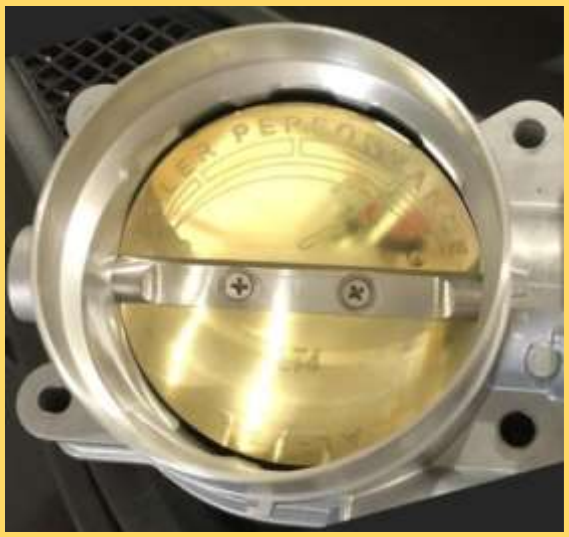
W A Technology

Soler Throttle Body "WHY & HOW TO" Install in Grand Sport



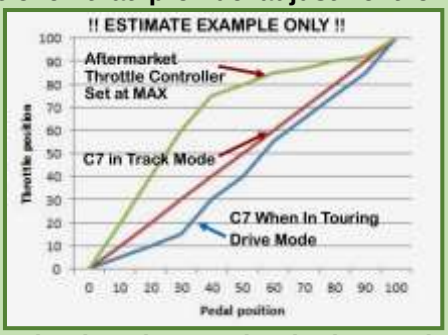
Since "HOW TO" is easy, we'll start off with "WHY TO" Install a Soler Modified Throttle Body!

There Are Two Issues Related to Throttle Response

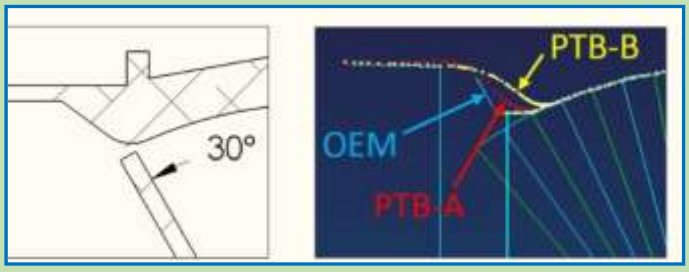
As the Owner's Manual defines, the C7 varies the amount the throttle butterfly opens versus the amount the throttle pedal is depressed from "slow" in Weather Mode to more linear in Sport and Track.

For Touring Mode, the fly-by-wire in the C7 appears to be set so a 15% throttle pedal depression only opens the throttle butterfly about 7%. That is a slow tip-in making the car easier to control in traffic. When in Sport and Track Mode the C7 offers a more aggressive, more linear throttle body butterfly movement with pedal movement.

There are aftermarket devices, like the Vitesse Throttle Controller that provide adjustment of throttle movement from an OEM setting to very aggressive where when the pedal is depressed 45% the throttle is opened 75%. In fact, I added a Vitesse to my Grand Sport since I was driving in Touring mode and felt the slow tip-in compared to the 3½ years I had driven my 2014 Z51 non-MRC always in Sport or Track (for the other benefits and aggressive throttle response.) It was a help. Could feel the difference particularly when talking off from a stop. When I got the Grand Sport MRC software update I now drive in Sport and the C7 response is about the same as my the Vitesse controller 4/5 setting!



A "tuner" posted he drove a Z51 and documented with a data log the throttle mapping in the stock ECM calibrations lags behind pedal movement. He modified with a "tune" and the lag was gone. His data log showed the throttle plate movement was following pedal movement very closely.



Mike from Soler responded in a post, stating in in addition to working better though all throttle positions, where the butterflies work on a contoured Throttle Body surface *(pic left,)* the Soler modified Throttle Body works better to control tip-in than a "tune," aftermarket throttle controllers or other modified throttle bodies they have tested. Note: a "tune" can increase power at larger throttle openings to WOT by changing timing and air/fuel ratio. An aftermarket throttle controller does not increase power. The Soler Modified Throttle Body has some increased power effect due to reduced throttle shaft restriction, polishing surfaces and other throttle body shape modifications. BUT a "tune" that changes the ECM programing will void a warranty. A throttle body modification nor an aftermarket controller do not.

In the following picture/text overview I'll try to explain what's occurring followed by my installation.

Photo/Text Details

CHOKED FLOW

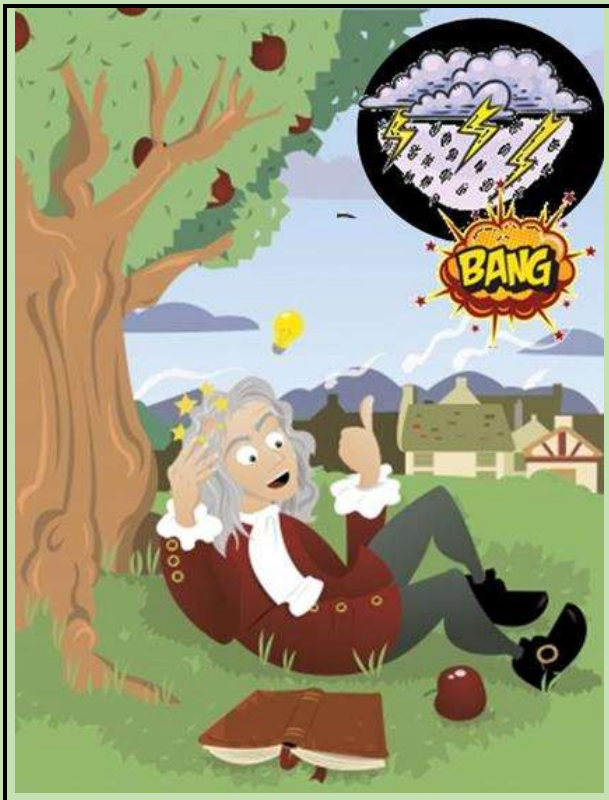
To help appreciate the benefits the Soler Modified Throttle Body can achieve, understanding "Choked Flow" is useful.

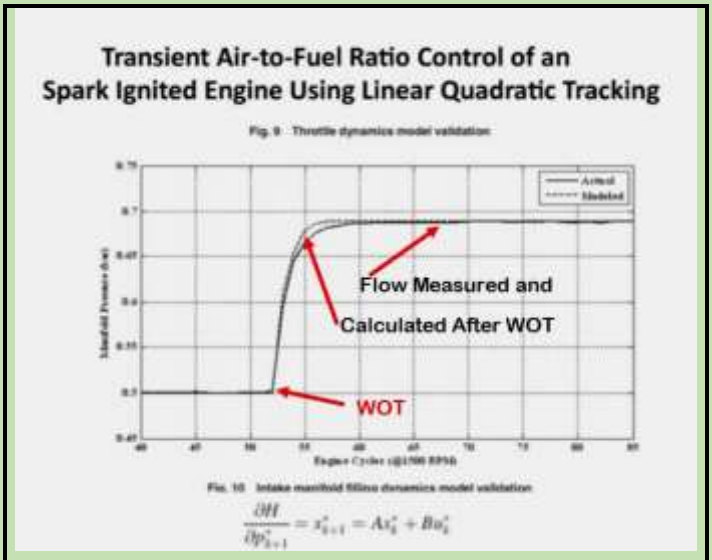
Sir Isaac Newton (the dude with the falling apple) measured the speed of sound fairly accurately in the 1700rds (~770 mph.) He would understand how choked flow works - *You Can Too!*

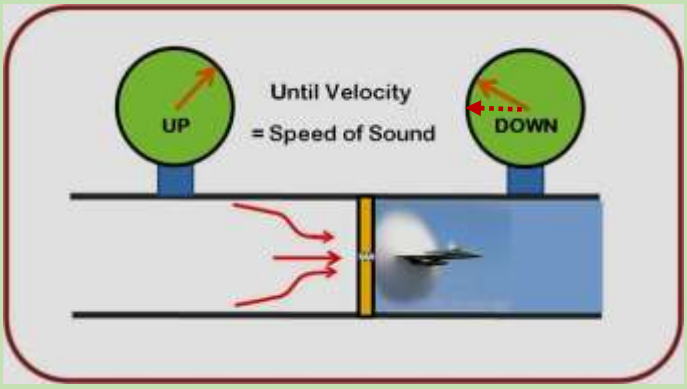
It's related to why you see lightening before you hear thunder! Light travels about 1 million times faster than sound! "Choked Flow" relies on the fact that *the speed of a gas through the passage like a throttle body (especially at small throttle plate opening) cannot exceed the speed of sound!*

Even if the Throttle butterfly opened with "Zero Delay" the pressure wave coming from inside the manifold through the throttle body to signal for more air flow only travels at the speed of sound!

The only way to get the flow rate somewhat higher, for a given pressure/opening size, is with a contoured intake and exit shape (google *"converging-diverging nozzle"* to see how air speed can exceed the speed of sound!)







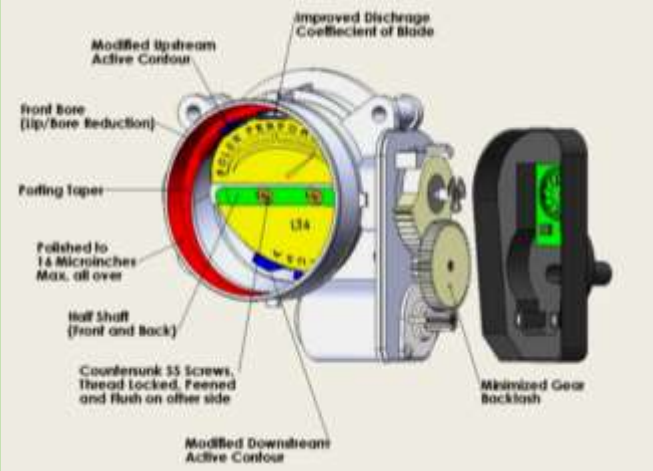
Flow Rate Controlled by The Speed of Sound

The flow rate after the butterfly's opened fully (WOT) was measured, calculated and presented in a 2014 ASME technical paper (pic top left.) As noted, it takes a finite time for the air velocity to increase to the maximum flow rate based on the pressure differential and size of opening. So, opening the Throttle faster with a Vitesse Throttle Controller, etc. or a "Tune" can help BUT can't counter that the flow will take time to increase, it's not instant!

My Internet welding related business (lower pic) relies on the maximum gas flow through a square edged orifice being at the speed of sound "regardless" of the downstream pressure, called "choked flow." ***BUT*** if the orifice opening is shaped like a cone and the exit a reverse cone (converging-diverging) the speed can increase above the speed of sound!

Recall years ago, asking a Professor in a fluid flow class, why square edged orifice flow does not increase when the downstream pressure decreases? He presented this nontechnical answer saying: *"It would **IF** the higher upstream pressure knew the downstream pressure was lower. But that pressure wave signal can only travel at the speed of sound, so it takes time for **"it to know!"*** Not technical BUT helps me remember why the flow in a square faced orifice is limited to the speed of sound! That flow volume is based only on the upstream pressure and orifice size (*once the upstream pressure is 2.1 time greater than that downstream.)*

Modified/Optimized Soler Throttle Body



What Soler Does:

- Modifies upstream and downstream contours to improve what are called discharge coefficients and increase flow starting from idle.
- Contours front lip to help Max flow
- Narrows center shaft to increase Max flow- peens screws for security.
- Polishes to 16 microns max all over
- Minimizes gear backlash

This Achieves:

- **Instant power**. Airflow/power gains start right from idle,
- **Much more power at part throttle**. Doubled mass airflow from 1.2 g/s-deg to 2.4 g/s-deg.
- **Higher quality.** Contour every thousandth of an inch and bench test each unit.

Flow Test Results With Throttle Plate Opened Through 40 Degrees,

The Initial Opening, Contoured Area, (RED in pic)

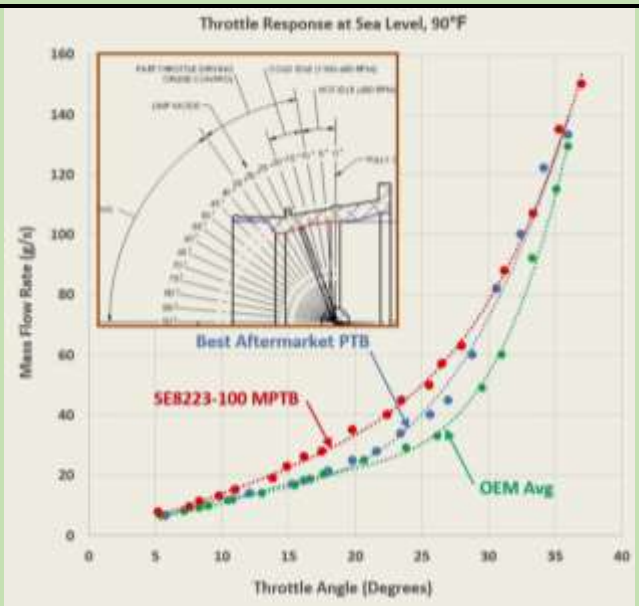
- Soler Modified SE8223-100

Compared to:

- OEM Throttle Body and

- The Best Aftermarket Modified Throttle Body Tested, PTB

Verifiable Results -check the numbers.

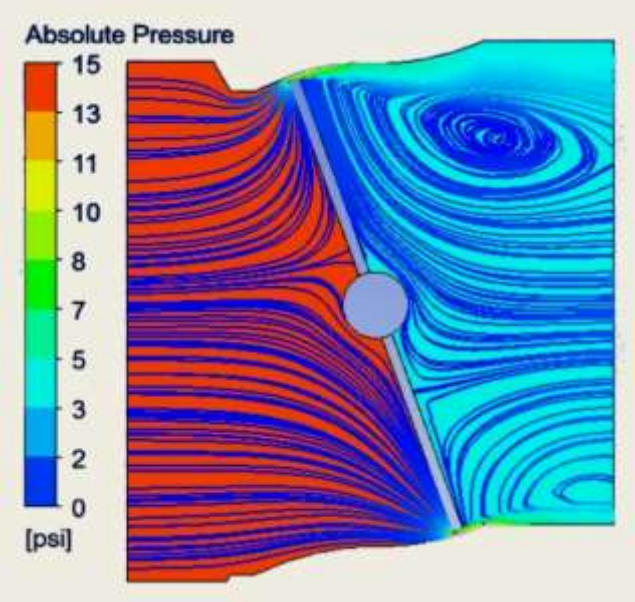


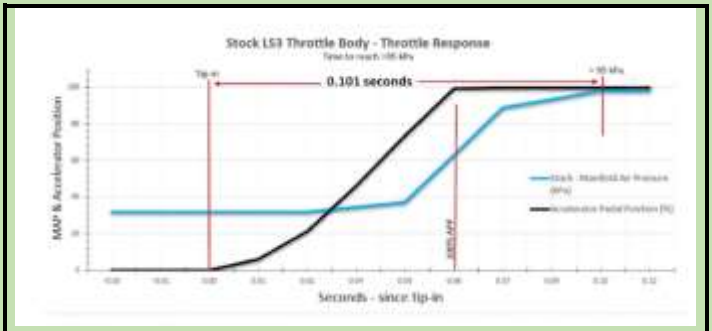
Soler has made Computational Fluid Dynamic (CFD) simulations of the OEM throttle body. They observed that all the pressure drop occurs at the flow gap between the plate and the active contour where the air is choked and reaches sonic speed. This sharp pressure drop across the plate clearly divides to very distinct zones, the inlet (red) on which the pressure is atmospheric and the outlet (cyan) which corresponds to the manifold pressure.

The predicted mass flow rate closely matches experimental data obtained from vehicle sensors.

Because the flow is chocked, it does not respond to manifold suction, regardless of engine type (naturally aspirated or forced induction). It does respond to upstream pressure (ambient) but that is not a controllable variable. Only changing the throat area and the discharge coefficient of the gap can increase airflow to the engine.

More Soler Technical Info in Appendix.





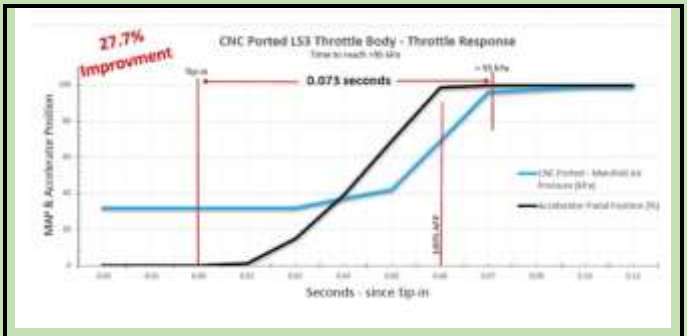
Thought this graph from a competitive modified throttle body that Soler tested would be useful to review. This graph is NOT from Soler but from the performance company's website.

Soler shows in graphs that their product performs even better.

Note this is for a LS3 throttle body but they are similar, and like most have a contoured area for the initial throttle plate opening.

This graph from the performance company shows 27.7% faster flow AFTER tip-in with their modified throttle body! It's independent support for the amount they can increase initial flow.

Soler quotes a 1983 patent from Nissan Motors, # 4,391,247 that describes the reason for the initial throttle opening being contoured and why straight bore throttle bodies had problems. May want to google, I found it interesting.



INSTALL

I bought a new modified Throttle Body and it came in <5 days, Priority Mail. Quick service!

It was well packed, and workmanship looked great.

4 pages of instructions look to be the same as those on their website if you want to check first:

https://static1.squarespace.com/static/5c50e9344eddecaef4c84713/t/5cb88980971a187551f51336/1555597697945/Installation+Instructions+Rev+NEW+%281%29.pdf

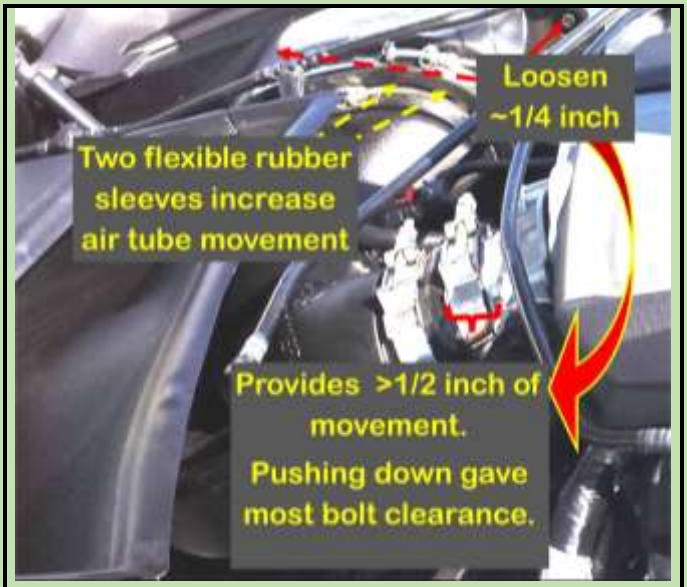
https://static1.squarespace.com/static/5c50e9344eddecaef4c84713/t/5cdf33953475050001ffd2a9/1558131605333/Relearn+and+Test+Instructions+Rev+NEW+V5.pdf

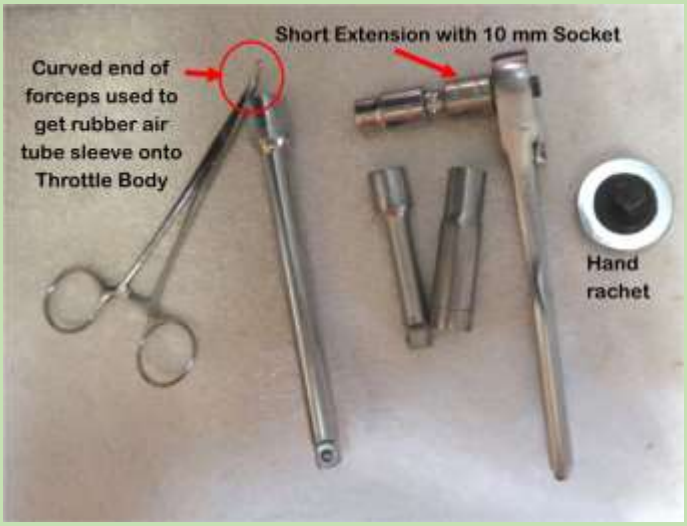
For OEM intake the two sets of bellows (*see in pic in the **aFe Appendix at the end of this PDF*) will leave enough room to pull the intake air tube back to remove the throttle body. It will also leave room for the Soler modified throttle body installation.**

However, my *aFe* low restriction air intake tube has no flexible bellows. Loosening the housing mounting bolts on the fender about ¼ inch will allow the throttle body tube end to move over twice as far.

There are two rubber sleeves where the tube connects to the filter housing. They provide extra movement of the Throttle Body end. Found for best access to the 4 Throttle Body bolts was achieved by pushing down on that tube end.

Removed the clamp on the rubber sleeve that fits over the throttle body intake.





To access the 4 Throttle Body Bolts, a few extensions were helpful as the tube end could only be pushed down a limited amount for bolt access.

One was a 1 inch very short extension in addition to two others. Once the bolts are loosened they come out easily. A hand rachet was useful.

To get the rubber sleeve over the new Throttle Body end, after it was installed, I first put it over the bottom. Then use the curved smooth end of closed forceps to help guide the last ~25% over the lip.

Note, the short extension being used to access the lower left Throttle Body bolt.

Disconnecting the ECM Wire Plug **is done with it upside-down. Pull the RED clip edge toward the fender. It just blocks the TAB that must be pressed to release the plug from the Throttle Body. The same clip arrangement is used on the MAF- BUT that clip is visible on top!**

Press hard on the Tab (yellow arrow) and pull.

Once the 4 bolts are removed just lift the old Throttle Body out.

As noted in the Soler Instructions; *"make sure the blue rubber gasket is in its grove."* Mine was fine, if not put it back in.

Any air leaking past the gasket did not go past the MAF and will provide the wrong info to the ECM!

Put the new Throttle Body in place and insert the 4 bolts. I put the two top bolts in first, hand tight.

Then installed the lower right and followed with the lower left. Snugged them all with the 10 mm socket and just the extensions.

Finally tightened the bolts in a crisscross pattern.

The rubber sleeve from the *aFe* low restriction intake 'just slips" over new Throttle Body inlet. Having had issues, the several times I have done this; I used a very small amount of soft hand placed on the inside. As noted with the tool's pic, I used the smooth curved end of closed forceps to get the last ~45 degrees over the lip. Worked great! Inserted the ECM connector and pressed in the RED clip cover. Tightened the filter housing bolts that had been loosened.

INSTALL FINISHED

ECM Learning Your New Throttle Body

The SE8223-100 Modified Throttle Body (MTB) and its reworked variants increase airflow at part throttle 0-33% throttle position (TP) range from 80-120% above stock/OEM throttle body (TB), and 55-85% over other aftermarket ported throttle bodies (PTB). Once installed, the engine control module (ECM) does not compensate instantaneously in terms of fuel, timing, etc. for these airflow increases. *Because the change is so drastic, the ECM is programmed to initially disregard this sudden airflow increase and rather compensate using time averages stored in memory, these come from mass airflow sensor (MAF) readings acquired from your previous TB/PTB.*

The MAF sensor reads real time airflow of your new MTB and sends it to the ECM. The ECM will in tum start replacing the oldest time averaged values from your previous TB/PTB and recalculating anew MAF time average and adjusting fuel, timing, etc. over time, miles, driving cycles. This is the learning period; your vehicle might not feel "smooth" until the new MTB is fully learned.

MAF readings outside ECM compensation range will set a diagnostic trouble code (DTC). These are not acceptable and indicate malfunctioning of the MTB. On the other hand. absence of a DTC upon installation and testing of your MTB indicates that the MAF offset is within ECM compensation limits and that the ECM will compensate for it given time to reconstruct the new MAF VB. TP curve/table. Fuel, timing, and other compensation types will follow MAF newer time averages of MAF VB. TP of your recently installed MTB.

This Simple Method of "Teaching" the ECM was Posted by Mike from Soler – The Formal Methods Follow:

The instructions are not clear regarding the ECM adjusting to the New Throttle Body. It doesn't specify miles or number of driving cycles, it just reads "a few driving cycles". We know from experience that 50-100 miles subdivided into 5-10 driving cycles, do the job. Many times the learning goes very smoothly and it is unnoticed. *At least do the following, it won't take long. (NOTE: this is similar what I did when installing my **aFe** Low Restriction Air Intake where 100 miles of normal driving was recommended.)*

1. Let idle for 3 min
2. Engine off for 1 min.
3. Let idle for 3 more min.
4. Off another min.
5. Drive at 44 mph or greater and let decelerate, several times.

There are two alternatives to force relearning the new MTB. Both are equally effective given enough use.

A) OEM ECM reset (TB values only) tool and relearn procedure. Available at the dealership, or OEM approved service centers. No actions need to be taken by user.

B) Full ECM reset and learning routine. Consisting of overnight power down of ECM by disconnecting battery for several hours. Followed by steps below.

• Disconnect negative battery terminal (black) located under the trunk mat/carpet toward the rear-right comer of the trunk for at least 8 hours.

Test and Re-learn Instructions (Procedure B)

In case of perceived malfunction or if the MIL illuminates on your screen during any step of this test, tum engine off and replace throttle body. Do not attempt to drive until step 6 below.

1- Install modified throttle body and connect battery.

2- Start engine. Depending on engine temperature, engine will start idling in between 650-1100 RPM.

If idling starts at greater than 650 RPM, it should slowly and consistently decrease RPM value to 650 RPM. Allow engine to idle for three minutes while monitoring idling process to ensure there are no RPM fluctuations greater than +/-30 RPM. Tum engine off for one minute.

3- Start engine and allow engine to idle at 650 RPM for three additional minutes and until redline has retracted to 6500 RPM. Accelerate engine slowly up to 4000 rpm. RPM's should always increase *wlo* interruptions. Remove your foot from accelerator pedal, RPM's should always decrease *wlo* interruptions.

4- Allow ECM partial learning of the new throttle body by repeating engine acceleration part of step 3 above four more times. Tum engine off for one minute.

(continued)

5- Start engine and allow engine to idle at 650 RPM. While pressing brake, test transmission in D Gear, R, and N while monitoring RPM's. Small fluctuations may occur while shifting. After shifting, RPM's should still be around 650 RPM and should not fluctuate more than *+/-30* RPM.

6- Test drive safely. Chose a place away from public roads and where no people, pets or property is in the way. Allow the ECM to fully learn the newly installed T8 as follows:

• Drive normally at or above 44 mph and allow vehicle to decelerate. Repeat 4 more times for 50-100 miles subdivided into 5-10 driving cycles, including cooldown periods between starts. (Normal everyday driving meets this step)

• For automatic transmissions, do not enter performance shift mode, driving in M mode is advised.

• Weather, Eco, or Touring modes are recommended during this period.

• Avoid high rates of change of throttle plate angle (aggressive acceleration).

• Revving up to 6500 RPM is okay if done progressively.

After meeting the full learning routine above, test all driving modes available in the car selector, performance shift mode, cruise control, and limp mode (disconnect ECM connector from throttle body). Bring tools and your original (OEM) throttle body to replace modified body in case of malfunction.

Testing limp mode will illuminate the MIL, but the code should go away after reconnecting T8 to the ECM.

I Used the "Simple Method" Outlined to "Teach" the ECM.

Car started fine and all during the 3 minute 1st idling, read ~600 rpm. After stopping the suggested 1 minute and repeating the 3 minute idle it also was a very steady ~600 rpm.

Drove 25 miles in Touring Mode on a low traffic rural highway and was able to deaccelerate from 50 to 55 mph to ~30 mph over 10 times. Stopped at the store and car started fine. ***This was my first chance to observe the easier throttle manipulation when taking off! No hesitation or slight bog using little throttle.***

All appears to be fine and compatible with my larger oiled cotton, low restriction ***aFe*** air intake system that has been installed for over 2 years. No ***CEL***s (***Check Engine Light***)

After ~75 miles my ECM has learned enough to at least be through "High School!

On this 2nd day I put the Drive mode in Sport, where I had been driving since the MRC software upgrade. Throttle response when starting was definitely faster. Everything was normal relative to idle etc, no CEL ever. Although Soler says don't use WOT until the ECM has fully "learned" I tried one fast acceleration approaching redline in 2nd and third. Felt fine.

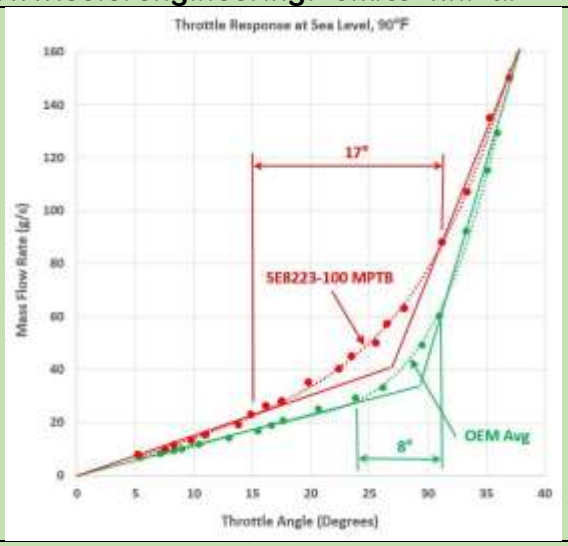
Been 4 months, works great, easy to add and much better/different than a Throttle Controller! Well worth the cost. 5 Stars!

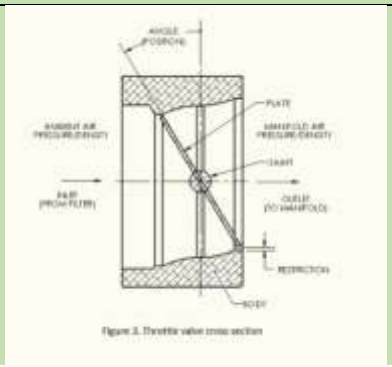
Appendix: From Soler Website: https://www.solerengineering.com/technical

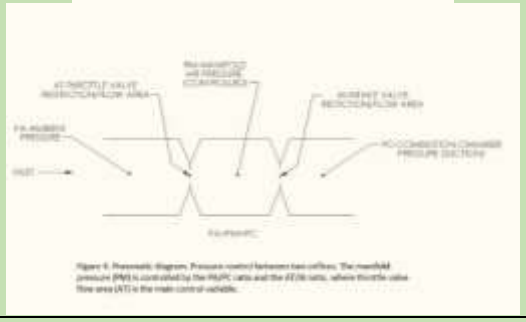
Technical Info from Soler

The following is excellent information supplied by Soler on their Website.
This graph is a good summary:

- **Instant power**. Airflow/power gains start right of idle, no need to wait until the blade has reached 20 degrees or more.
- **Much more power at part throttle**. We doubled the rate of change of mass airflow (MAF) from 1.2 g/s-deg to 2.4 g/s-deg.
- **Higher quality.** We made sure every thousandth of an inch was accounted for, that our surface finishes were the best, we road tested extensively, we bench test each unit.







The throttle body is a butterfly type valve that regulates the amount of air in proportion to the accelerator pedal position. It is the main control of engine power as the amount of air permitted into the engine defines a limited amount of fuel that can be burned in the combustion chamber hence the amount of energy released by the fuel.

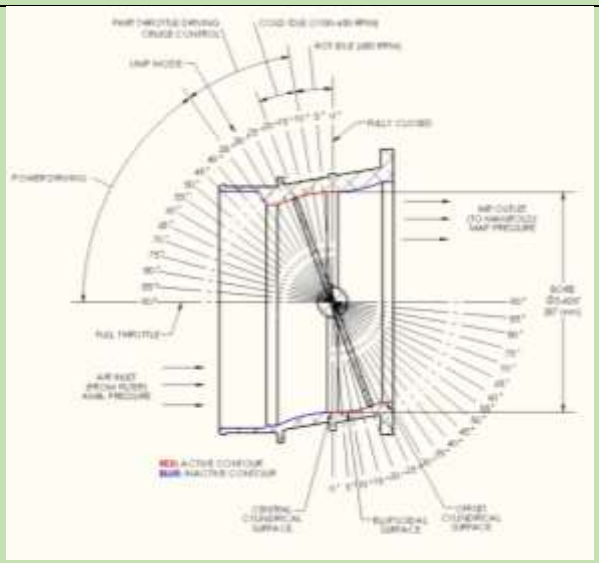
More specifically, the throttle valve regulates the pressure in the intake manifold via a pressure drop caused by the gap (restriction) between the throttle plate and the active contour of the throttle body which in turn regulates the air density inside the manifold. At low throttle plate angles the pressure drop is high and the manifold air pressure (MAP) is low, the opposite occurs at high throttle plate angles.

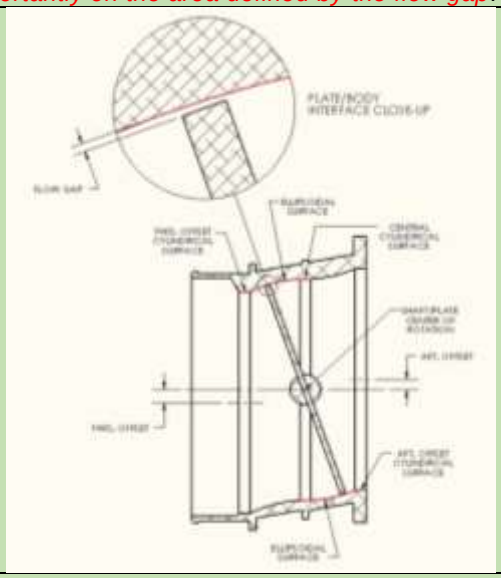
The air density inside the intake manifold is proportional to the MAP and because the volume of air admitted into the combustion chamber and the vacuum created during intake stroke is predefined by the engine displacement and rpm, then the total mass of air admitted is limited by the air pressure/density in the intake manifold.

Body: Cast Aluminum alloy, provides structural support for other components.
Torque Motor: Induction, brushed, 8 wound rotor poles, 2 permanent magnet stators. Provides torque required to move and hold the plate at the desired position.
Reduction Gear: Multiplies motor torque by providing a total transmission ratio of 21:1 from pinion to sector gear and shaft.
Sensor Target: Rotates with shaft and faces inductive sensor to create an inductive effect on sensor windings that signal plate position to ECM.
Inductive Sensor: A set of coils printed on a circuit board. The transmitter coil induces a voltage on receiver coils as a function of target/rotor angular position, indicating actual plate position/angle.

OPERATING REGIONS

Cold Idle: Set to control the idle speed at 1100 rpm Max. to 650 rpm depending on temperature.
Hot Idle: Set to control the idle speed at 650 rpm once the engine is at an operating temperature.
Limp Mode: Set by equilibrium/preload of torsion springs and limits amount of air, for malfunctions.
Power Driving: High flow rate where active contours (red) become inactive. Flow is mainly restricted downstream at intake valves, where manifold pressure nearly equals ambient pressure.
Part Throttle Driving: Occurs between idle throttle position (~5°) and the end of the active profile (~35°). It accounts for about 1/3 of the valve range and it is where most of the driving occurs. *Airflow reaches a sonic speed (**choked flow**) and does not respond to manifold pressure (vacuum). Flow is totally dependent on upstream pressure and more importantly on the area defined by the flow gap*.





Active Contour:

The active body contour (red area) is composed of a central cylindrical surface (87 mm bore) from which tangent ellipsoidal surfaces extend forward on the upper side and aft on the lower side and ending in cylindrical surfaces offset downward on the inlet side and upwards on the outlet side, both of these offset surfaces have the same size (87 mm) as the central bore.

The upper and lower active contours are symmetrical to the shaft/plate center of rotation and closely follow the edge of the plate as it rotates.

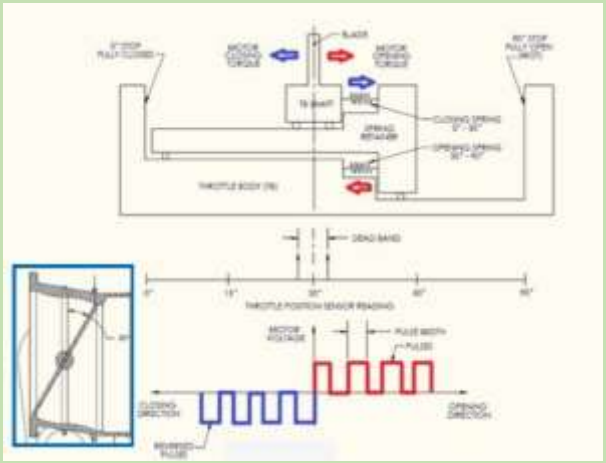
Except for the ellipsoidal surfaces of the contour are sized and positioned to slowly increase the size of the air gap as the plate angle increases, allowing for small increments of air flow. The gap changes from a few ten-thousandths of an inch when the valve is fully closed to several thousandths of an inch at 30°.

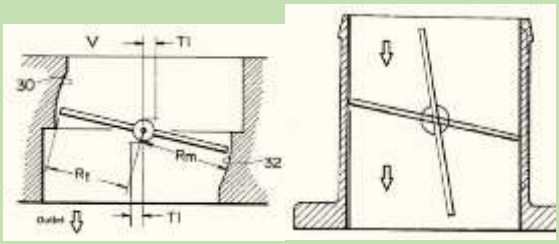
Operation

The throttle body blade has a home position at 30 degrees. This is where the blade is set when no loads are acting on it. It is held at that position by means of springs and mechanical stops.

When closing is requested, the electric motor in the throttle body receives voltage pulses from the ECM (pulse width modulation PWM) to apply a torque that can overcome and balance the torque of the closing spring, then it holds the blade at the desired position (between 0 to 30 deg).

When opening is requested, the same happens *except* the pulses must be reversed to apply torque in the opposite direction to overcome and balance the torque of the opening spring between 30 to 90 deg.
Blade angular position is continuously related to the ECM by the throttle position sensor.





The active contour found on the OEM throttle body dates to the 1980's. One of the earliest patents of this design is U.S. patent number 4391247, described as a device having S-shaped flow path for the air (left pic.)

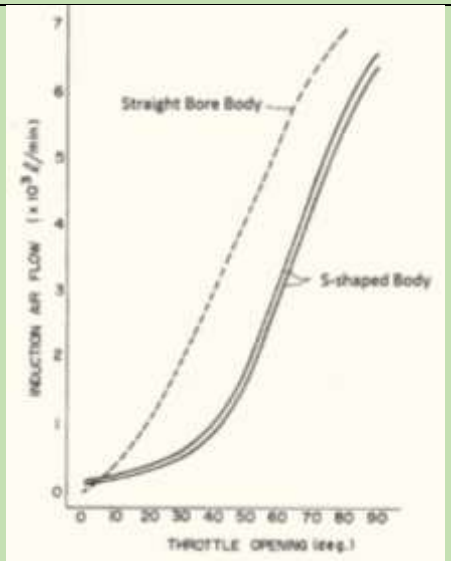
Prior to this invention, the "straight bore" type throttle body (right) was widely used, mostly in applications where the accelerator pedal was mechanically linked to the throttle shaft.

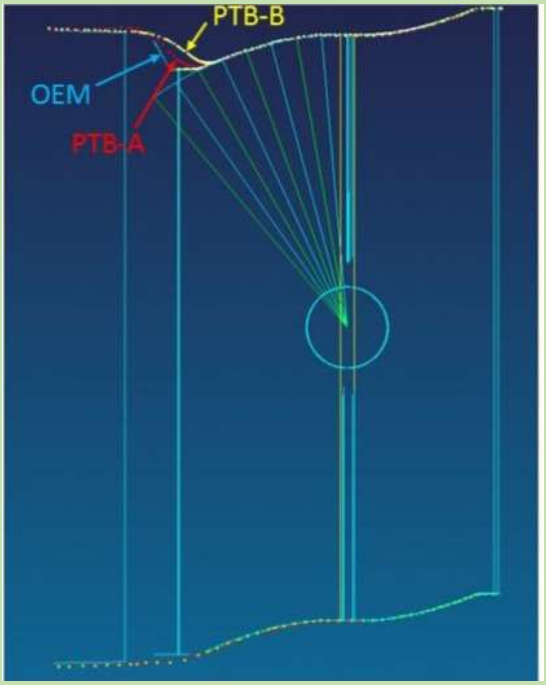
With "drive-by-wire" systems, it was possible to control idling and other low to part throttle functions without the need for an idle control valve among many other benefits.

The main limitation for idle control in a straight bore body is flow changes rapidly at low throttle angles and could not be used to meter air when mass flow sensors were not accurate. It can be clearly seen from figure right, that response of a straight bore body is much faster and more linear than that of the S-shaped body for the same size bore.

Another observation on this plot is that the S-shaped design has three clearly defined zones;
1) 0°-30° a slow response
2) 30°-50° transition to power
3) 50°-90° steep response for power driving

The inventor recognized the drawbacks of the slow response in the 0°-30° region and tried to compensate with the calibration of the accelerator pedal module.

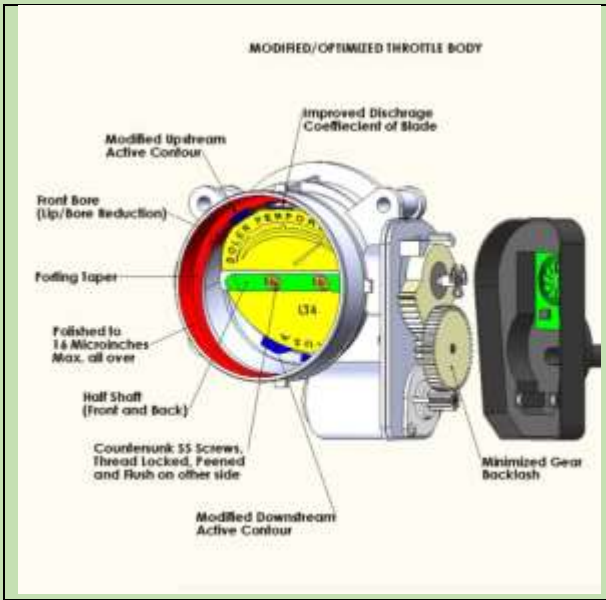




Aftermarket ported throttle bodies tested (PTB)
Aftermarket PTB-A (red) was reworked by reducing the taper on "lip" from 60° to 45°. Then a .185-inch radius was added tangent to the taper and the ellipsoidal surface of the upper active contour.
Aftermarket PTB-B (yellow) was reworked by reducing the taper on "lip" from 60° to 30°. Then a .160-inch radius was added tangent to the taper and the ellipsoidal surface of the upper active contour.
Aftermarket PTB's showed an improvement on over the OEM in the 25° to 35° range of throttle position, however, from idle and up to 25°, the issues persisted as it can be expected given the extent of this aftermarket modifications.

PTB-B showed better performance than PTB-A, also a consequence of the extent of the modification reaching further into the ellipsoidal contour and its better surface finish.

BOTTOM LINE
None of the aftermarket throttle bodies tested modified the lower active contour on the outlet side of the valve body.



What Soler Does:

- Modify upstream and downstream contours to improve discharge coefficients and increase flow from idle.
- Contour front lip to help flow
- Narrowed center shaft to increase flow- peen screws for security.
- Polish to 16 microns max all over
- Minimize gear backlash

Achieves

- **Instant power**. Airflow/power gains start right of idle,
- **Much more power at part throttle**. Doubled mass airflow from 1.2 g/s-deg to 2.4 g/s-deg.
- **Higher quality.** We contour every thousandth of an inch and bench test each unit.
- **Guaranteed to last**. Made from new OEM parts, machined the latest in CNC technology, assembled with care and safety

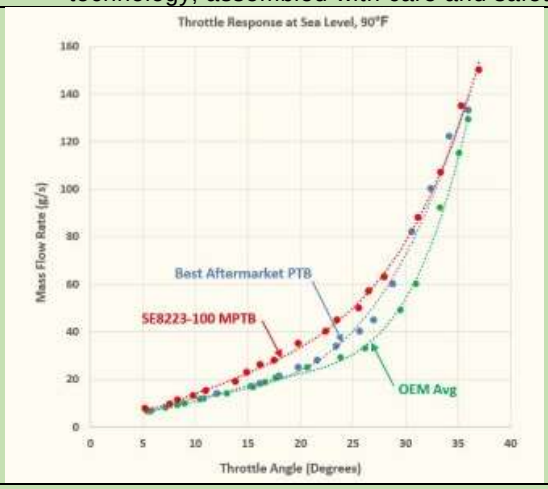
These Are The Test Results With:

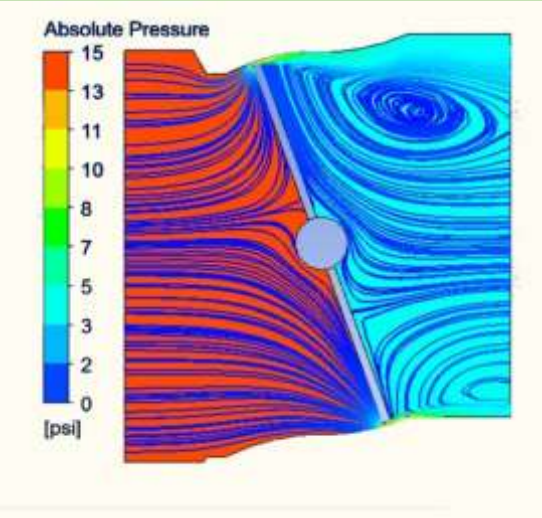
- Soler Modified SE8223-100 Compared to:

- OEM Throttle Body and

- The Best Aftermarket Modified Throttle Body Tested

Verifiable Results -check the numbers and compare the quality.





Soler has also made Computational Fluid Dynamic (CFD) simulations of the OEM throttle body. They observed that all the pressure drop occurs at the flow gap between the plate and the active contour where the air is choked and reaches sonic speed. This sharp pressure drop across the plate clearly divides to very distinct zones, the inlet (red) on which the pressure is atmospheric and the outlet (cyan) which corresponds to the manifold pressure.

The predicted mass flow rate, in this case, closely matches that of experimental data obtained from vehicle sensors.

Because the flow is chocked, it does not respond to manifold suction, regardless of engine type (naturally aspirated or forced induction). It does respond to upstream pressure (ambient) but that is not a controllable variable. Only changing the throat area and the discharge coefficient of the gap can increase airflow to the engine.

W A Technology

Appendix: Info, Low Restriction & Oiled Cotton Air Filters

There is misinformation and false conjecture about the use of low restriction air filters. Oiled cotton filters are often maligned because of lack of knowledge or filter tests that can be made to say about anything! One of the often made statements is if low restriction air filters were so good GM would use them!

Fortunately Tadge Juechter, the Corvette Chief Engineer in response to a forum question answered, This is a summary of what he said, quoting the key points:

"Aside from the exhaust, there is no greater noise source on a performance vehicle. Induction systems generally have many tuning elements that ensure the quality of the sound emanating from it are pleasing and harmonious with the exhaust note. These tuning elements also dampen the sound energy to help with pass-by requirements.

Aftermarket companies don't have to worry about it, but as the OEM, we must guarantee that our products are quiet enough to be driven at full throttle by a microphone by the side of the road and meet certain decibel levels. There are pass-by laws in many states and pretty universal around the world.

Another important element in the induction system is the mass air flow sensor or MAF. Engines can only run at their optimal efficiency if they have very precise data on the amount of air flowing into them. Although most people think of air flow into an engine as fairly continuous, it really is not. The opening and closing of valves and reciprocating nature of internal combustion engines means the air flow is really a series of pulses which make measuring the exact flow challenging. Intake engineers spend a lot of time optimizing the system to get excellent signal quality out of the MAF. In addition to efficiency, or fuel economy, the precise metering of air and fuel is directly correlated with tail pipe emissions, an area of extreme scrutiny by government agencies for we manufacturers.

The air filter itself is the focus of many discussions on low restriction. Its job is to keep foreign material out of the engine. Here again, there are many trade-off decisions balancing restriction with filter life (service interval) and filtration quality. Sacrificing either of the latter two improve the former. We tend to be conservative to make sure that our engines are very durable, so that does open up an opportunity for aftermarket system.

As with many of the questions on this forum, all vehicle design is a balance of trade-offs. We do what is legal and right for the vast majority of customers. Aftermarket companies offer products that strike a different balance that might appeal to some folks."

I installed an *aFe* low restriction oiled cotton filter on my C7 but have used K&N oiled cotton filters for Years

The following are some technical details about the K&N test facility.

K&N ENGINEERING AIR FILTRATION EFFICIENCY TESTING PROTOCOL

(from their website)

SCOPE AND APPLICATION

K&N Filters performs air filter tests for efficiency and capacity in compliance with the ISO-5011 Standard for Performance Testing of Inlet Air cleaning equipment for internal combustion engines and compressors. Previous to the adoption of the ISO-5011, testing was performed in compliance with the SAE J-726 - Air Cleaner Test Code. The ISO standard states that the basic performance characteristics of greatest interest are air flow restriction, dust collection efficiency, and dust capacity. K&N adheres to the ISO standard in the measurement of these test parameters.

LAB ENVIRONMENTAL CONDITIONS

K&N maintains the ISO Filtration Lab at 70° F and 50% RH within the limits of the ISO standard for normal testing.

CALIBRATION AND EQUIPMENT CHECKS

Check Lab conditions each morning to verify they are stable and within the prescribed limits. Verify that the dampers are open and operate the system air blowers at a predetermined rate. Monitor computer data channels to ensure that all instruments are working properly. Verify that the digital cameras are charged and operational.

Allow test dust to acclimate to lab conditions for 24 hours and load the necessary amount into the dust feeder hoppers for the first test to be performed.

Set the weighing oven to 105°C (221°F) and allow it to come up to operating temperature.

Periodically - Validate the efficiency of absolute filter media as required by the ISO standard. Calibrate instrumentation periodically as required by the calibration schedule.

SIDEBAR

Another K&N article shows that by selecting the dust size (ISO-5011 does NOT specify what should be used) most filters can be compared and show an advantage over another! You must be careful, when you see a test saying Fram is better than Purolator, that a test could probably be conducted to show the opposite using different dust size range, end point etc!

Quoting K&N: *"The air filter industry uses the ISO 5011 testing protocol when testing filtration efficiency and dust capacity. The test protocol calls for the introduction of a measured amount of "test dust" into the air filter at a selected airflow rate. The test is then terminated after the filter*

reaches a selected level of restriction (terminal test pressure). The test protocol then measures the percentage of dust retained by the filter (efficiency) and the total amount of dust held by the filter (capacity).

This means that you can change the grade of test dust, the airflow rate, the beginning and end points of the test, and other factors while still being in conformity with the protocol. *For example, the filter can be tested in a special "test housing" or in the factory air box. The ISO 5011 test protocol it is not an absolute test or standard; it is meant to help engineers design air filters by holding conditions constant while one variable is changed to measure the change impact.*
Because the ISO 5011 protocol uses fixed airflow and is often conducted with the air filter in "test housing," it is not intended to develop a filtration number you will experience in actual use. While in a vehicle, an air filter will experience a range of operating conditions, airflow and dust feed rates.
K&N operates an in-house filtration test lab with two different testing machines built in consultation with Southwest Research Institute, one of the pre-eminent testing companies in the world.
We perform tests of filters both in the factory air box and in SAE/ISO recommended test housing fixtures. Our goal is to design filters with the maximum possible airflow achievable while providing guaranteed engine protection."

TEST FIXTURES

K&N uses three types of fixtures to enable testing of the broad types, shapes and sizes of the filter we manufacture. For OEM replacement filters we have found that using the OEM air box or filter housing allow the best comparison and repeatability when testing these filters. Another type of fixture used is a filter housing conforming to the design specifications spelled out in the ISO 5011 protocol. This ISO Fixture is used for specific testing as specified by the engineering staff as well as for most round filters. Lastly, K&N has developed a cabinet type of fixture, modeled after the ISO fixture for testing universal clamp-on type filters. This cabinet allows repeatable consistent dust loading of these open element type filters.

Once the test fixture has been specified, the Dust Test procedures are the same for all filter types except for some minor differences in mounting, orientation and placement of the dust nozzle and pressure taps, which become apparent when finalizing the setup of the test apparatus.

LAB TEST PROCEDURES

Condition and Restriction Test - Verify that the dust feeder has been loaded with the proper amount and type of dust for the test to be performed.

Install a new absolute filter into the test stand filter tray. Condition the absolute filter at 110% of the rated flow of ambient air for 15 minutes to reduce any subsequent errors in measurements caused by losses of fibers or materials. The conditioning of the absolute filter can be performed in the Manual Test Mode.

While performing absolute filter conditioning, prepare test data sheets and other required documentation, mark test articles with appropriate task number, photograph test articles and create test folder on the appropriate server as required. Record the test information into the control computer and create the necessary data file in the appropriate folder.

Install the test article (fixture) onto the test stand specified in the test request. The connections for the upstream and downstream pressure measurements are made using the two tubes marked Test Filter Restriction and Test Filter Delta-P. The tubes are connected depending on the fixture to be used as follows:

ISO Housing or Dust Cabinet - Install the tube marked Test Filter Restriction to the dust cabinet outlet tube pressure port (clean side of the filter). Install the tube marked Test Filter Delta-P to the dust feed tube pressure port (dirty side of the filter). Attach grounding cables to test fixture and test article as recommended by the ISO test standard.

OEM Air box - Install the tube marked Test Filter Restriction to the upstream absolute filter pressure port of the test stand plenum. Leave the tube marked Test Filter Delta-P open to atmosphere. Attach grounding cables to test stand and test article as recommended by the ISO test standard.

Perform the Condition and Restriction Test using test filter and absolute filter at the air flow rate specified by the test request. Condition the test apparatus for 15 minutes as required by the ISO standard. Measure and record the restriction and differential pressure versus flow rate at 50%, 75%, 100%, 125%, and 150% of the requested air flow rate.

Measure and record the mass of the test article and dust chamber (fixture). Stabilize an absolute filter using the ventilated oven at the required temperature. Measure and record the mass of the absolute filter.

Reinstall the absolute filter and test article with fixture into the appropriate test stand. Re-attach grounding cables to test fixture and test article as recommended by the ISO test standard.

INITIAL EFFICIENCY TEST

The purpose of the Initial Efficiency Test is to determine the dust retention capability of the test article when loaded with an initial amount of test dust.

The initial efficiency will be determined after the addition of 20g of dust or the number of grams numerically equivalent to 6 times the air flow in m3/min (cubic meters / minute), whichever is greater. Using the appropriate worksheet, determine the actual number of grams to be applied in the initial efficiency test based on requested flow rates and enter the appropriate amounts including the termination criteria into the control computer. Enable the control computer to record all necessary data parameters for the duration of the test.

At the Lab computer interface, lock in the scale reading by checking the appropriate dialog box. Switch on the blower and verify that it reaches the required test air flow rate and allow the system to stabilize. Turn on the dust feeder using the dialog box control button and record the initial restriction (delta-p).

Monitor the system parameters until the termination point has been reached. The control computer will automatically shut down the blower and dust feeder at the termination point. Record screen data on the appropriate data sheet and file it in the test folder.

Remove the test filter, fixtures and the absolute filter from the test stand. Photograph the test article and fixtures, and note any anomalies in the comments section of the datasheet. Place the absolute filter in the ventilated oven and periodically check for the weight to stabilize. Record the final absolute filter weight on the data sheet.

Weigh the test filter and fixture. Record the weight(s) on the appropriate data sheet. If the test filter reached its full-life termination pressure during the initial test phase, record that fact in the data sheet and archive the test filter, otherwise prepare the test filter and fixtures for the full-life/capacity test.

FULL-LIFE/CAPACITY TEST

The purpose of the Full-Life/Capacity Test is to determine the total mass of dust retained by the test filter by recording the incremental weight of the dust fed until the test filter reaches a terminating pressure restriction as specified by the test request.

The full-life efficiency will be determined after adding a quantity of dust at the rate of 1 g/m3 (grams per cubic meter) until the test filter reaches a predetermined pressure restriction. Enter the air flow rate, dust feed rate, and termination pressure into the control computer dialog box. Set the control computer to record all necessary data parameters for the duration of the test.

Reinstall the absolute filter, test filter and appropriate fixture onto the test stand. At the Lab computer interface, lock in the scale reading by checking the appropriate dialog box. Switch on the blower and verify that it reaches the required test air flow rate and allow the system to stabilize. Turn on the dust feeder using the dialog box control button and record the initial restriction (delta-p).

Monitor the system parameters until the termination point has been reached. The control computer will automatically shut down the blower and dust feeder at the termination point. Record screen data on the appropriate data sheet and file it in the test folder.

Remove the test filter, fixtures and the absolute filter from the test stand. Photograph the test article and fixtures, and note any anomalies in the comments section of the datasheet. Place the absolute filter in the ventilated oven and periodically check for the weight to stabilize. Record the final absolute filter weight on the data sheet.

Weigh the test filter and fixture. Record the weight(s) on the appropriate data sheet and archive the test filter.

Other Questions Also Raised (My notes, not from K&N)

Will Oiled Cotton Filters Contaminate MAF Sensors?

First, when delivered they are oiled and don't feel oily! The key is they should be cleaned and reoiled with the procedure and solutions supplied by the manufacturer. This usually states after using their cleaning solution rinse with a soft water stream. Then I let it dry overnight. Then apply a small amount of oil along only the top edge of each seem and allow the oil to spread into the remainder of the cotton. This leaves some uncolored spots on some of the valleys. After about an hour then put a few drops in each of these uncolored spots. I find it takes some time so best to start on the end of one day, let it dry, then reoiling takes about an hour to spread. They should not feel oily. Have never had an issue with MAF sensors.

Mitsimoto Engineering, a performance company, comments on possible oiled cotton MAF damage. "*Let's nip this right in the bud. Usually the only way for something like this to happen is if you over-oil your filter when re-applying the oil.*"

Does Oiled Cotton Filter as Good as an OEM Filter?

Probably not, the compromise made, as Tadge notes aftermarket air filter companies can elect, is for lower restriction. Mitsimoto Engineering states this about oiled cotton: *"Generally, high-performance dry filters can catch up to 99% of the incoming contaminants due to the smaller micron size of the filter media, while oiled filters catch about 98% – a minute difference, but a difference none-the-less."*

Photo Info

What is Different About *aFe* Filter

One way the *aFe* low restriction Intake gets more power is by using a larger air filter. The filter on the right is the GM OEM paper filter that comes with the Grand Sport (note made in Thailand!) You can see the oiled cotton *aFe* filter (left) is not only made from a lower restriction material, it is significantly larger.

To hold the larger filter, the filter housing and air tube are redesigned.

The oiled cotton *aFe* Vette filter will flow 318 CFM versus the OEM GM paper filter for the same pressure difference, 1.5 inches of water, flows only 224 CFM. *aFe* also has a replaceable paper filter option but it has a somewhat higher restriction. Some info showed the *aFe* paper filter flowed about 10% less than the oiled cotton, or ~285 CFM.

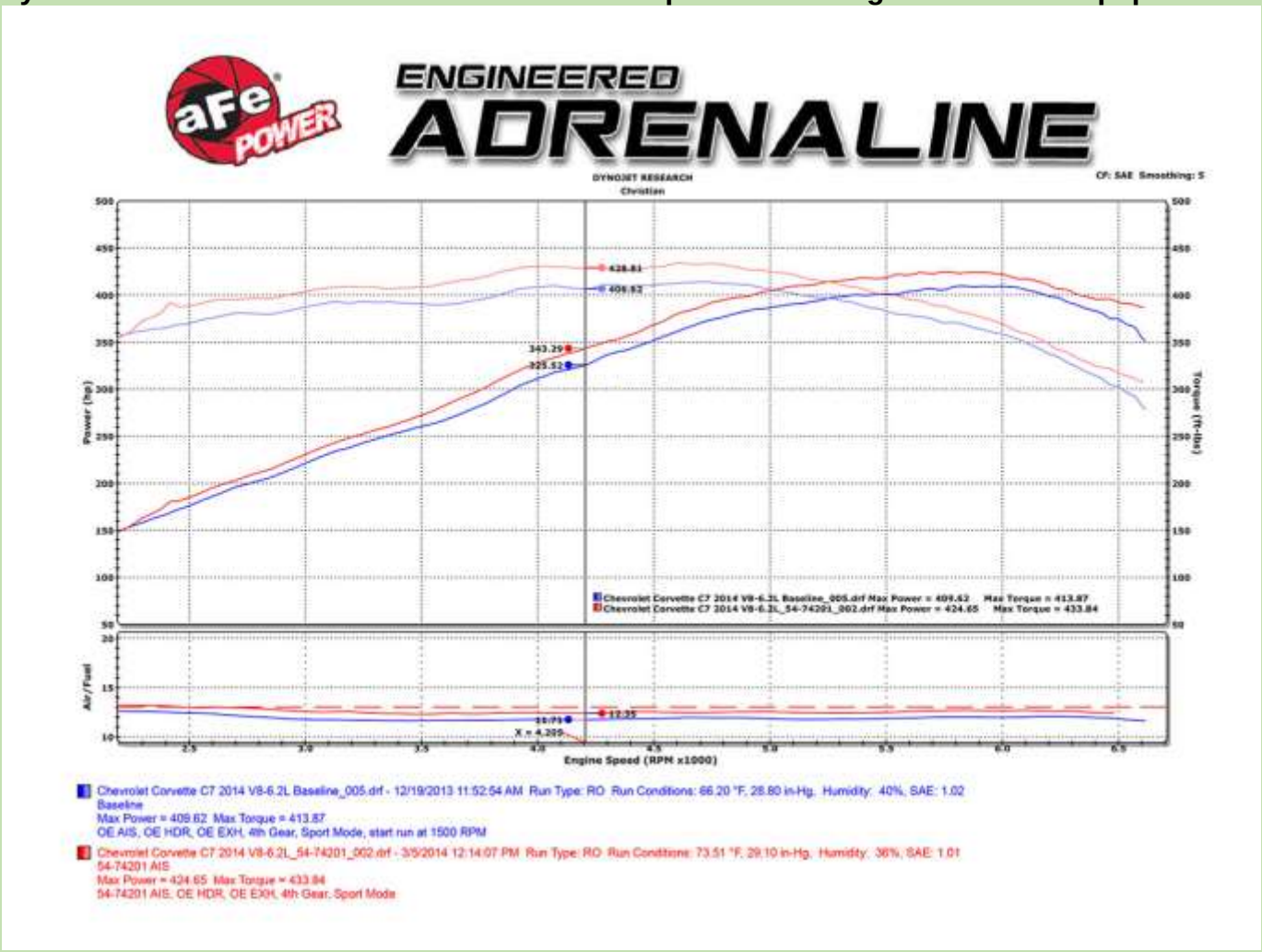
A Helmholtz Resonator in the intake tube forces air wave pulses coming back out of the engine to slow down to fill the cavity, thus expending a great deal of its energy.. **Since these pressure waves are essentially sound, giving them a place to expend their energy before exiting the air filter box ends up dampening the intake noise and quieting the engine.**

The smaller resonator on the smother *aFe* tube provides less noise abatement!

The OEM intake tube (above pic) has two sets of bellows that add to flow restriction as well as a sharp angle, the *aFe* has smooth bends and only a small bellow.

The *aFe* plastic air tube is larger. There is a tight clearance between the air intake duct and the bottom radiator hose so *aFe* put a recess in the area for clearance. Good design.

aFe **dyno data show a hp increase from ~2500 rpm with a peak increase of ~14 hp. Is that what you'll achieve? They no doubt publish their best values but a forum poster had his dyno'd before and after install and found 10 hp with their higher restriction paper filter.**



Is an *aFe* System Worth the Cost?

An *aFe* intake system cost ~$450 on Amazon. If you get ~10 hp you'll also get a great "sucking sound" at WOT!

An NPP exhaust cost ~$1100 and you get 5 hp and a louder sound!

So the *aFe* is about 4 times the value! Twice the power for half the cost. If you only get 5 hp It's still twice the value!

I removed mine from my 2014 Z51 I drove for 3 years then reinstalled the OEM system when I sold it. Cleaned and reoiled the filter and the *aFe* is now on my Grand Sport. Cost effective, IMO.

WA Technology

"48" 2017 Grand Sport & 2014 Stingray PDF's Available:

48 PDFs discuss improvements or information about a 2017 Grand Sport and 2014 Stingray function and/or esthetics. Some are minor and others, like the installing the rear diffuser & MGW shifter, include detailed install information.

Below are the PDF's available. Click on picture (may need Ctrl pressed.) Or just copy and paste the PDF info (Blue type) into your browser. Or email me at GUttrachi@aol.com **and state the title desired, shown in Yellow:**

Note: **A GS in the title indicates the info was updated from that available for the C7 Z51 PDFs.**

Rusty GS/C7 Muffler ***Why the C7 muffler is rusted and a simply way to make rust turn matte black.*** ***Bottom pic rusted, top pic treated*** **http://netwelding.com/Muffler_Rust.pdf**	
Change GS/C7 Oil ***WHY change your own oil and HOW to do it*** ***Revised, includes C7 Lifting Methods*** **http://netwelding.com/Changing_Oil.pdf**	
C7 Carbon Fiber Side Skirts ***How to install side skirts with jacking information for DIY's without lifts*** **http://netwelding.com/Side_Skirts.pdf**	
C7 Carbon Fiber Splitter w/End Plates ***How to install Splitter & Nylon bra fit*** **http://netwelding.com/CF_Splitter.pdf**	
C7 Removing GM Plastic Film ***How To Remove The Rocker Panel Film*** **http://netwelding.com/Rocker_Panel_Film.pdf**	

 GUttrachi@aol.com

GS/C7 Mirror Proximity Alarm

Limit switch alarm warns when passenger mirror is too close to door frame

http://netwelding.com/Mirror_Proximity_Alarm.pdf

Jacking Pads for GS/C7

Manual says Jacking Pads 2 1/2 inch max OD.. Have 1 inch, 2 inch pads semi-permanent pads.

http://netwelding.com/Jacking_pads.pdf

GS/C7 Radar Power

For C7 tapped rear fuse panel. For GS tapped mirror

http://netwelding.com/Radar_Detector_Power.pdf

GS/C7 Belt Rattle

Passenger seat belt rattles against the seat back. The solution, add a shoulder belt pad.

http://netwelding.com/Eliminate_Rattle.pdf

Aluminum C7 Chassis and Weld Repair

The C7 has an all aluminum chassis, made from 117 welded pieces. Includes weld repair info.

http://netwelding.com/Aluminum_Chassis.pdf

GS/C7Ceramic Brake Pads

The Z51 has very dusty brakes. These pads help!

http://netwelding.com/Ceramic_Pads.pdf

GS/C7 License Plate Frame;

Must Meet South Carolina Law

http://netwelding.com/License_Plate_Frame.pdf

Manage GS/C7 Spilled Gas & Door Lock

Protect the side of the Vette when filling up with gas. Includes info on preventing door lock failure.

http://netwelding.com/Manage_Spilled_Gas.pdf

GS/C7 License Plate & Cargo Lights

LED license plate light & cargo area bulbs are brighter and whiter

http://netwelding.com/License_Plate_Light.pdf

GS/C7 Rear Cargo Area

Rear cargo area needs storage device and rear protector

http://netwelding.com/Rear_Cargo_Area.pdf

GS Rear Diffuser (Fits Any C7)

Rear Carbon Flash Composite Diffuser

http://netwelding.com/Rear_Diffuser.pdf

GUttrachi@aol.com

GS/C7 Door Panel Protector

Black plastic protector added to prevent scuffing of door when exiting

http://netwelding.com/Door_Panel_Protector.pdf

GS/C7 Improved Cup Holder

A solution to the cup holder spilling under hard braking or shape turns.

http://netwelding.com/Improved_cup_Holder.pdf

GS/C7 Wheel Chatter/Hop

Why sharp, low speed turns with cold tires causes the front tires to chatter/hop.

http://netwelding.com/Wheel_Chatter.pdf

C7 Carbon Fiber Grille Bar

Install genuine carbon fiber grille bar overlay

http://netwelding.com/CF_Grille_Bar.pdf

Jacking a GS/C7 Vette

Safely jacking either front only or back & front

http://netwelding.com/Jacking_A_C7.pdf

Deer Whistle Installed on GS/C7

Do they work? Plus Install Info

http://netwelding.com/Deer_Whistle.pdf

Replacing C7 Battery

After using a GM type charger and showing fully charged a voltage low, replaced battery with AGM!

http://netwelding.com/Battery_Issues.pdf

GS/C7 Window Valet

Lower Windows with FOB

Window Valet Helps 2014/2015 Latch Hatch

http://netwelding.com/Hatch_Latch.pdf

GS/C7 Splash Guards

GM offers splash guards for the C7 Corvette. An easy DIY installation. ACS Best Front Guards for GS.

http://netwelding.com/Splash_Guard.pdf

GS/C7 Blind Spot Mirror

Smaller rear and side windows cause C7 blind spots. Small "blind spot mirrors" help

http://netwelding.com/Blind_Spot.pdf

GUttrachi@aol.com

GS/C7 Skid Pad Protector

After the air dam, the aluminum "skid pad" hits driveway ramps etc. Plastic protector helps.

http://netwelding.com/Skid_Pad_Protector.pdf

GS/C7 Wheel Locks

Wheel locks, torqued to required 100 ft-lbs, help protect your expensive wheels from theft.

http://netwelding.com/Wheel_Locks.pdf

GS/C7 OnStar Lights

Rear view mirror OnStar LED's, at a quick glance, look like a police car flashing light! This is a fix.

http://netwelding.com/OnStar_Lights.pdf

GS/C7 Skip Shift Eliminator

Skip Shift Eliminator install with suggestions on jacking a C7.

http://netwelding.com/Skip_shift_Eliminator.pdf

GS/C7 Catch Can & Clean Oil Separator

Direct inject engines are subject to "coking." What is Coking and how to reduce the potential?

http://netwelding.com/Catch_Can.pdf

GS MGW Flat Stick Shifter

The MGW shifter shortens throw and is more precise

http://netwelding.com/MGW_Shifter.pdf

GS/C7 Round Shift Knob

A round shift knob shortens throw on OEM shifter

http://netwelding.com/Shift_Knob.pdf

GS/C7 Stingray Sill Plate

Stingray sill plate replaces original.

http://netwelding.com/Sill_Plate.pdf

GS/C7 Nylon Bra

Nylon Bra Stops Bugs on Front and Grill. Fits with Stage 3 Winglets

http://netwelding.com/Nylon_Bra.pdf

GS/C7 Clutch Fluid Change

Clutch fluid after 3000 miles gets dirty

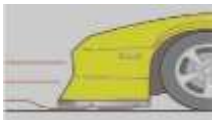
http://netwelding.com/Clutch_Fluid.pdf

C7 Carbon Fiber Hood Vent

Replaces Plastic Hood Vent

http://netwelding.com/Hood_Vent.pdf

GUttrachi@aol.com

GS/C7 Cold Air Intake ***Low Restriction Air Filter & Duct*** **http://netwelding.com/Cold_Air_Intake.pdf**	
GS/C7 Soler Modified Throttle Body ***For Improved Throttle Response*** **http://netwelding.com/Soler_Mod_TB.pdf**	
Garmin GPS for GS Cubby ***Garmin Mounts in GS Cubby & Apple CARPLAY*** **http://netwelding.com/GPS_In_Cubby.pdf**	
GS Splitter Stage 3 Winglet ***Stage 3 Winglets Integrate with Spats*** **http://netwelding.com/Stage_3_Winglets.pdf**	
GS 2LT to 2.5 LT ***Red Upper Dash Pad Like 3LT*** **http://netwelding.com/Red_Dash_Pad.pdf**	
Jake Emblem/Decals for GS ***Jake Symbols Support GS Racing Image*** **http://netwelding.com/Jake_Emblems.pdf**	
GS Splitter Protector ***Scrape Armor Protection for Splitter*** **http://netwelding.com/Splitter_Protectors.pdf**	
GS Engine Compartment Mods ***Cosmetic Additions in Engine Compartment*** **http://netwelding.com/Engine_Compartment.pdf**	
GS Vitesse Throttle Controller: Fits All C7s ***Adjustable Throttle-by-Wire Control*** **http://netwelding.com/Throttle_Control.pdf**	
Boomy Bass Solution ***Use Presets to Adjust Bass etc Tone/Balance*** **http://netwelding.com/Boomy_Bass**	
GS/C7 Air Dam, Functions ***Why Missing from Z51, Some GS & Z06*** **http://netwelding.com/Air_Dam.pdf**	
Engineering a ProStreet Rod ***How Our '34 ProStreet Rod Was Designed and Built*** **http://netwelding.com/Engineering%20Street%20Rod%203-08.pdf**	
Motorsports Welding Article ***Wrote a 5 Page Article for AWS March 2018 Journal Covers NHRA and NASCAR Chassis Design*** **http://netwelding.com/Motorsports_Welding_2018.pdf**	

 GUttrachi@aol.com