RK AUTOWERKS

Automotive Performance R&D

G8x M3/M4 Billet Port Injection Manifold

“The RESULTS Manifold”

The RK Autowerks G8x M3/M4 Manifold Features

- **Performance**
  - **0-2F Degree IAT delta below 30psi from 20-130mph at 85F**
  - **5F Degree IAT delta at 35psi from 20-130mph at 85F**
  - **12F Degree IAT delta at 45psi from 20-130mph at 85F**
  - **45% core volume increase**
    - **Factory manifold is 215 in^3, RK manifold is 315 in3**
  - **No increase in pressure drop even though the core is 45% bigger**
  - **High performance Wagner Tuning tube and fin core for maximum heat transfer**
    - **Lightweight core with the same BMW fin configuration but split into 2 channels and taller fins**
  - **CFD testing to optimize port design**
    - **Velocity stack and tapering of runners to optimize flow**
  - **Thermal analysis to reduce material in necessary locations**

Features

- **Includes a Port matched phenolic spacer**
  - **Acts as a thermal barrier that separates the manifold from the cylinder head**
  - **Lowers intake temps and reduces heat soak**
- **Top feed billet fuel rail with -8AN provisions on each side using EV14k body**
  - **Any fuel rail that bolts on factory manifold works with RK manifold**
- **3x 1/8 NPT sensor pad to assist with external sensors**
  - **Allows installation of external sensors and fittings**
- **6x 1/8 NPT ports in the runners for Nitrous or methanol**
  - **Port matched to prevent fuel from dripping down walls**
- **2x 1/8 NPT ports pre cooler for using meth or nitrous to freeze manifold while staging**
  - **Allows you to purge manifold with meth to bring IAT down prior to a run**
- **TIG welded and pressure tested in house**
- **Self bleeding manifold like OEM, eliminating any concern for air pockets**
- **Block off caps included for plugging OEM vacuum lines**
- **True plug and play bolt on installation with all hardware included**
- **Comes with the standard RK Autowerks LLC warranty**

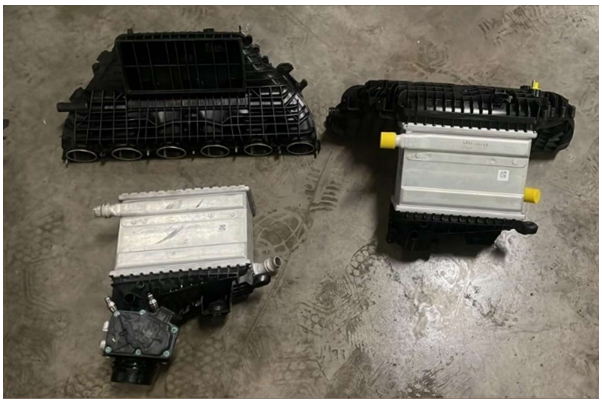
Manifold Options

- **Oversized port matched runners for oversized cylinder**
  - **Allows you to send runners to us to match to your CNC head**
  - **If not, port matched the CNC head becomes choked by manifold**
- **Optional Bosch 750cc or ID1050cc injectors with fuel line integration**
- **Specialty fasteners burst panel, SFI Spec 23.1,**
  - **Prevents backfires from nitrous installation**
- **Custom laser engraving, powder coating and thermal coating**

Engineered, designed, manufactured, tested, and packaged in Texas, United States

THE MISSING PIECE TO UNLOCK THE S58 PERFORMANCE

The S58 platform has already been proven to be one of BMWs most well-rounded performance engines to date. With a simple tune and downpipes, the vehicle can run 9s in the ¼ mile. But as we all know, we all want to go faster. Our first area of concern was the OEM intake manifold. The OEM manifold offers more than sufficient cooling, but the construction with plastic end tanks leaves a large weak point. With our own testing, we broke 2 manifolds trying to push past 35psi.



Partners

Naturally, we were going to produce our own manifold. We partnered with M Powerhouse in New York along with Wagner Tuning and Utku Noa Performance in Germany. Together, we were able to produce a product that checks every box one could possibly ask for, creating the ultimate manifold.

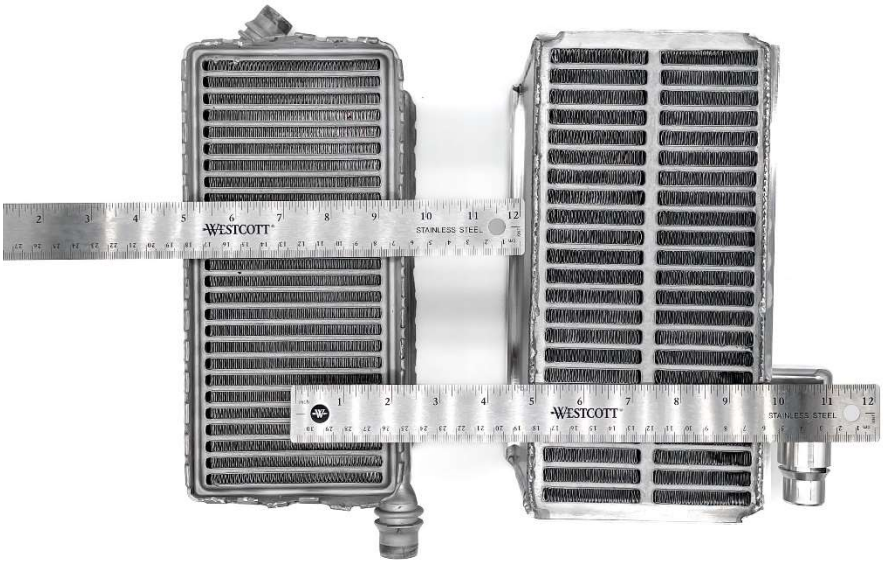
Wagner Tuning: Founded in 1994 by Carsten Wagner in Germany, they specialize in cooling products and automotive performance. Wagner is a one stop manufacturer that develops all their products in house, from reverse engineering, design, and testing. They even manufacture their own coolers, cores, downpipes, and other performance parts. Wagner recently skipped across the pond and built their US HQ is in Kilgore, TX, about an hour east of Dallas, Texas.
https://www.wagner-tuning.com/ https://www.instagram.com/wagnertuning/?hl=en

M Powerhouse was founded by Merrick McDonald in 2020 in New York. Merrick's team specializes in building fast cars. They hold several records with the BMW B58 and S58 platforms. They are your one stop shop for installation, diagnosing, tuning, and consulting. With their assistance, we were able to conduct extensive testing and make the necessary changes during development. Contact M powerhouse for your BMW performance needs.
https://www.instagram.com/_mpowerhouse/?hl=en

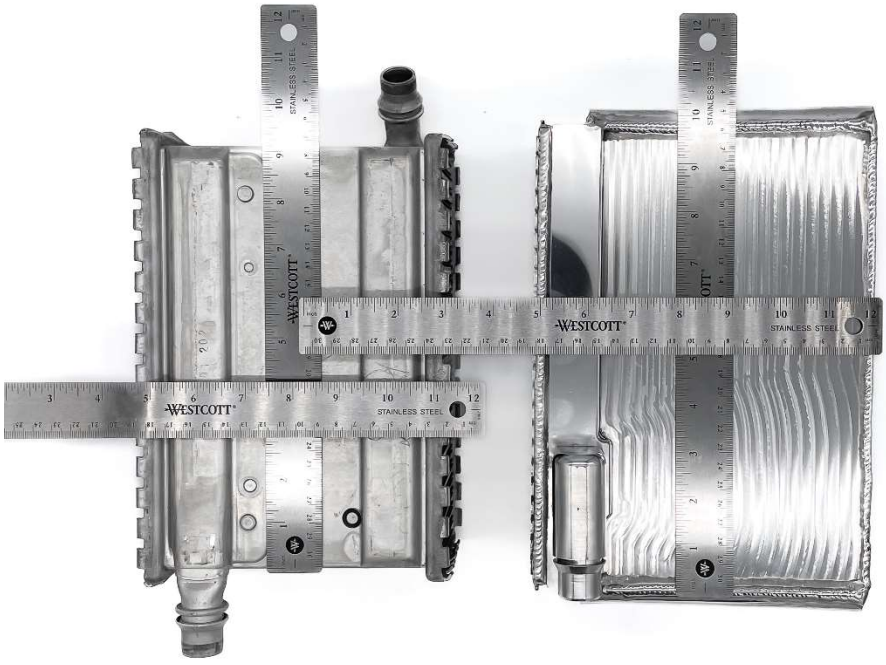
Utku Noa Performance was founded by Utku Bulbul in Germany in 2020. He was a BMW senior calibration engineer for the M division. He now tunes high performance vehicles from your BMW to any of your exotics. All his calibration work is on the ECU, no piggybacks or trickery. He is our personal tuner when it comes to our vehicles, having tuned our F9x, F1x, and G8x. Contact him for all your tuning needs
https://www.instagram.com/utkunoaperformance/?hl=en

The Core: Powered by Wagner Tuning

The core is the most important part of the manifold and is provided by **Wagner Tuning**. The OEM unit is very efficient at cooling and improving upon it was rather difficult. BMW also did a phenomenal job with the factory manifold, but with extensive testing we were able to maximize cooling. The factory unit has a volume of 215 in^3. By increasing the core size in every direction, we were able to squeeze in 315in^3, a nearly 50% increase in core size.



The fin density was a large area of focus. BMW utilized shallower stack height at about 0.225". This does a great job with cooling, but as you raise the pressure, it creates a restriction to flow with the size core we are trying to run. As a result, we compromised with a taller stack height at 0.270" but retained the fin density. This allows the unit to provide the necessary cooling without becoming a restriction. The combination yielded the expected results from our manifold.

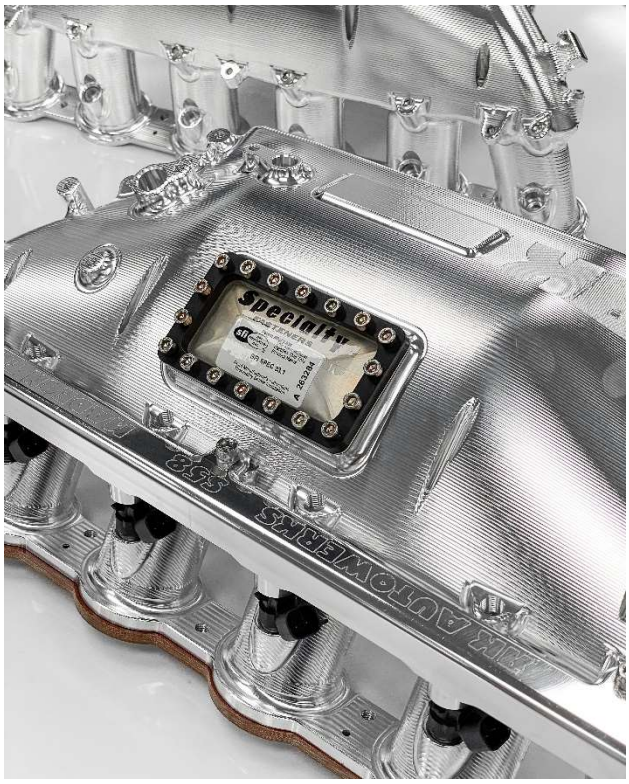


Core volume comparison	
OEM	**215 (in^3)**
RK Manifold	**315 (in^3)**
Volume Increase	**46.51%**

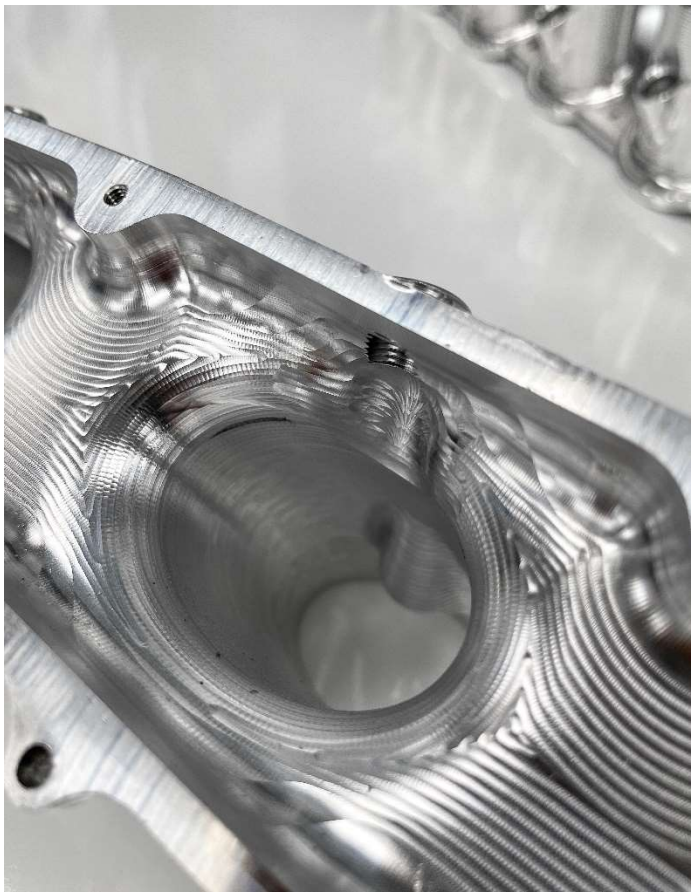
Design:

An area we excel in, we made sure we listened to our customers and partners. With the assistance of M Powerhouse and Antonis at Tans Designs, we were able to go through several revisions and dialed in the manifold to have every feature possible. The first thing that stands out is the all-billet construction.

Billet Construction



The manifold was designed and constructed in house to keep welding to a minimum. The RK manifold bolts together and comprises of 10 pieces of billet to form the final unit. Air flow begins with the bottom inlet, travels into the core which has 2 water end tanks along with 2 end caps. The flow then merges into the collector, which is all machined out of 1 solid piece of billet. After the flow merges, it routes itself to the runners, also machined from one piece, and they bolt onto the collector. This is all done in house on our two 5-axis CNCs running alongside our 4-axis mill.



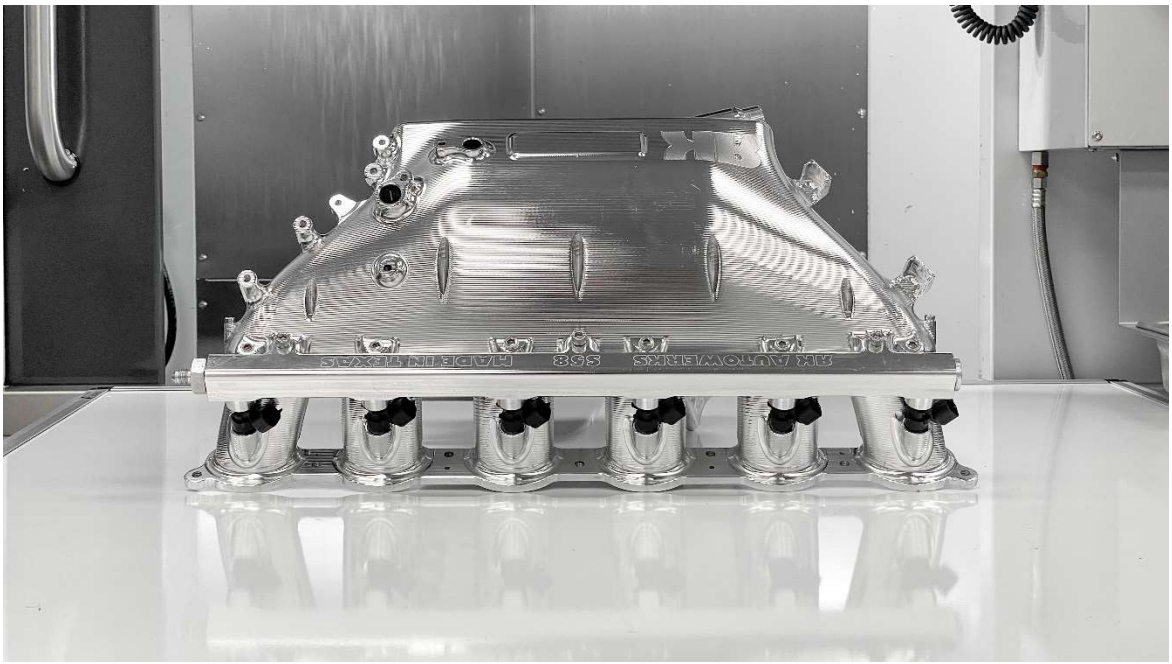
Each runner is port matched to the OEM cylinder head. The shape and slope of the ports were matched to ensure there was no disruption. But like many stock manifolds, this area becomes a choke point when you run an oversized cylinder head. With our manifold, the runners have the option to be port matched for the oversize setup. You're not stuck with a manifold that will choke the flow for mods down the road. Simply remove the runners and ship them to us to be oversized. Additionally, each runner is ever so slightly tapered to assist the flow being accelerated as it enters the cylinder head. With the velocity stack machined into the runners at the top, this maximizes the performance.

Integrated Manifold Design Features

The first thing that stands out are all the features incorporated into the RK manifold, the most distinct being the specialty fastener burst plate. This was incorporated for those wanting to run nitrous and is used to prevent backfires from nitrous. The plate is designed to blow out, so you don't damage your engine or the rest of the induction system. The burst plate is not standard, but an option on the RK manifold. It's as functional as it is aesthetically pleasing.

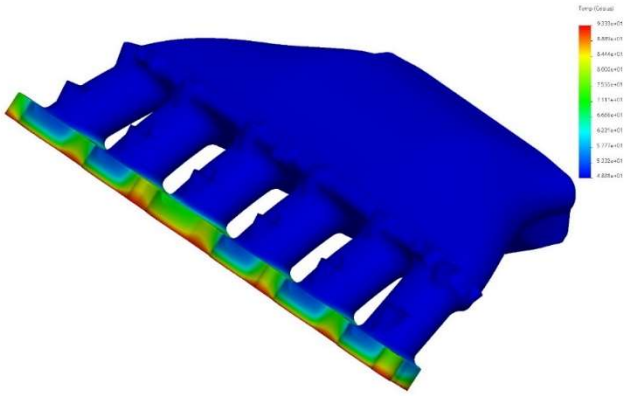
We know many of you want additional cooling or a shot of nitrous, so we've made sure the option is there. 6 1/8 NPT ports, which are port matched as well, allow you to run nitrous or methanol without the fuel catching the walls. Three additional NPT ports are on the back for additional sensors to assist with these systems, if needed.

As found on the factory manifold, the RK manifold has port injection. The manifold works with any fuel rail that works on the stock manifold. We still offer our billet fuel rail if needed, along with the injectors, and fuel lines; to complete your install. All of this done on the runner section separating each cylinder to keep fuel and flow uninterrupted.



Phenolic spacer

Another key feature is our phenolic spacer. As found in the aerospace industry, we wanted to keep heat transfer to the manifold to a minimum. This was done by detaching the manifolds mounting face from the cylinder head. Our CFD thermal analysis testing showed this would provide a benefit when it came to heat transfer.



This means the manifold will cool down faster, rejecting more heat, and not be forced to take in the heat from the engine. Unlike many spacers in the industry, a flow critical feature we want to bring to your attention is the port matching of the spacer. Many will sell you a generic spacer, but our spacers are cut individually to each manifold, so the transition is seamless.

Combined with the dovetailed o-ring and the m4 bolts securing the spacer to the manifold (your installer will appreciate this), it makes install for the consumer effortless and maintenance free. The dovetail o-ring groove ensures the o-ring has fill space making it a lifetime part.

Testing and Data Collection

Testing was done by our partner M Powerhouse on their shop G80. The runs were all conducted on the same night with same vehicle. The manifold was swapped after stock manifold testing was completed. The new manifold was installed and the external variables were controlled as much as possible.

- Test vehicle
  - 2022 M3 X-drive
- Modifications
  - RK manifold
  - RK stage 2 turbos
  - RK downpipes
  - RK forged rods and pistons
  - E85 fueling

Tests conducted

1) 20-130mph IAT delta
   a. Vehicle driven from 20-130 mph with IAT logged to analyze the delta increase
   b. Tests repeated at 35psi and 45psi

   Purpose: To compare IAT temperature increase over a controlled speed

2) Recovery of intake air temperature (IAT)
   a. Vehicle driven after a 20-130mph WOT pull at 20-30mph until IAT recovers back to where it was at the start of the test.
   b. Both tests conducted under the same pressures

   Purpose: To analyze how long it takes for the IAT to recover

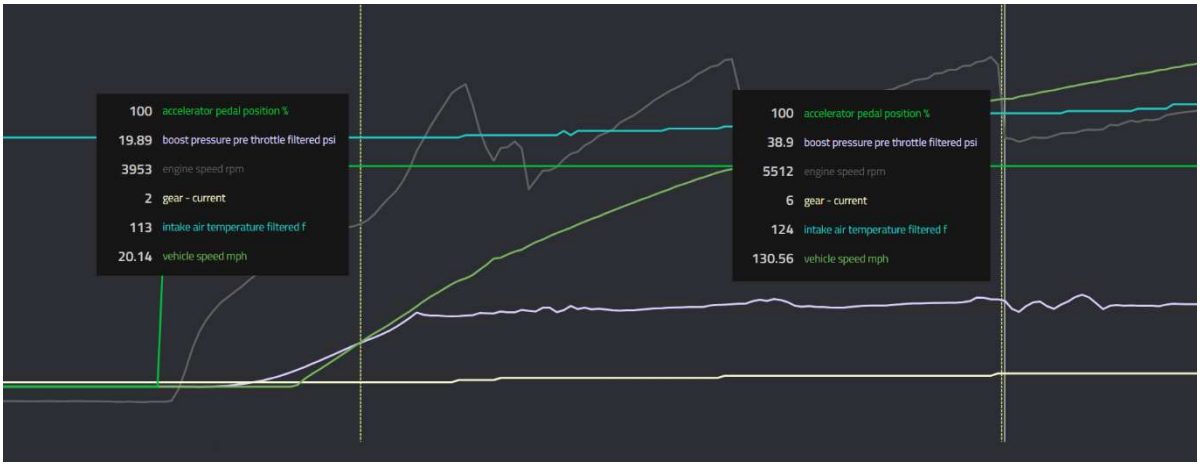
3) Flow bench pressure drop analysis
   a. Both manifolds flowed on a superflow flow bench at a variety of pressures

   Purpose: Validation of pressure drop to ensure the manifold is not a choke point

4) IAT repeatability
   a. Repeated back to back runs with a long cooldown period at the end to
   b. Testing conducted at 40psi

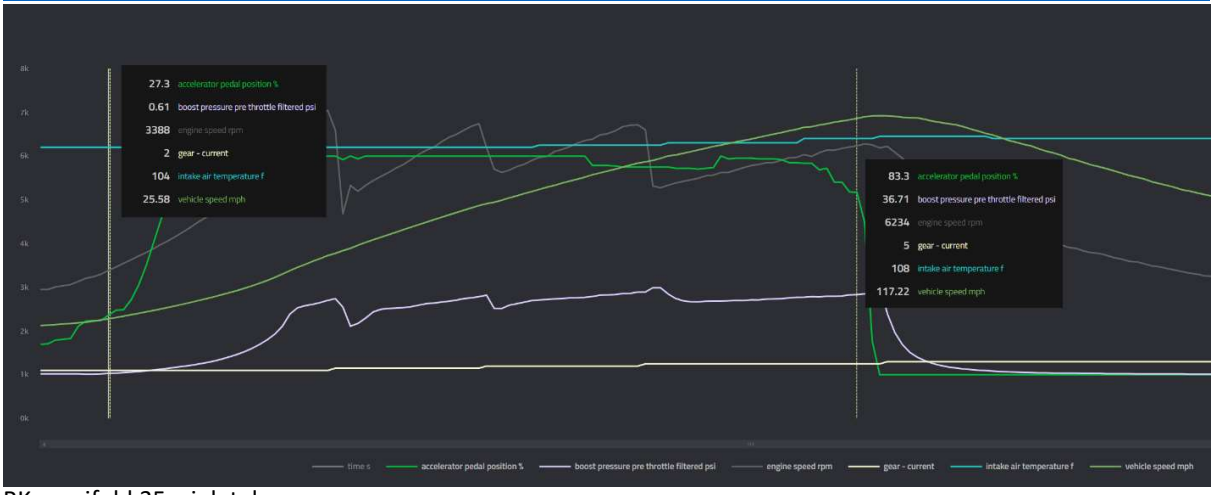
   Purpose: analyze how resistant the manifold is to heat soak and how quickly it recovers under extreme conditions

20-130Mph IAT Delta



Stock manifold 35psi

https://datazap.me/u/rk-autowerks/log-1662073342?log=0&data=1-2-3-4-5-6&zoom=626-970&mark=802-711



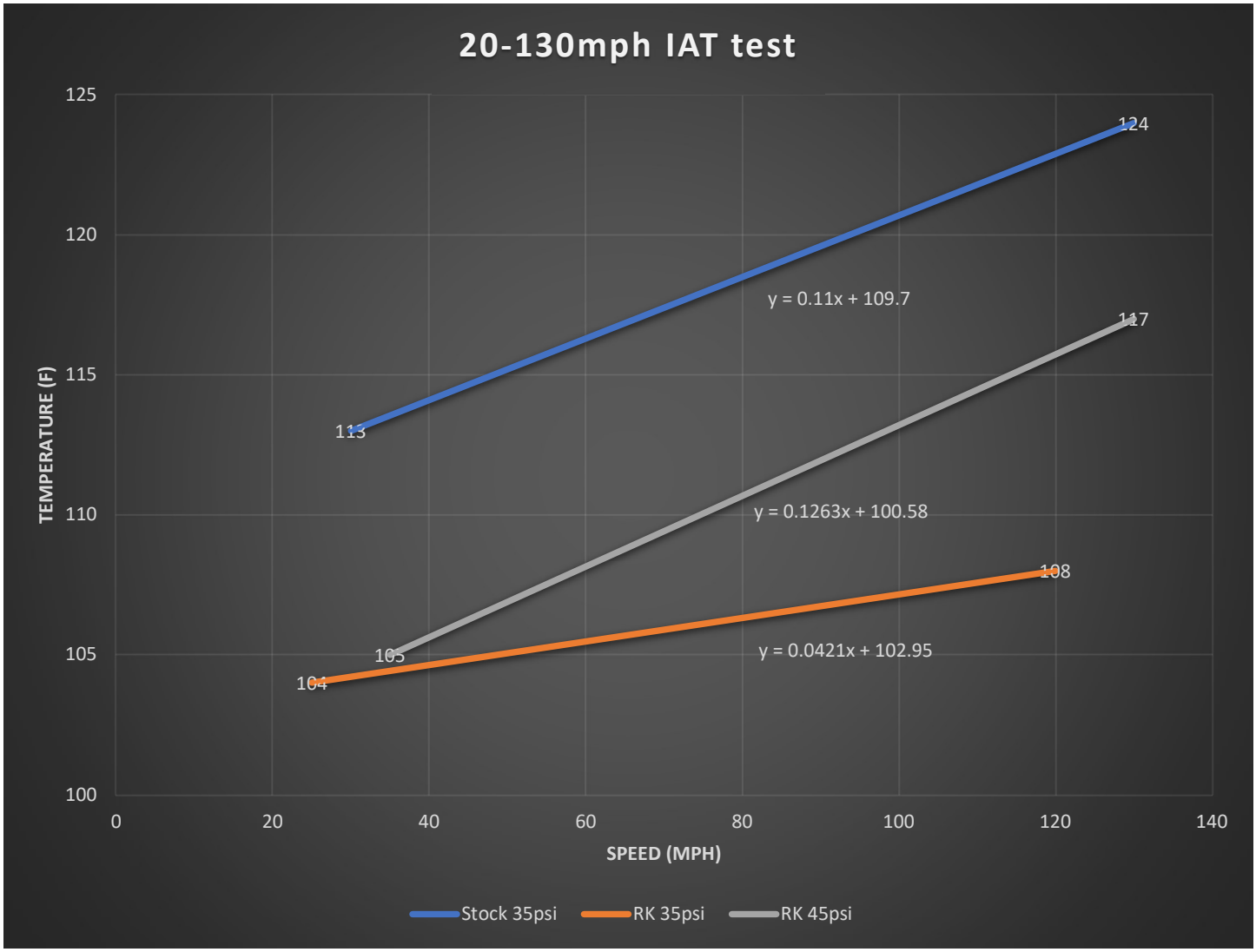
RK manifold 35psi datalog

https://datazap.me/u/rk-autowerks/log-1662043508?log=0&data=1-2-3-4-5-6

RK RK manifold 45PSI datalog

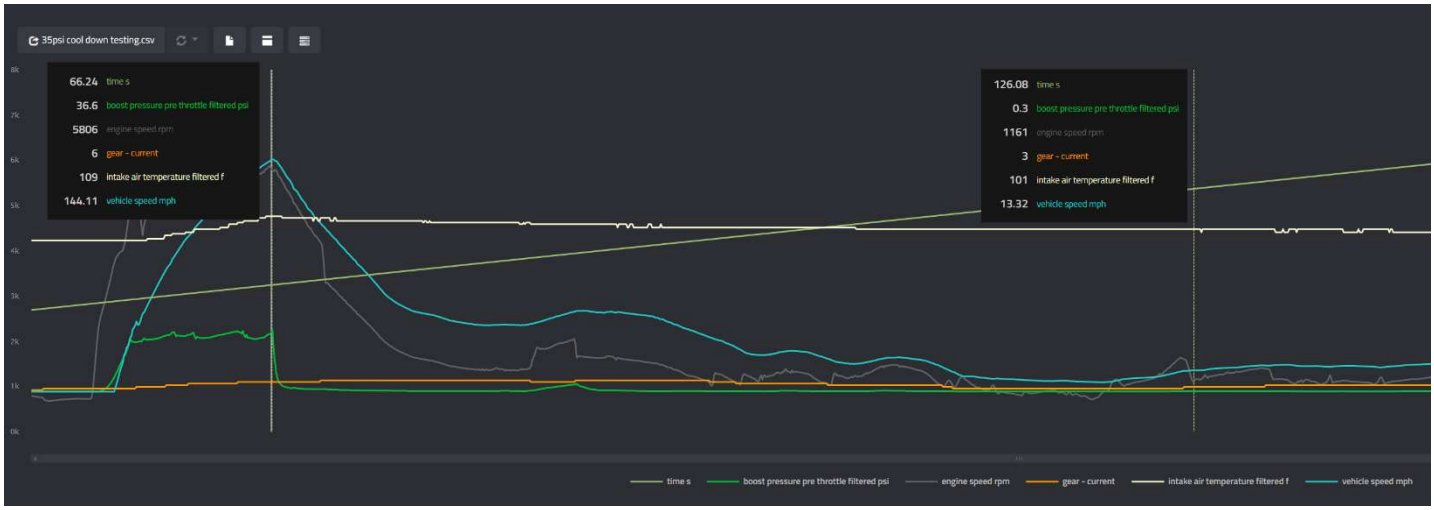
https://datazap.me/u/rk-autowerks/log-1662043707?log=1&data=1-2-3-4-5-6&mark=41-118

Manifold	Ambient conditions	Boost (psi)	Temp start (F)	Temp end (F)	Delta_T (F)	Start speed (mph)	End speed (mph)	Delta_V (mph)
Stock	85	35	113	124	11	30	130	100
RK manifold	84	35	104	108	4	25	120	95
RK manifold	84	45	105	117	12	35	130	95



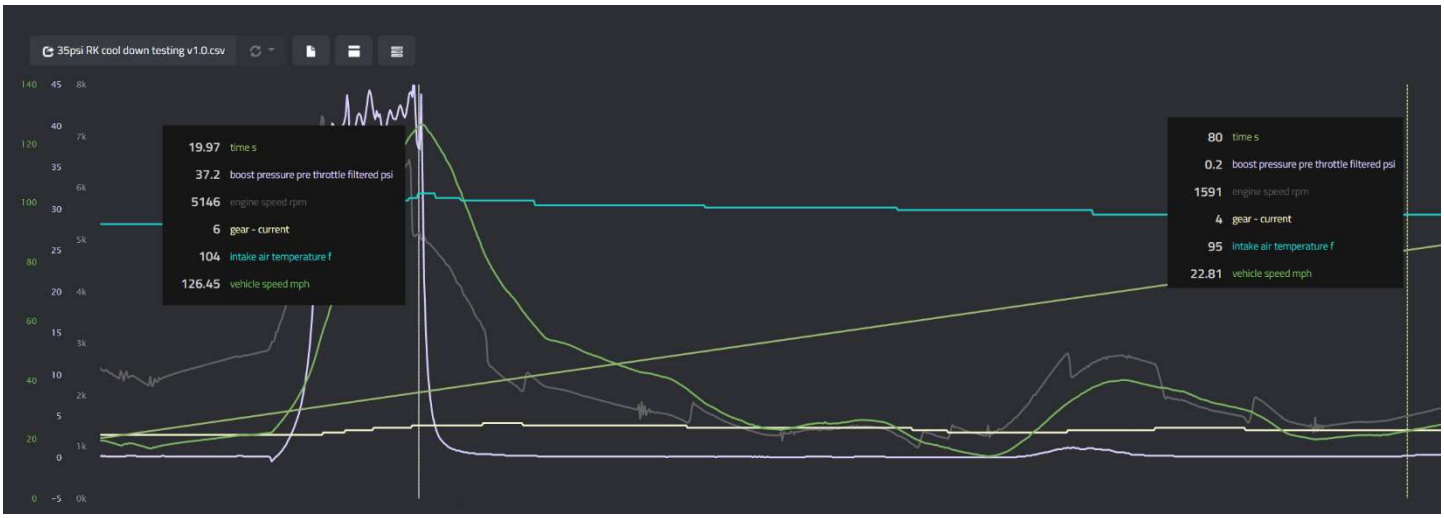
Conclusion: When boost is the same, the stock manifold has a higher starting IAT, as well as a steeper slope for the increase in temperature when compared to the RK manifold. The RK manifold experiences a similar slope when the boost is increased by 10PSI, but once again the starting point is lower than the OEM manifold. This results in **lower IAT under any conditions when compared to stock, by as much as 60%**

Recovery of Intake Air Temperature (IAT)



35PSI stock manifold cooldown

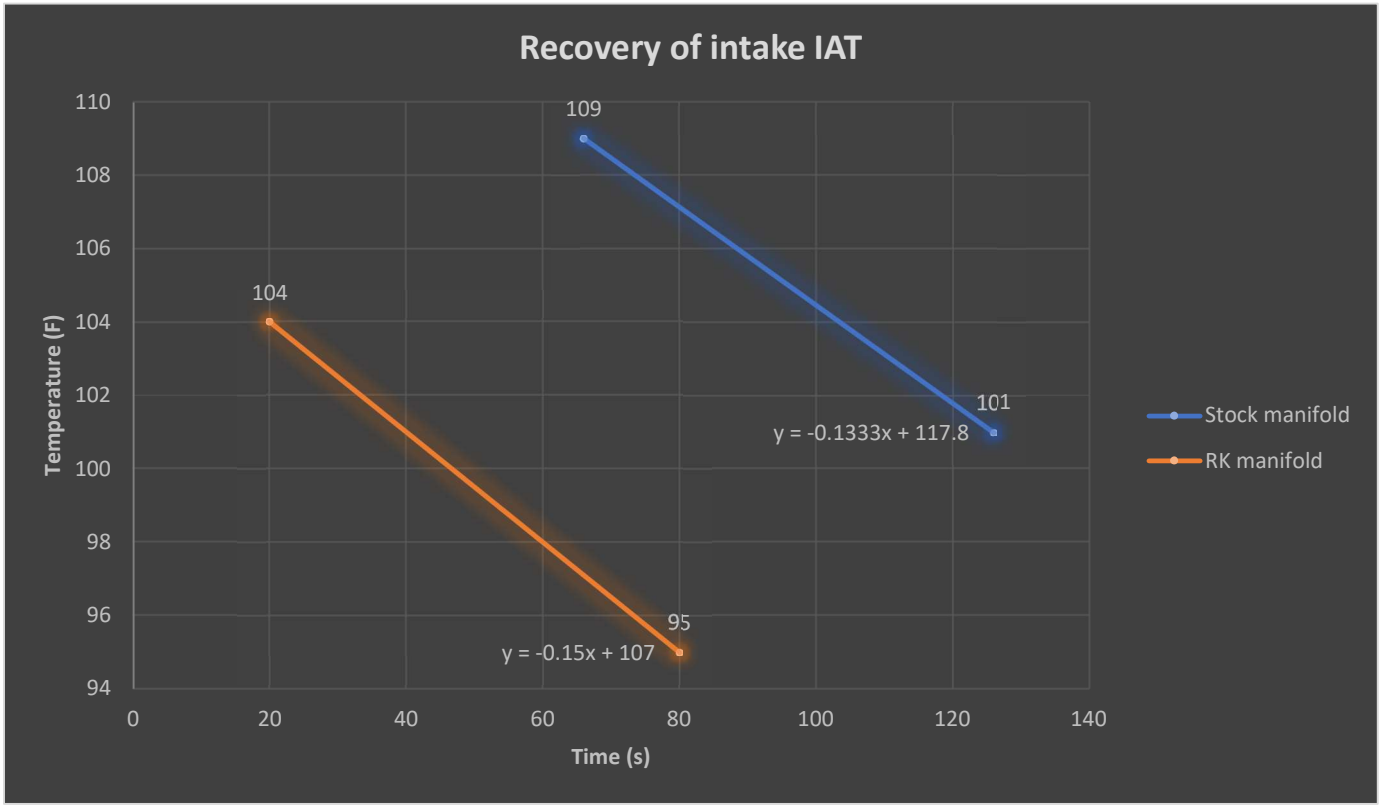
https://datazap.me/u/rk-autowerks/log-1662091266?log=0&data=0-2-3-4-5-6&solo=2-6&zoom=5-1497&mark=220-888



40psi RK manifold cooldown

https://datazap.me/u/rk-autowerks/log-1662091266?log=0&data=0-2-3-4-5-6&solo=2-6&zoom=5-1497&mark=220-888

Manifold	start IAT (F)	start speed (Mph)	start time (s)	end IAT (F)	end speed (mph)	end time (s)		Delta IAT (F)	Delta time (s)
Stock	109	144	66	101	25	126		8	60
RK	104	126	20	95	25	80		9	60



Stock vs RK manifold at 35 psi showing the IAT recovery

IAT Recovery Conclusion: Most will jump to the conclusion that the RK manifold has a better IAT recovery, when you first look at the graph and see lower IAT, you would believe this is true.

THIS IS NOT TRUE.

There is no benefit to IAT recovery between the two manifolds with the data presented under OEM operation. For those who understand the calibration side of the business as well as how a cooling system works, they will agree. The way the vehicle works is that the car does not run the cooling pumps when there is no request from the DME. This is the case after a WOT pull because the cooling capacity is only as good as the cool water in the heat exchanger in the front fascia. If the system were to keep running even when you're out of boost, the benefit would not be as great for when the DME demands it under WOT condition. So for a company to try and advertise an IAT recovery without any data, is one not telling the truth or they do not understand how the system works. This is further reinforced by the slope of the two manifolds, they are nearly identical, nothing worthy to advertise or to use as a selling point, for the reasons explained above.

I realize many of you will question the statement above, but the way the OEM vehicle runs, that is the result you will see with the way the test was conducted, we at RK do not make false claims to sell a product. So I will enjoy the online debate that is to come pertaining this matter.

This data above does prove though the thermal conductivity, under two identical data sets, shows that **our manifold does not heat soak when the turbo is not introducing compressed air.** The manifold cools down at the same rate of the stock manifold and is not absorbing the additional heat introduced in the engine bay.

To further expand on the matter above I will say that the RK manifold, if the pumps were to continue running, would reduce the IAT quicker between runs because the manifold is able to dissipate more heat. This can be reinforced by the Y = MX + B equation derived from the 20-130mph testing.

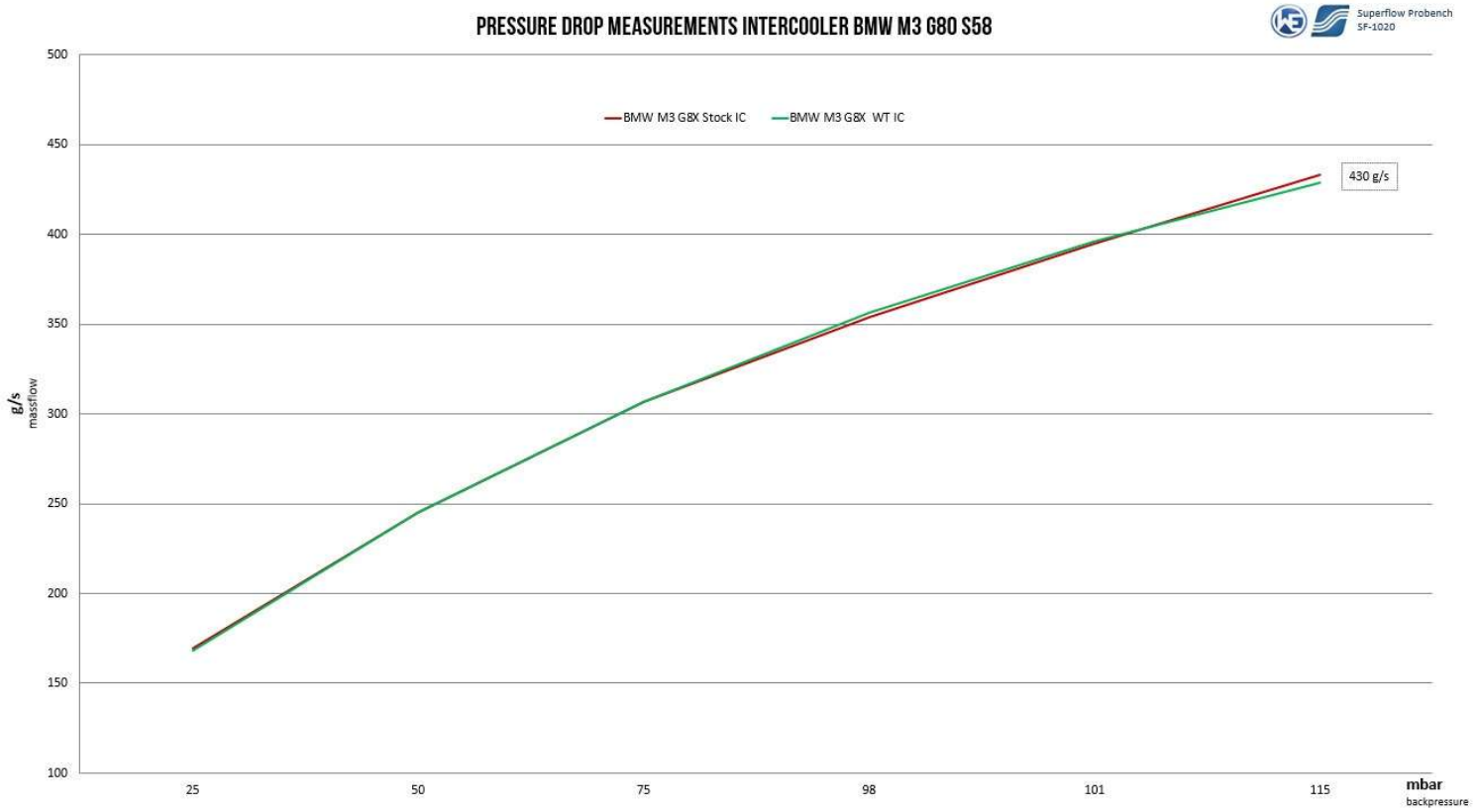
Derived equations for manifold performance at 85F

Manifold	equation
Stock 35psi	Y = 0.1100x + 109.70
RK 35psi	Y = 0.0421x + 102.95
RK 45psi	Y = 0.1263x + 100.58

This equation above is what really matters because that is what governs the data for the manifold under a WOT condition. I realize a few assumptions have to be made because the data set yields a linear line, in a perfect test condition with many data sets, it would be an exponential curve because the manifolds efficiency will be reduced as more heat is introduced over an extended timespan. This is a safe assumption because the slope is increasing at 45PSI compared to the RK 35psi results, and increasing even more when we look at the curve for the stock manifold.

Having derived the equations above, it can be calculated that the **RK manifold has a cooling benefit of 60% over the stock manifold at 35psi** if we were to compare the slope of the two data sets. Many would say that's impossible, but as shown, the data doesn't lie. I personally don't think this is telling the whole story, but my marketing team says we should run with it. 😉 **Another benefit being the 10F delta between the two, the RK manifold starts much lower and keeps temps lower.**

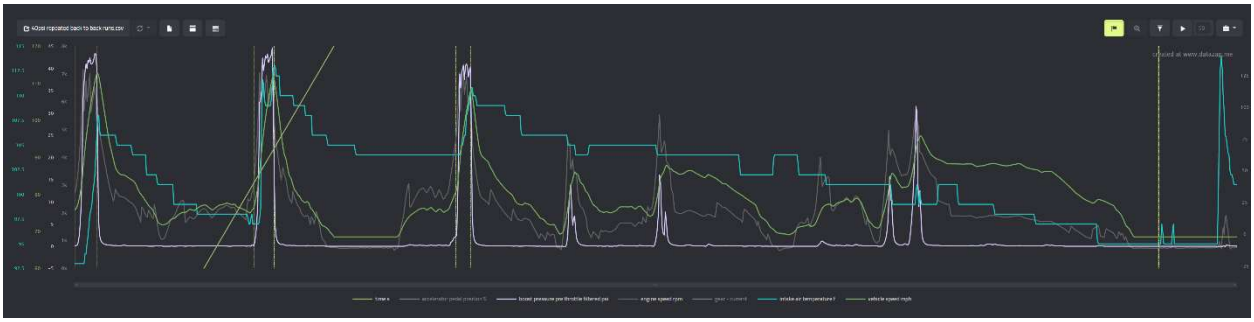
Flow Bench Pressure Drop



Flow bench conclusion: Using a SuperFlow SF-1020 both manifolds were tested at different mass flows to simulate the mass air being introduced into the manifold. This is important because we don't want to increase the restriction the manifold has, also known as pressure drop. Sweeps were conducted at a variety of mass flows and as the data shows, **even though we increased the core volume by 46%, our core did not effect the pressure drop.** This is a testament to the fin selection and fin density selected in our core. A phenomenal job by the guys at Wagner Tuning. Without the help of Carsten and his team this would not be possible.

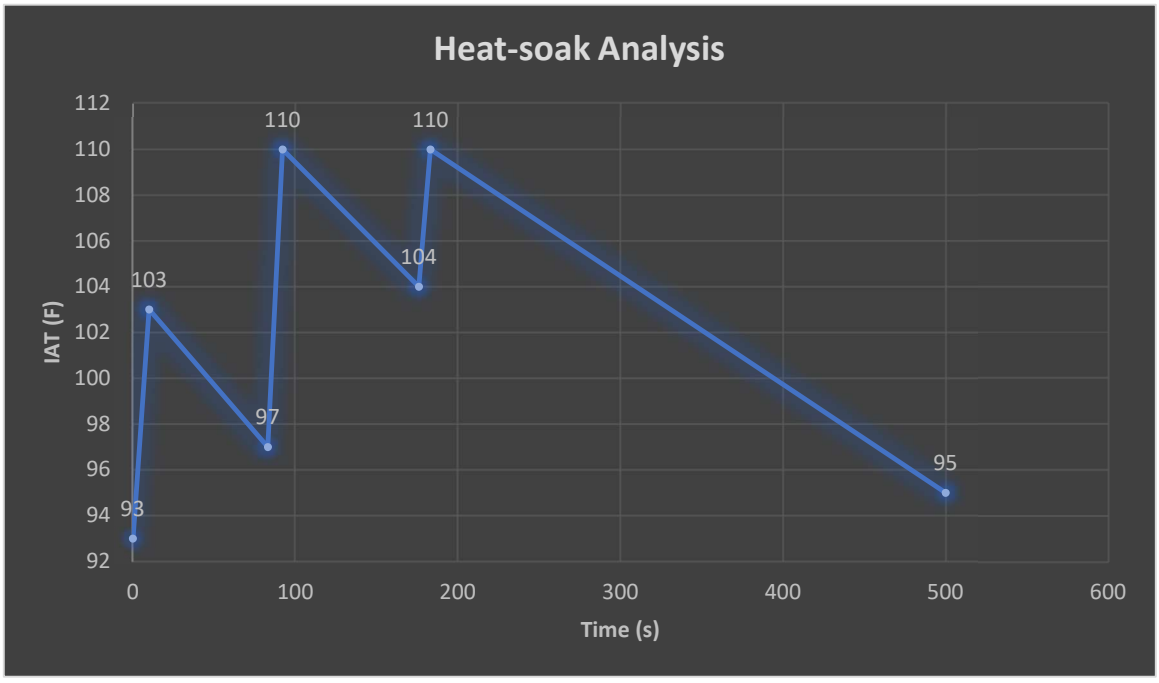
IAT repeatability

Test procedure: vehicle was driven with 3 back to back runs and then allowed to cool down to show the ability to cool the IAT under extreme conditions. Testing was done at 40psi to introduce as much heat as possible, cool down periods inbetween were roughly 1 minute of driving, followed by a very long cool down at the end.



https://datazap.me/u/rk-autowerks/log-1662127457?log=0&data=0-2-3-5-6&solo=0-1-2-4-5&mark=114-2-922-1025-1958-2034-5560-5558

Time Stamp (s)	IAT (F)	Speed (MPH)
0	93	20
10	103	120
83	97	20
92	110	120
176	104	40
183	110	120
500	95	0



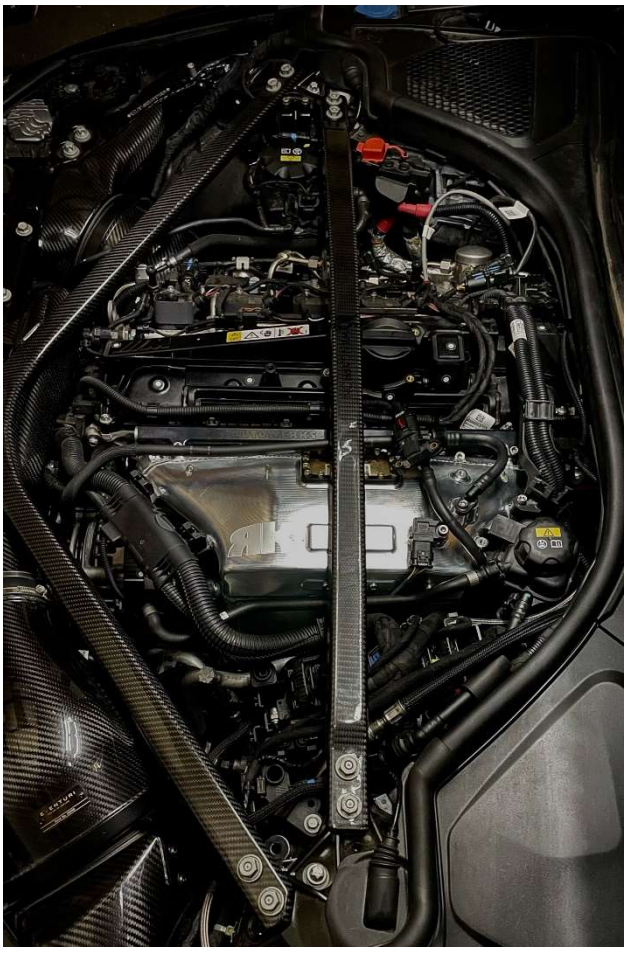
IAT Repeatability Conclusion: The initial run had the lowest end of run IAT, but it can be seen that the IAT max with 40psi runs is 110F, the manifold temperatures normalize and the vehicles coolant system reaches its maximum ceiling. This extreme condition is great for those that plan on road racing with the manifold. Most will not be on the track with these extreme conditions with this much boost. So to operate the vehicle at lower temps its safe to assume that you would have consistent repeatability. The manifold also cools down back to where the IAT started at the beginning of the run.

Final conclusion

As shown through our testing, it is very clear that our manifold works and produces the results we are looking for. To say how much of an improvement with one number would not be fair to the end consumer. Each application is going to be different. But for those going beyond 30psi, the performance benefit is nearly 40-50%

I will go on record to say our manifold works amazing, it was designed to compete with OEM IAT, it beats the OEM manifold when comparing cooling. It comes with full billet construction ensuring you can run all the boost, it looks super cool, and its built by the enthusiast for the enthusiasts in Texas.

Category	Results
IAT Beginning of run reduction	10%
IAT Transient reduction	60%
Cooler size increase	46%
Pressure drop change	0%
Capable of 30psi+	yes
Port injection	yes
Meth/NOS	yes
Port matched	yes
Made in America	yes
World exclusive	Yes



Until next time,
-Raza Khalid
Lead engineer at RK Autowerks LLC