CorkSport Mazdaspeed Electronic Boost Control Solenoid

White Paper

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Introduction

Need a faster and more precise method to control boost pressure? CorkSport is proud to announce the release of the Electronic Boost Control Solenoid (EBCS) designed specifically for the DISI MZR platform. The CorkSport EBCS is engineered to fit like OEM and outperform any other EBCS on the market today. Utilizing the latest technology in solenoid actuated valves, the CorkSport EBCS can actuate with mili-second precision.

Boost Control Basics

In order to understand what an EBCS is and what it does you need to know some turbocharger and forced induction terminology.

Anatomy of the Turbocharger

The most common terms are turbocharger, turbine housing, compressor housing, center section, waste gate, boost bypass valve (BPV), and of course the EBCS.

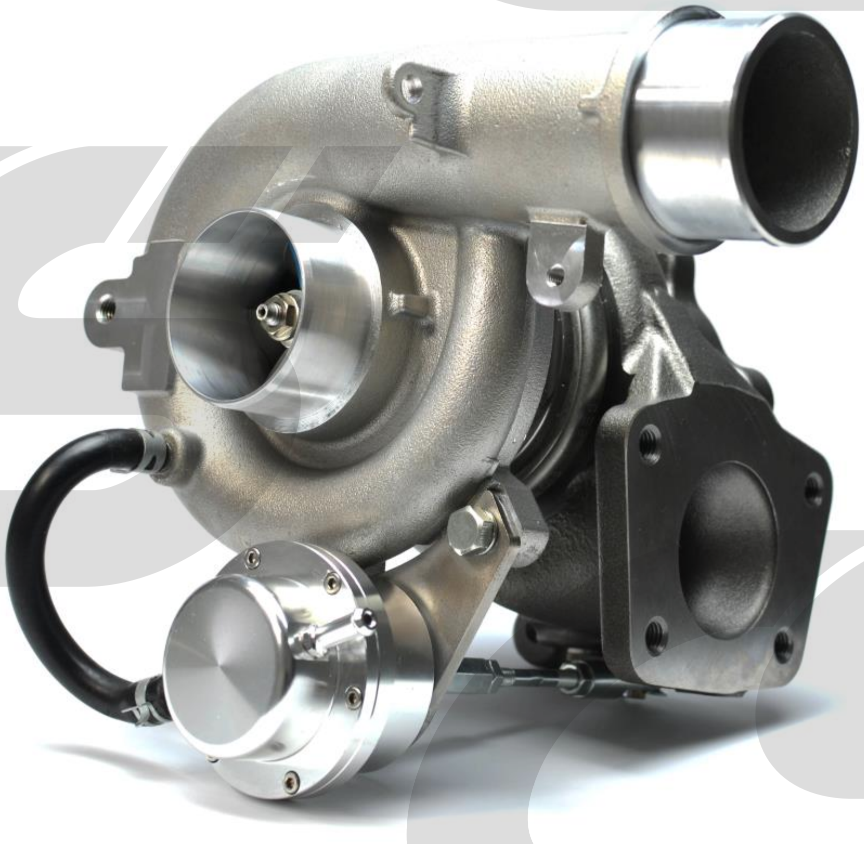
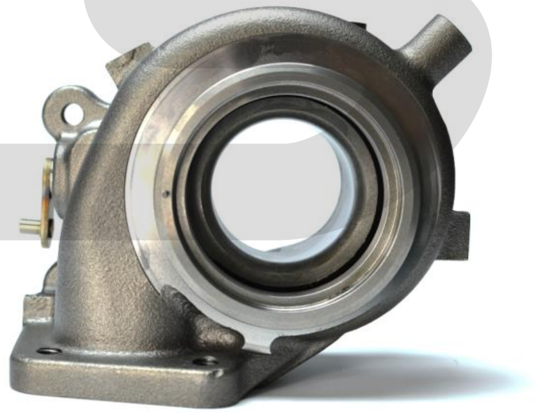


Figure 1: Assembled turbocharger

Turbine Housing – Exhaust gases flow through this housing from the exhaust manifold and are forced through the turbine wheel. This converts the thermal fluid energy of the exhaust gas into mechanical shaft energy.



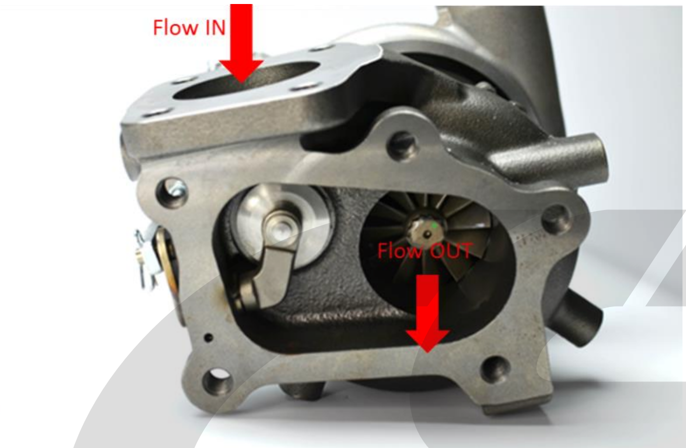


Figure 2: Turbine housing cartridge side (left) and outlet side assembled (right).

Compressor Housing – Clean atmospheric pressure air is pulled into this housing and then compressed by the compressor wheel. The mechanical shaft energy is converted back to fluid energy as pressurized (boosted) air.

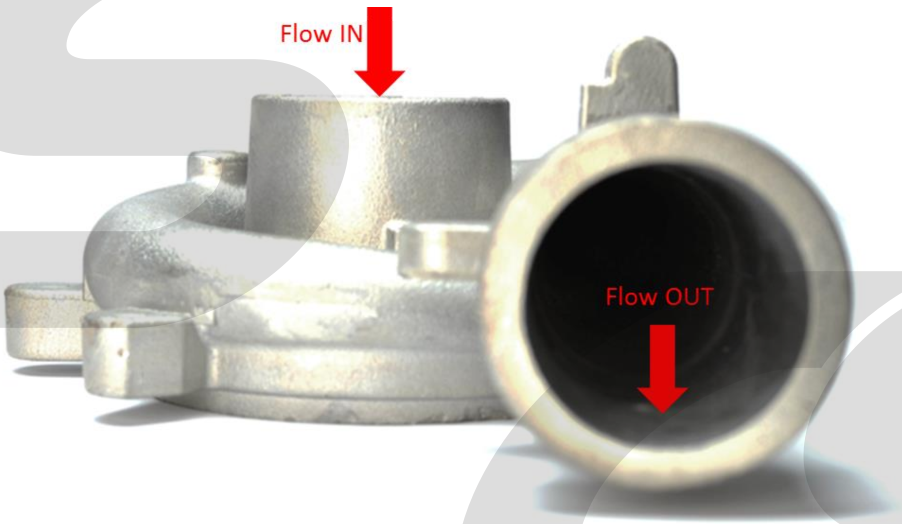


Figure 3: Compressor housing before finish machining.

Center Section – The center section contains the lubrication, coolant, bearing, and shaft which are connected to the turbine and compressor wheels.

Figure 4: Assembled turbocharger center section.

Wastegate – Exhaust gas control valve used to control the amount of exhaust gas going through the turbine housing and wheel.

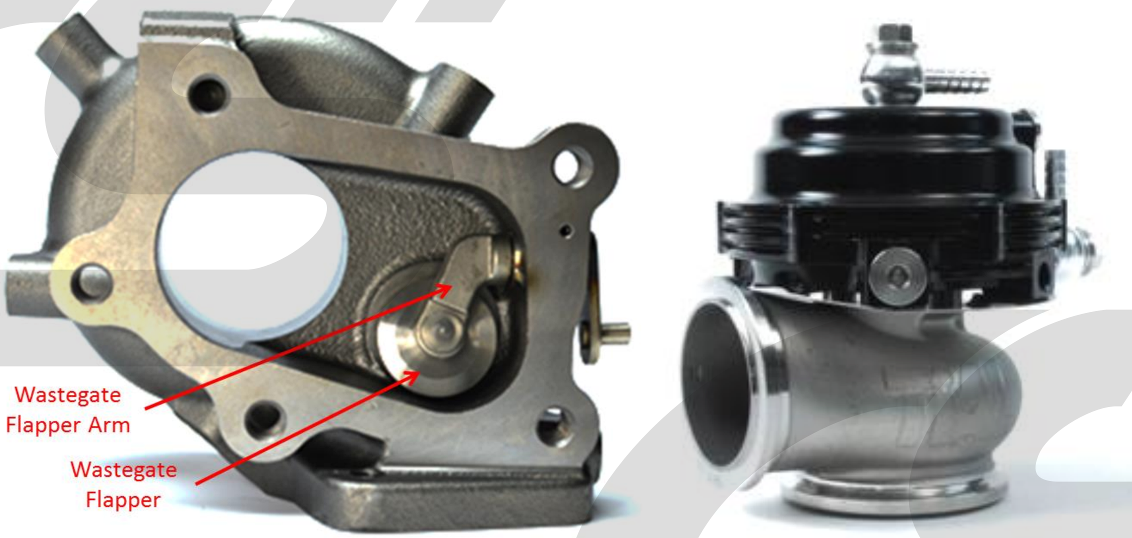


Figure 5: Typical internal wastegate design (left) and typical external wastegate design (right).

By-Pass Valve (BPV)/Blow Off Valve (BOV) – The BPV/BOV is a safety valve that opens when the post compressor intake tract becomes over-pressurized. The BPV vents directly into the intake tract post MAF and pre compressor inlet, whereas the BOV vents to atmosphere. Neither the BPV nor BOV directly control boost pressure.

Figure 6: Typical BPV/BOV found with forced induction engines.

Electronic Boost Control Solenoid (EBCS) – The EBCS actively controls the wastegate based on the current measured boost pressure. Controlling the wastegate regulates how much exhaust gases goes through the turbine wheel, therefore controlling the compressor RPM and boost pressure.

Figure 7: Assembled EBCS with 3-port configuration.

The Purpose of Boost Control

Whether you are using an internal or external type wastegate, the wastegate will have a spring inside to keep the wastegate from opening until a specific boost pressure. Now what if you want more boost pressure than the spring will allow? This is where the boost controller comes in. The EBCS is controlled by the engine control unit (ECU) via a voltage signal which opens and closes the valve. The percent time that the valve is open is called the duty cycle (DC), therefore if the ECU signals the valve to be open 30% of the time that is called a 30% DC. This is not to be confused with the solenoid's operating frequency which happens to be in the 5-30hz range for OEM and is controlled by the ECU based on RPM. The frequency is how many times it can operate in 1 second, referred to as hertz (Hz).

So how does the EBCS actually control the boost pressure? In order for the wastegate to be actuated, the wastegate must get a boost signal to overcome the spring pressure. The EBCS is the "boost signal control valve" in the system. The ECU reads boost pressure via the manifold absolute pressure (MAP) sensor to determine the duty cycle for the EBCS. A 0% duty cycle will allow boost pressure to the wastegate actuator effectively opening the wastegate and lowering the boost pressure to whatever the wastegate spring is set at. A 100% DC will stop boost pressure to the wastegate actuator effectively closing the wastegate and increasing the boost pressure until the target boost value is reached. The EBCS is setup this way as a failsafe; if the EBCS loses signal then the boost pressure will be controlled by the wastegate spring.

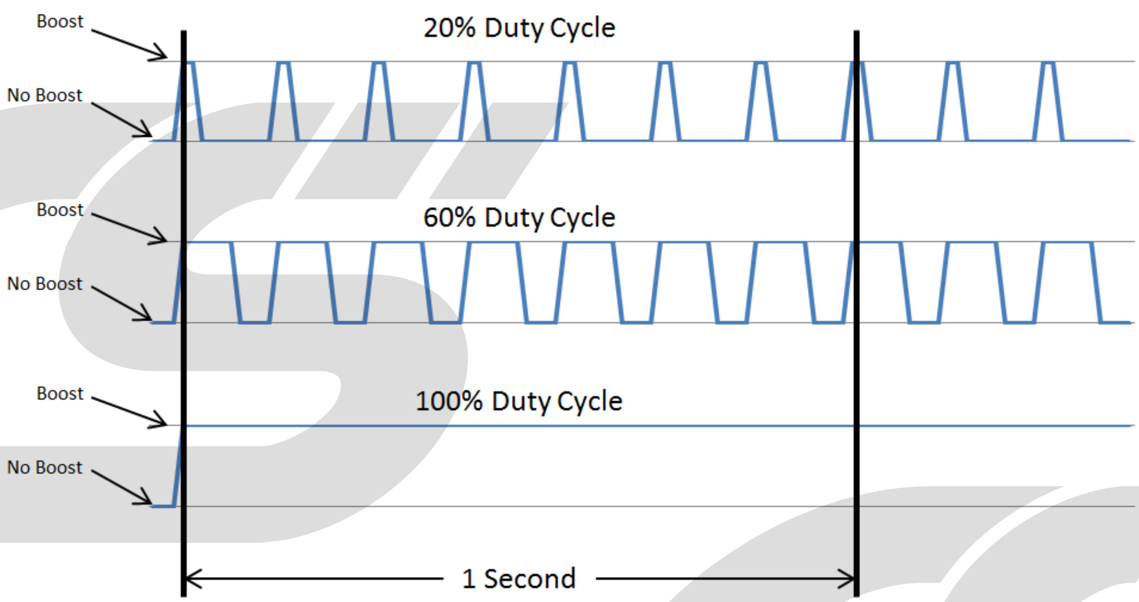


Figure 8: Diagram to demonstrate duty cycle control at 7Hz.

The rate at which the ECU changes the duty cycle is very fast and the rate is never constant while it is determining the target boost pressure. There are many readings that the ECU references to determine the duty cycle such as air inlet temperature boost air temperature, throttle position, engine load, engine knock, and many more.

Boost Control Setups

The boost control system is most commonly setup in one of three methods: bleed, interrupt, and external push/pull. Each has its pro's and con's which are discussed below.

Bleed Type

The bleed type setup is most commonly found on OEM applications because it is brutally simple and very cost effective. However is lacking from a performance standpoint. OEM applications also use this because it is slower which makes it easier to control and if the valve ever fails you will get much lower boost. For bleed type the EBCS is incorporated into the system via a T-connection (the wastegate actuator in this case); this setup typically has a slower response time then the interrupt and external setups therefore it is less effective at regulating the boost pressure.

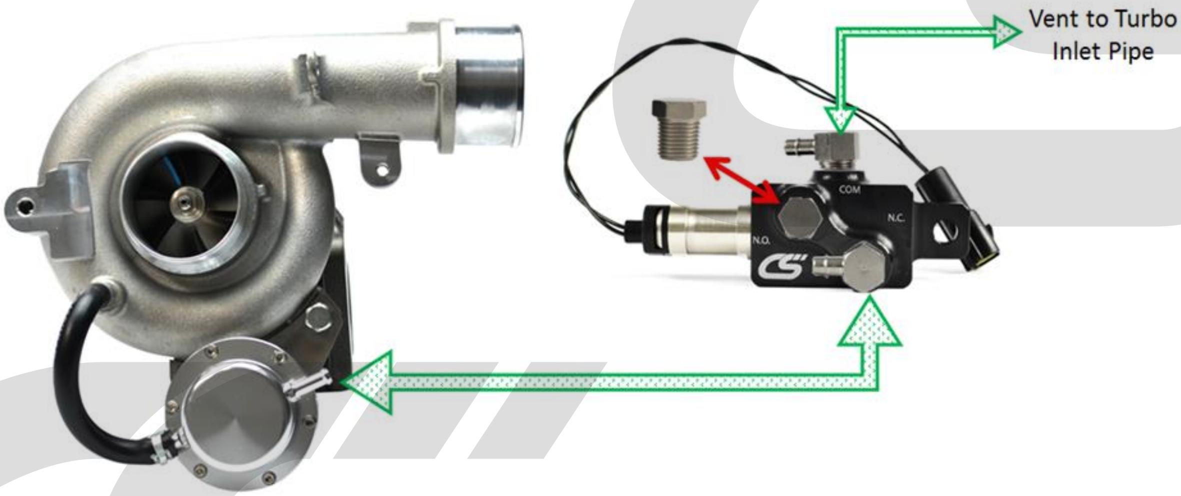


Figure 9: Hose routing for bleed type setup.

When using the OEM EBCS, the duty cycle can be maxed out to 100% and still not provide the desired boost pressure. This situation results in unwanted power loss because the EBCS cannot do its job. This is very common when power adding modifications are done to the vehicle such as an accessport, intake, and exhaust.

Interrupt Type

The interrupt type setup is similar to the bleed setup, but far more effective and faster at regulating the boost pressure. The difference is in the routing of the pressure hoses. In the interruption type setup the EBSC replaces the T-connection and therefore “interrupts” the boost signal instead of just bleeding air from it.

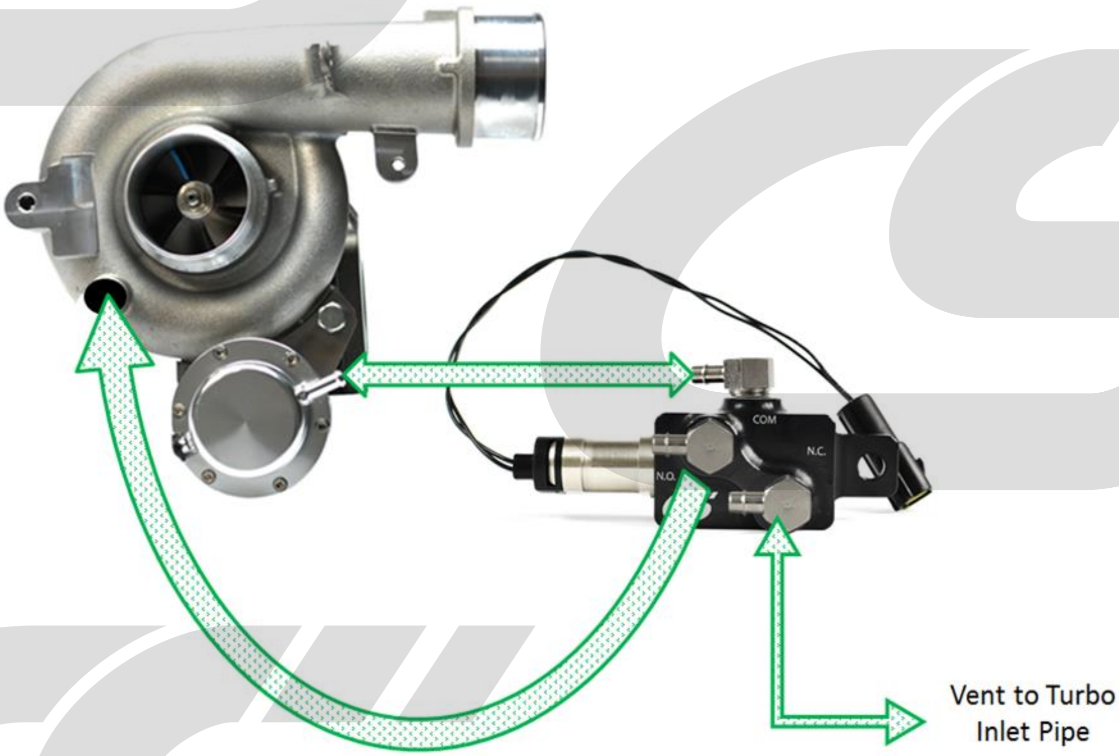


Figure 10: Hose routing for interrupt type setup.

This is the fastest option for an internal wastegate setup because it completely blocks the pressure going to the wastegate. The interrupt setup also has a faster response time and it cannot be maxed out like the bleed setup. With all boost control setups, there is one catch though; eventually the exhaust gas drive pressure will over power the spring pressure and begin opening the wastegate. This can happen when trying to run lower boost on large turbochargers or from mechanical designs in the wastegate system. This is called boost creep and the only fix for this is to mechanically modify the wastegate actuator.

External Push/Pull Type

The use of an external wastegate is not as common and is typically used when substantial power is the goal. An external wastegate can be setup as a bleed or interrupt type, but those setups do not take advantage of the dual port design common in external wastegates. With that being said, a correctly set up dual port external wastegate along with the CorkSport EBCS can provide a more reliable and efficient setup than the interrupt type.

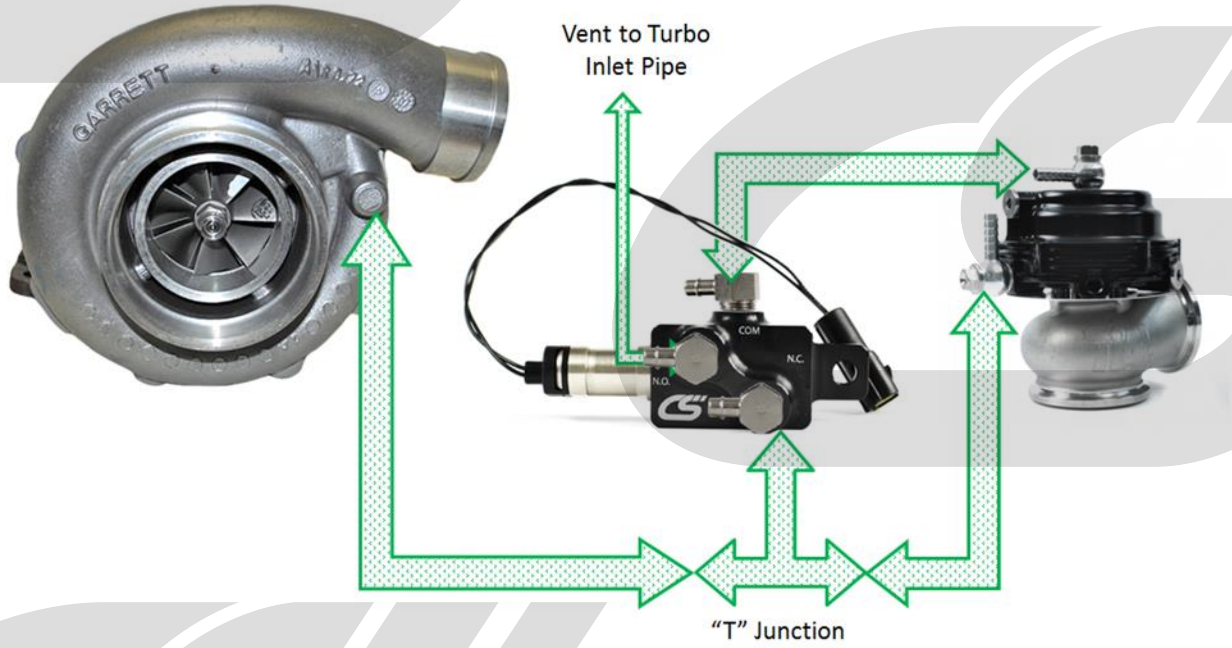


Figure 11: Hose rounting for an external wastegate push/pull type setup.

To take full advantage of an external wastegate the push/pull type setup must be utilized. With the push/pull type setup, both ports on the wastegate are connected to the EBCS. While the EBCS is closed (0% DC) the boost signal is only sent to the lower port, forcing it open at spring pressure. While the EBCS is open (1%-100% DC) the boost signal is sent to the lower and upper port causing the valve to open with higher and higher boost. As long as the wastegate valve is large enough, boost creep is no longer an issue now that you can control the boost pressure to both the upper and lower ports. The more boost you create the harder you can push the wastegate closed. The only job of the spring is to give the upper chamber a pressure advantage; therefore you can run a very light spring (like 10PSI) and still be able to create 30+PSI. However, it is recommended to run spring pressure at 50-75% of you peak boost target.

The CorkSport EBCS

Designed for the DISI MZR

Unlike other options available for the DISI MZR platform today the CorkSport EBCS is designed specifically for the MZR. There are no additional brackets to mount it and it comes wired with an OEM plug for flawless integration. The solenoid manifold is manufactured from 6061-T6 aluminum and anodized to resist corrosion.

Figure 12: CorkSport EBCS with OEM electrical connector.

The one piece manifold design can be mounted in the OEM location when using the OEM or similar turbocharger and can also be mounted in the valve cover valley for the big turbo cars with a top mount intercooler or front mount intercooler. To accommodate both daily drivers and racing, the CorkSport EBCS manifold is compatible with both NPT and AN- fittings.

The Bullet Valve

The bullet style solenoid valve is the latest technology in high flow fast response fluid controls. So what separates the bullet valve from the many other solenoid actuated valves available in the market today?

1) Cylindrical profile allows flexibility in manifold design
2) Operating frequency up to 1000Hz
3) Energizing response time of 700µs (0.0007sec)
4) De-energizing response time of 600µs (0.0006sec)
5) Pressure balanced valve

What does this really mean in a boost control application? 1. The manifold was designed specifically for the MZR platform without compromise. 2. The actuating frequency of the solenoid is RPM dependent therefore ranges from 0 – 58Hz if the redline is 7000RPM. There is a problem with this though; the OEM solenoid has an operating frequency of 5 – 30Hz. This is part of the reason why the OEM solenoid can be overpowered in high RPM high boost situations. The bullet valve isn't breaking a sweat at 58Hz. 3. The bullet valve response time and pressure balance piston design are what truly separate the

CorkSport EBCS from the competition. These two features work together to create a perfect control valve and here's why:

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Figure 13: Bullet valve operation.

The response time is a measure of how fast the valve can open or close. With a non-balanced design, such as the OEM solenoid, the response time is dependent of the pressure it is trying to control. As the pressure increases the response time will increase proportionally. This is not the type of variance conducive to tuning or driving a vehicle. This makes for a very unpredictable setup which can be dangerous to the vehicle's engine. The bullet valve's balanced design eliminates this issue; from vacuum to 120psi the response time will never vary.

To accurately compare the OEM EBCS to the CorkSport EBCS boost pressures were logged:

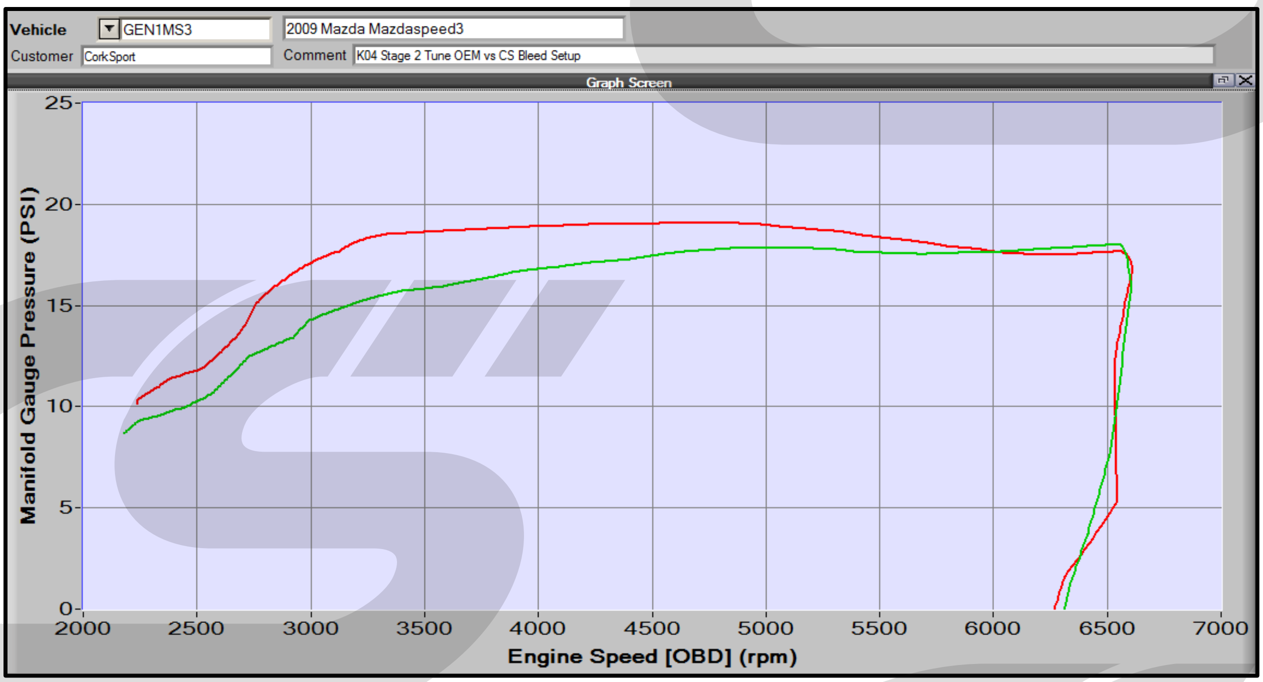

Figure 14: Bleed type setup boost pressure from K04 turbo; OEM EBCS (green) vs CorkSport EBCS (red). The downward taper in the red curve after 5000rpm is a result of tuning, not the efficiency of the CorkSport EBCS.

Tuning

The CorkSport EBCS does require the use of an aftermarket tune and Accessport (or other tuning device). Due to the increased efficiency of the CorkSport EBCS, the EBCS should not be operated without making tuning corrections. Over boosting will occur which can destroy the engine. It is recommended to start with wastegate duty cycles 25% lower for bleed and 40% lower for interrupt setups. If a push/pull external wastegate setup is used, contact a professional tuner for recommendations.

Conclusion

Whether this is the first aftermarket component added or adding to your heavily modified Mazda, the CorkSport EBCS will improve overall performance. The 6061-T6 aluminum manifold is durable and looks great in both MZR specific mounting locations. The CorkSport EBCS is backed by genuine customer service and a one year limited warranty.