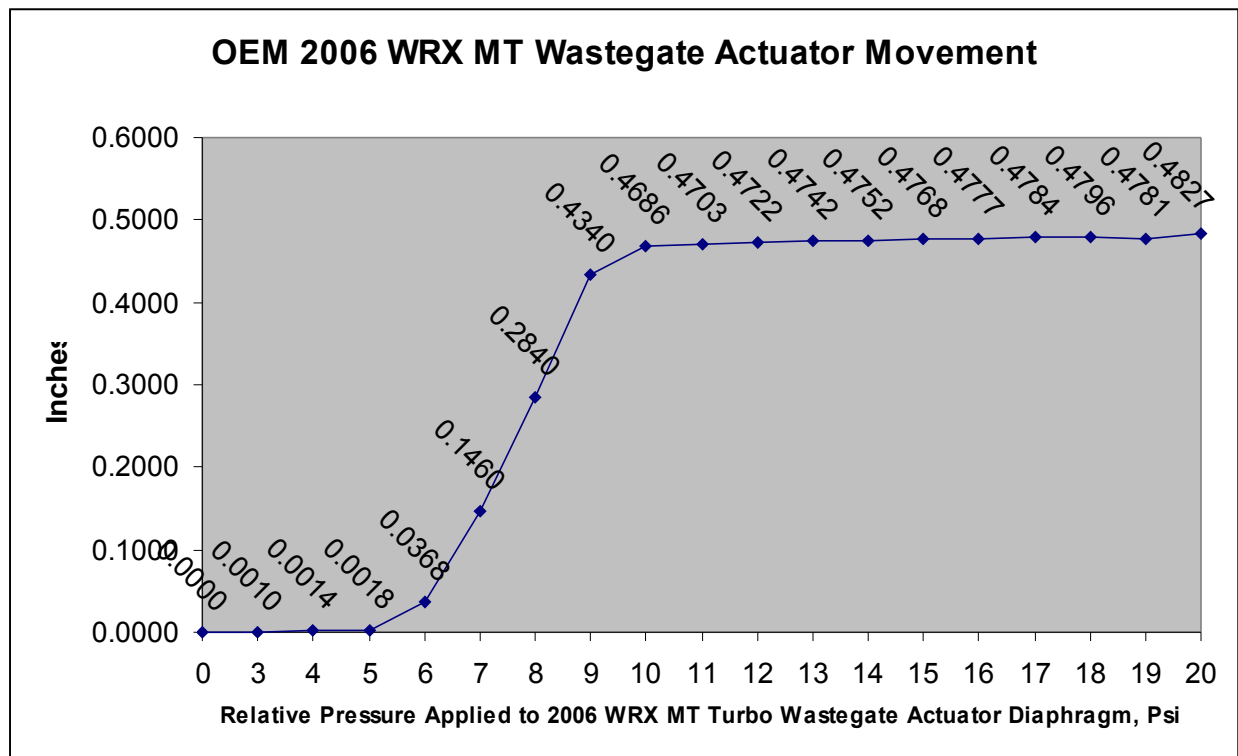
Plumb the vacuum line so it goes directly from the pump nozzle to the wastegate actuator nipple.



Be sure to set the pump so it is in pressure mode.



Now you can slowly pressurize the wastegate diaphragm; at some pressure level you will see the wastegate rod move. Below is a graph of the WG rod movement for a 2006 WRX MT.



As you can see the WG rod begins to aggressively move at ~7psi. The pre-tension measurement for the WG actuator would be ~7psi, which means if you connected this actuator directly to a high-pressure source on the turbo compressor housing, your vehicle would produce around ~7psi of turbo boost (manifold) pressure.

To summarize, you have several mechanical options for fine tuning your boost control system.

**Option 1 = Restrictor Pill Sizing**, you can change the size of the restrictor pill employed in your system.

- A smaller restrictor pill will allow the system to generate greater boost pressures with the same or less WGDC, the trade-off is that the smaller restrictor pills can potentially induce boost spikes. These spikes can sometimes be tuned out by greatly lowering WGDC a few hundred RPM before the boost spike occurs.

- A larger restrictor pill will force the system to use more WGDC to achieve boost, which makes the conditions safer when you lose a section of vacuum line and the turbo goes into an overrun condition.

**Option 2 = Wastegate Actuator Pre-Tensioning**, you can change the amount of pre-tension on your WG actuator.

- Creating greater pre-tension will allow the system to generate greater boost pressures with the same or less WGDC, the trade-off is that the greater pre-tension can potentially create a phenomenon known as “boost creep” by not allowing enough exhaust gas energy to by-pass the turbine housing. On rare occasions, this boost creep condition may be tuned out by greatly lowering WGDC or setting the WGDC to zero at higher RPM.

- A larger restrictor pill will allow the system to use more WGDC to achieve boost, which makes the conditions safer when you lose a vacuum line and the turbo goes into an overrun condition.

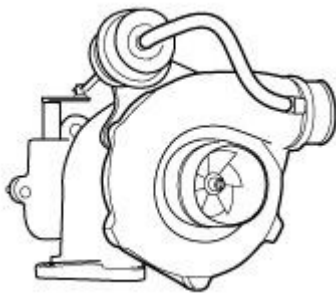
Below are the various plumbing diagrams for the different types of electronic boost control systems. We will start with the more common, internally wastegated system in which the wastegate assembly is a design element of the turbocharger itself. Subaru employees a bleed-type boost control system (as opposed to an interrupt type) for controlling the internal wastegated systems. The logic present in the Subaru ECU is capable of tuning either internally or externally wastegated systems as long as they are properly set up. Please refer to the below diagrams to make sure your boost control system is mechanically set up in the proper manner.



Prodrive EBCS Port Diagram

The operating voltage for most EBC solenoids is usually 12 Volts, and the polarity is unimportant since the solenoid will require +12V power and the other wire is grounded by the ECU. When the Prodrive solenoid is energized, ports 1 & 2 are connected allowing air to flow between them; when de-energized, ports 2 & 3 are connected allowing air to flow between them. Please take this port diagram into account when reading the below plumbing instructions.

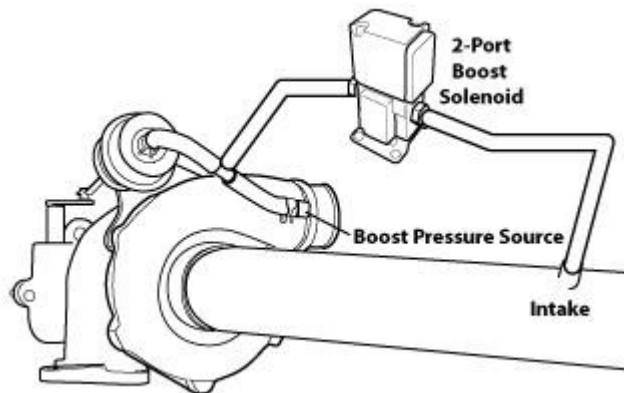
NOTE: As a rule of thumb, you can generally only create turbo boost pressure which is twice your mechanical wastegate spring pressure through electronic wastegate manipulation. In other words, if you have a 7psi wastegate spring (in your external wastegate) or you have internal wastegate that is pre-tensioned to 7psi then you should only be able to create around ~14psi of peak boost pressure by locking down your EBCS @ 100% WGDC. Of course, your actual results may vary based on how well you have located your external wastegate, or how well the internal wastegate is ported, what size of restrictor pill you are using, what your turbine A/R is, etc.



#### Basic Internal Wastegate Set-up

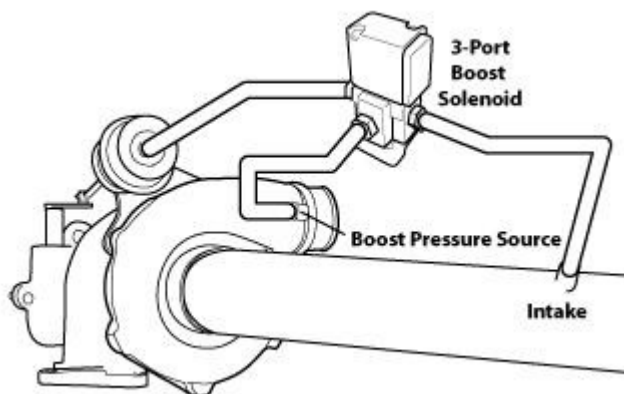
For basic mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to the wastegate actuator nipple. This set-up uses no electronic boost control solenoid and will force the turbo to run on minimum, mechanical wastegate spring pressure.





### 2-Port EBCS Internal Wastegate Set-up, Bleed-type (used on the stock FI MAZDASPEEDs, Subarus, and EVOs)

For the mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to a vacuum T. The opposite side of the vacuum T will be plumbed to the wastegate actuator nipple. A 3<sup>rd</sup> vacuum line plumbs the middle of the T-fitting to port (1) of a 2-port wastegate solenoid valve. A 4<sup>th</sup> vacuum line will need to be plumbed from port (2) of the 2-port wastegate solenoid valve to the intake system, prior to the compressor inlet and after the air filter. This set-up uses a 2-port electronic boost control solenoid valve to bleed of air from the wastegate actuator. This set-up commonly uses a restrictor pill which is located in the vacuum line just off the compressor housing before the T-fitting.



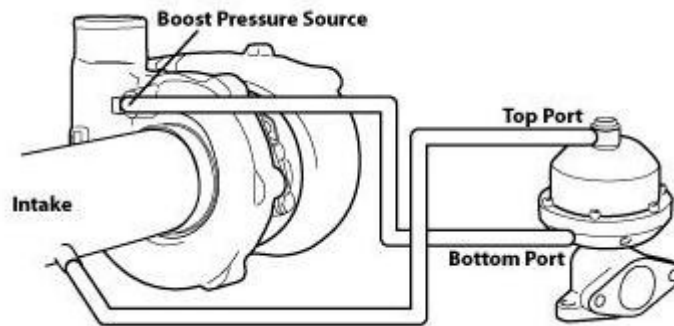
### 3-Port EBCS Internal Wastegate Set-up, Interrupt-type

For the mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to the pressure inlet port. If you blow through this port you should notice that air is coming out of one of the other two ports. Attach a 2<sup>nd</sup> vacuum line from the port which air comes out to the intake system, prior to the compressor inlet and after the air filter. A 3<sup>rd</sup> vacuum line should be connected from the 3<sup>rd</sup> port of the solenoid to the wastegate actuator. This set-up uses a 3-port electronic boost control solenoid valve to interrupt the air stream to the wastegate actuator. This set-up usually does not employ a restrictor pill which is located in the vacuum line just between the compressor housing and the solenoid valve, although a restrictor pill can be used here to help increase minimum WG pressure. **WARNING!** This set-up will increase the minimum boost pressure which is expected to run. We suggest you set all WGDC settings to zero so you can test your new minimum boost pressure achieved by this method of connection.



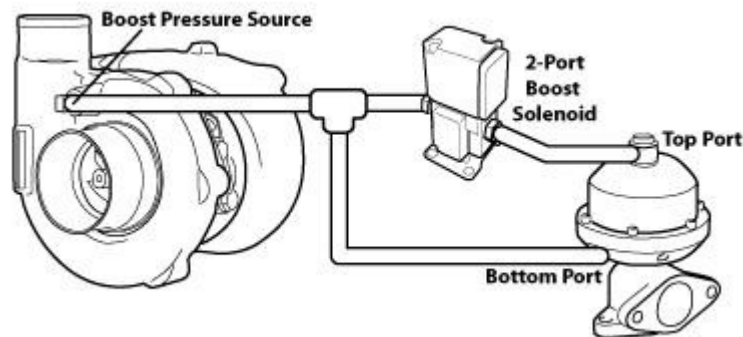
### !!!IMPROPER Internal Wastegate Set-up!!!

Having no pressure source vacuum lines attached to the wastegate actuator will force the wastegate valve to stay shut until the exhaust gas back pressure forces the wastegate valve open, which usually occurs at dangerously high boost levels.



### Basic External Wastegate Set-up

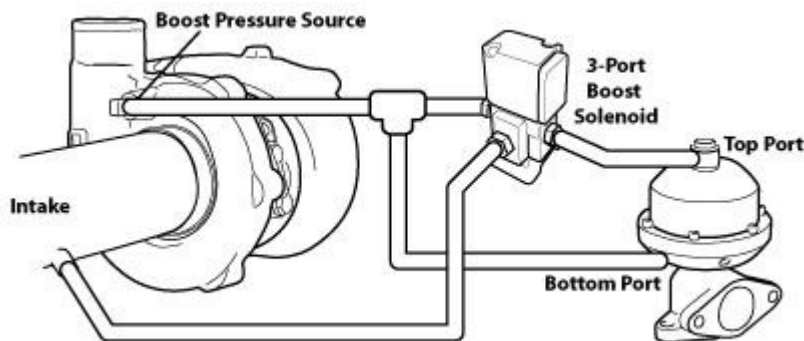
For basic mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to the bottom port of the external wastegate. A second vacuum line should be plumbed from the top port of the external wastegate to the intake system, prior to the compressor inlet and after the air filter. This set-up uses no boost electronic boost control and will force the turbo to run on minimum, mechanical wastegate spring pressure.



### 2-Port EBCS External Wastegate Set-up

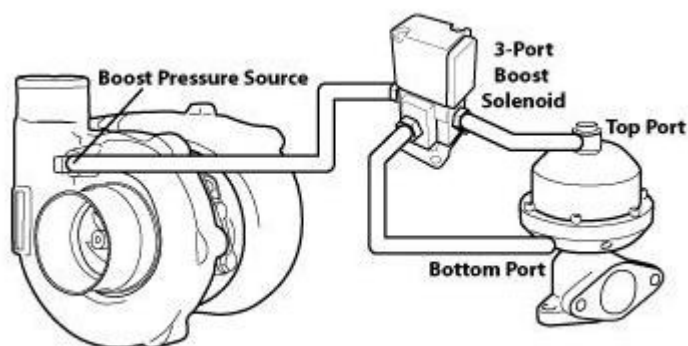
For the mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to a vacuum T. The opposite side of the vacuum T will be plumbed to port (1) of the 2-port wastegate solenoid valve. A 3<sup>rd</sup> vacuum line plumbs the middle of the T-fitting to the bottom port of the external wastegate. A 4<sup>th</sup> vacuum line will need to be plumbed from port (2) of the 2-port wastegate solenoid valve to the top port on the external wastegate. This set-up uses a 2-port electronic boost control solenoid valve to manipulate the air pressure going to the top port of the external wastegate.

**WARNING!** This set-up will increase the minimum boost pressure which is expected to run. We suggest you set all WGDC settings to zero so you can test your new minimum boost pressure achieved by this method of connection.



### 3-Port EBCS External Wastegate Set-up Option 1

For the mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to a vacuum T. The opposite side of the vacuum T will be plumbed to port (1) of the 3-port wastegate solenoid valve. A 3<sup>rd</sup> vacuum line plumbs the middle of the T-fitting to the bottom port of the external wastegate. A 4<sup>th</sup> vacuum line will need to be plumbed from port (3) of the wastegate solenoid valve to the intake system, prior to the compressor inlet and after the air filter. The final and 5<sup>th</sup> vacuum line will need to be plumbed from port (2) of the 3-port wastegate solenoid valve to the top port on the external wastegate. This set-up uses a 3-port electronic boost control solenoid valve to manipulate the air pressure allowed to reach the top port of the external wastegate.



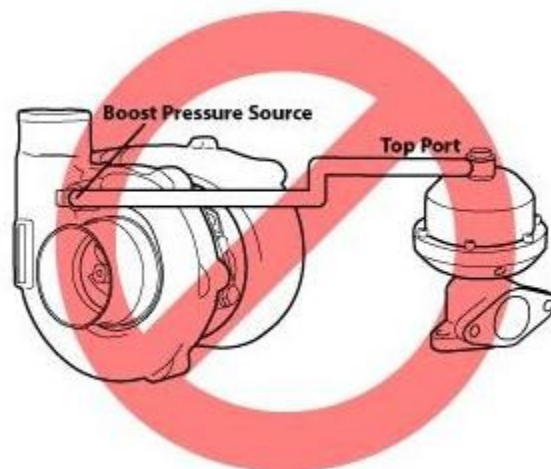
### 3-Port EBCS External Wastegate Set-up Option 2

For the mechanical set-up you will need one vacuum line plumbed from the turbo compressor housing (pressure source) to port 2 on the 3 port wastegate solenoid valve. A 2<sup>nd</sup> vacuum will need to be plumbed from port (1) to the top port on the external wastegate. A 3<sup>rd</sup> vacuum line plumbs port 3 to bottom port of the external wastegate. This set-up uses a 3-port electronic boost control solenoid valve to manipulate the air pressure going to the top port of the external wastegate. **WARNING!** This set-up will *significantly* increase the minimum boost pressure which is expected to run. We suggest you set all WGDC settings to zero so you can test your new minimum boost pressure achieved by this method of connection.



**!!!IMPROPER External Wastegate Set-up !!!**

Having no vacuum lines attached to the external wastegate will force the wastegate valve to stay shut until the exhaust gas back pressure forces the wastegate valve open, which usually occurs at dangerously high boost levels.



**!!!IMPROPER External Wastegate Set-up 2!!!**

Having only one pressure source vacuum lines attached to the top port of the external wastegate will force the wastegate valve to stay shut until the exhaust gas back pressure forces the wastegate valve open, which usually occurs at dangerously high boost levels.

V1.01