ENGINEERING REPORT

2020+ Ford Explorer ST Front Mount Intercooler Kit | SKU: MMINT-EST-20

By Mitchell Levy, *Mishimoto Product Engineer*

REPORT AT A GLANCE

- **Goal:** Create a direct-fit front mount intercooler for the 2020+ Explorer ST with the largest core size that can fit with all other factory components. (Including factory intercooler piping).
- **Results:** On a tuned vehicle, the peak charge air temperatures dropped by a whopping 117 ° F (47°C), resulting in a 65-horsepower gain. With the factory calibration, the temperature drop was 97°F (36°C) with a 34-horsepower gain while having a lower pressure drop across the core than the factory intercooler.
- **Conclusion:** The Mishimoto intercooler is a great upgrade over the undersized factory intercooler on the Explorer ST. The Mishimoto intercooler will allow a great power increase on a stock vehicle and unlock extra power on a modified vehicle, while supporting future upgrades. It is a must have to improve performance on this platform.

CONTENTS

DESIGN OBJECTIVES

The design requirements assigned to this project are as follows:

- Create an intercooler with cast end tanks and a large bar and plate core
- Bolt on installation
- Compatible with factory charge pipes
- Ensure that the intercooler does not have a detrimental effect on other vehicle cooling systems
- Utilize extra mounting points so that the heavier intercooler does not damage factory intercooler mounting points
- Integrated air diverter in hot-side end tank

DESIGN AND FITMENT

Our design process started with taking apart the stock systems to analyze them. The factory Explorer ST intercooler is the same part number as its non-ST (but still turbocharged) counterparts. The 2.5"-thick, 6.25"-tall and 26"-long tube-and-fin core is smaller than what was used on the 350 hp Focus RS. The stock intercooler is hidden behind a large grille shutter assembly and mounted directly to the plastic radiator end tanks. Unlike other longitudinal V6 EcoBoost applications, the Explorer has a single inlet and single outlet as the hot-side intercooler pipes merge before the intercooler. The space available between the grille shutters and radiator does not leave much room for a thick intercooler, as the A/C condenser is located just below the factory intercooler, shown in figure 1.

FIGURE 1: *Factory Explorer ST Intercooler.*

With the help of rapid prototyping, 3D scanning, and 3D modeling, we decided upon a 2.15"-thick, 16.5"-tall and 26"-wide core as it look up most of the available exposed frontal area that the grille shutters would allow. Although slightly thinner than the factory unit, the Mishimoto has significantly more frontal area to make up for it.

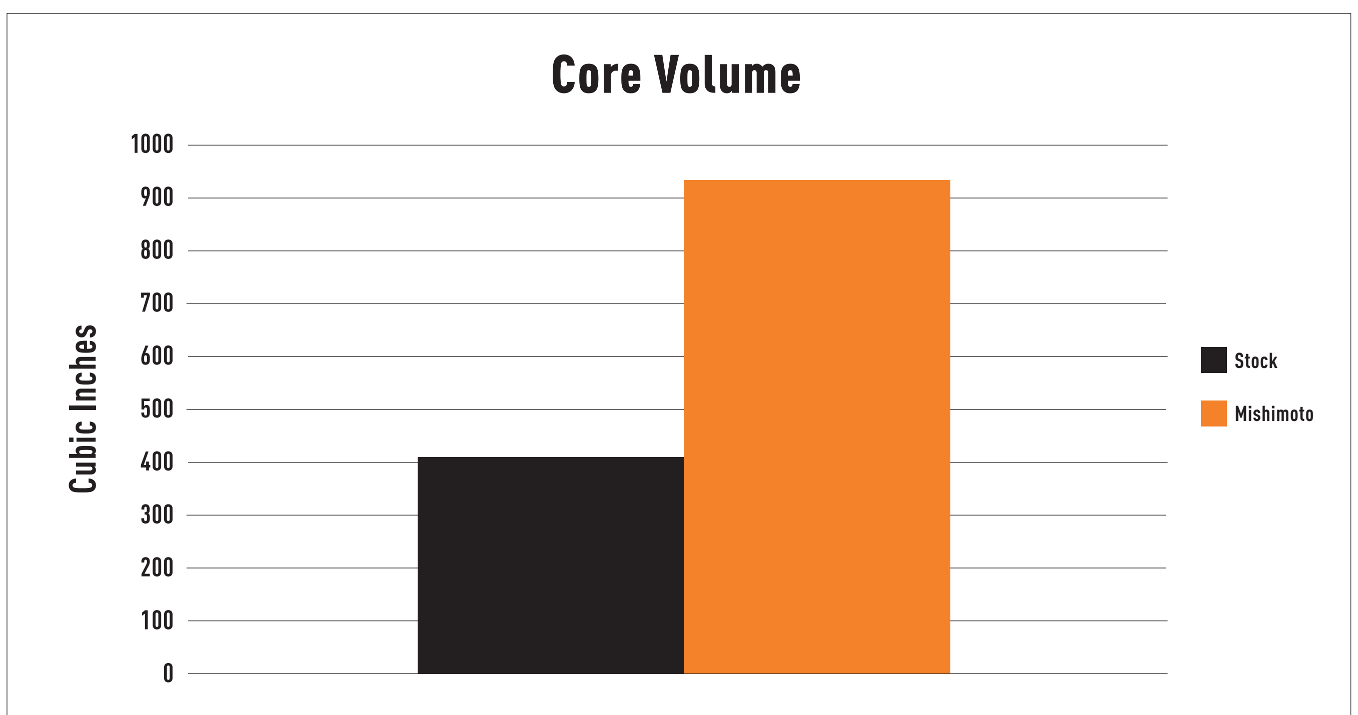

FIGURE 2: *Core Volume Comparison.*

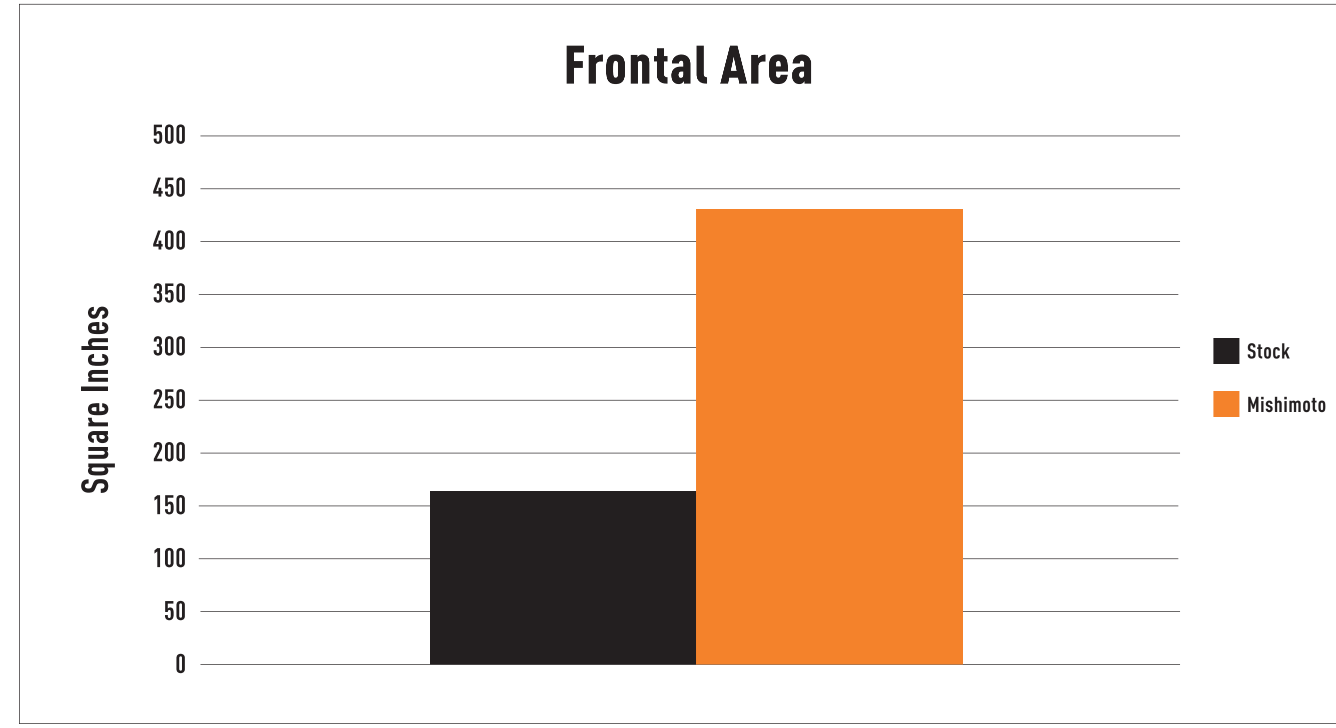

FIGURE 3: *Frontal Area Comparison.*

FIGURE 4: *Scan Data overlayed on Mishimoto Intercooler.*

As the intercooler is significantly longer than the factory unit, and the inlets and outlets are located in the top portion of the cooler, we were concerned that the air would only flow through the top of the core, reducing the intercooler's ability to exchange heat effectively. To combat this, we employed a cast diverter within the hot-side tank to push air toward the bottom of the core, maximizing cooling. As shown in figures 5 and 6, the diverter fin showed to be quite effective in CFD analysis

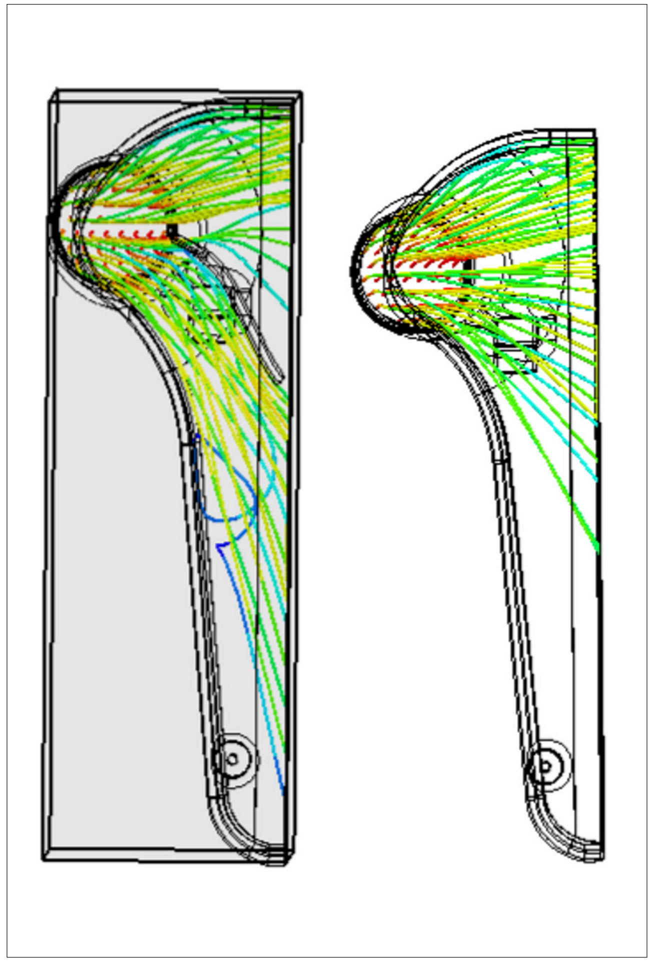

FIGURE 5: *Flow with and without diverter.*

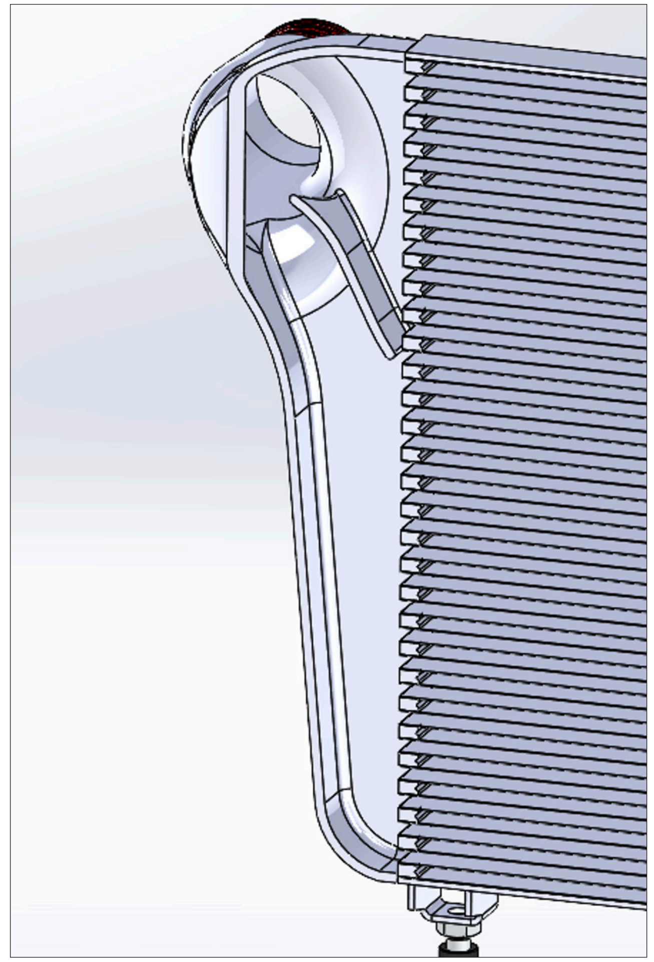

FIGURE 6: *Hot side end tank cutaway.*

PERFORMANCE TESTING

Our testing vehicle was a 2020 Ford Explorer ST, with a HP Tuners ECU calibration and Mishimoto catch can kit. The testing was performed on our in-house DynoJet™ AWD linked chassis dynamometer. The vehicle was left on the dyno during parts changes to ensure that dyno results were not affected by how the vehicle was strapped down to the dynamometer. The vehicle was able to be switched back and forth between the aftermarket calibration and the factory calibration so that both calibrations could be tested.

Data was collected on the AEM AQ-1 data acquisition system through temperature and pressure sensors located in both the hot-side and cold-side charge pipes, close to the intercooler. HP Tuners software was utilized to gather data from the engine control unit through the OBD-II port. A variety of data was collected, including pressure and temperature data from the factory sensors as well as other important information such as coolant temperature, ignition timing, and knock.

FIGURE 7: *Explorer ST on DynoJet Dyno.*

Once warmed up to a consistent coolant temperature of 185°F, several test pulls were performed on each intercooler, both with the factory and aftermarket calibrations. The aftermarket calibration targeted significantly higher boost levels, especially at higher RPM. Boost levels at 6,000 RPM were 13.6 PSIG on the factory tune vs. 21.4 PSIG on the aftermarket calibration. This required the turbochargers to spin significantly faster, likely out of their efficiency range, which creates significantly more heat for the intercooler to cool. On the tuned vehicle, the peak power increased by 65 horsepower and peak torque increased by 12 lb-ft.

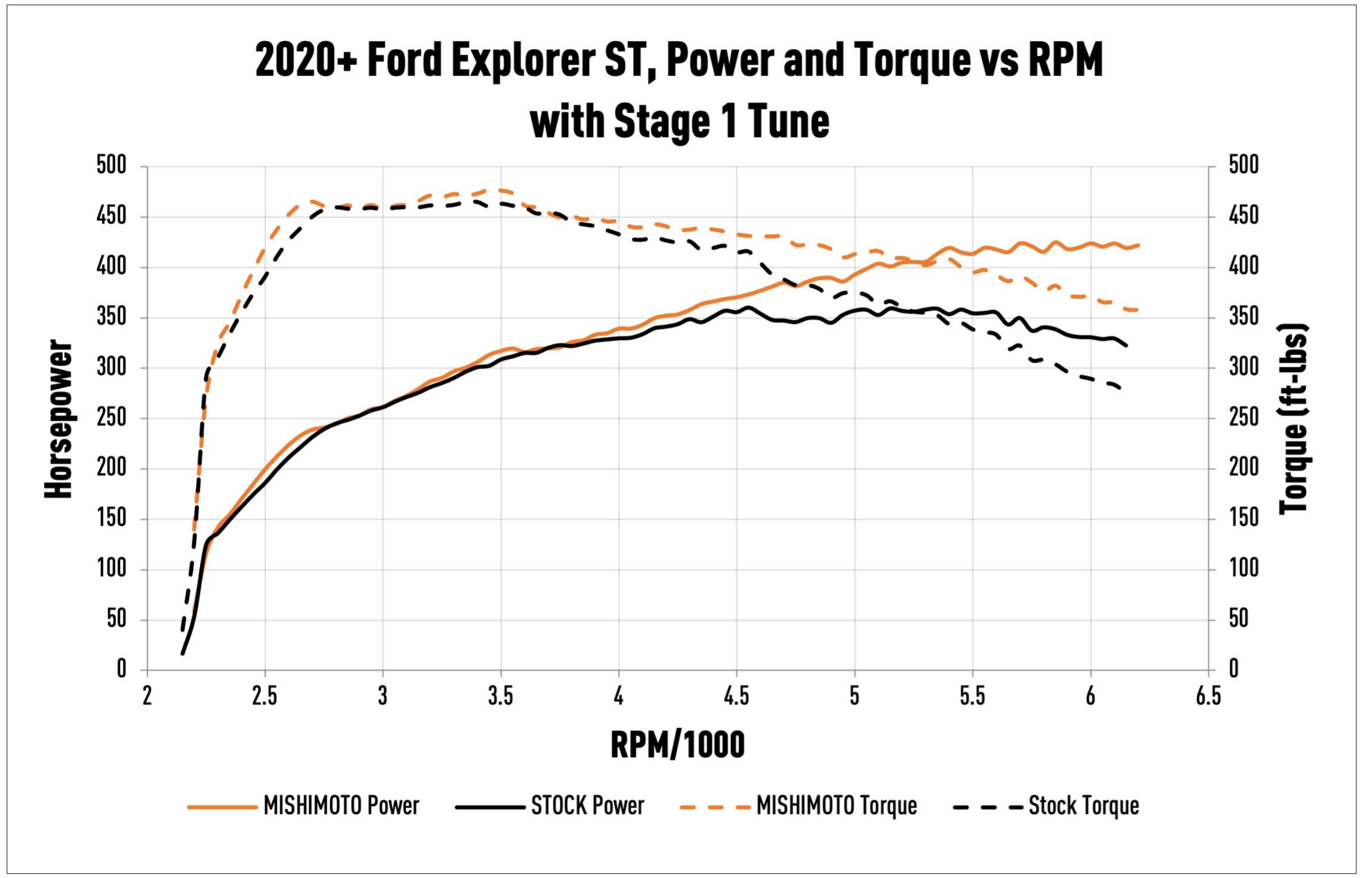

FIGURE 8: *Dyno Results on Aftermarket Calibration.*

The difference in power and torque was most significant in the higher RPM range as the intercooler inlet temperatures were approaching 300°F, the highest temperature that our sensor could read. The factory intercooler proved it was not up to the task as its outlet temperatures reached 203°F at the end of a single dyno pull. As a result, the engine control unit decreased the ignition timing to prevent knock events and damage to the engine. Alternatively, the Mishimoto intercooler kept the outlet temperatures at a cool peak of 85°F, within 10° of the ambient temperature in our engineering facility.

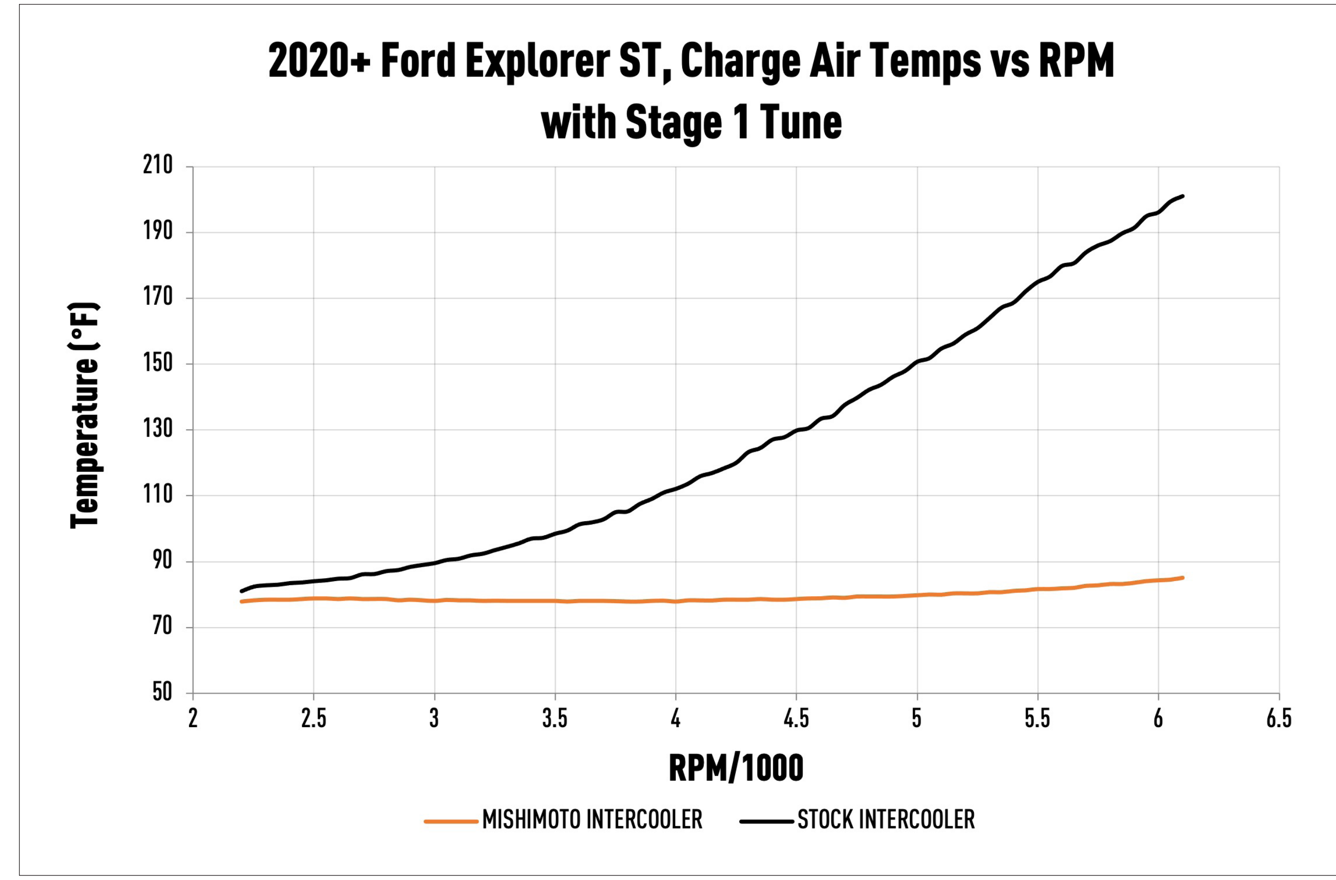

FIGURE 9: *Intercooler Outlet Temperatures.*

In addition, we wanted to prove the benefits of bolting the Mishimoto intercooler onto a vehicle with the factory calibration. The results were just as impressive with a peak power increase of 34 horsepower and 7 lb-ft. Like the aftermarket calibration, the intercooler outlet temperatures rose significantly on the factory intercooler in the high RPM range, so the benefit of the cooler charge was mostly seen above 4500 RPM, causing a large increase in power with a modest increase in peak torque.

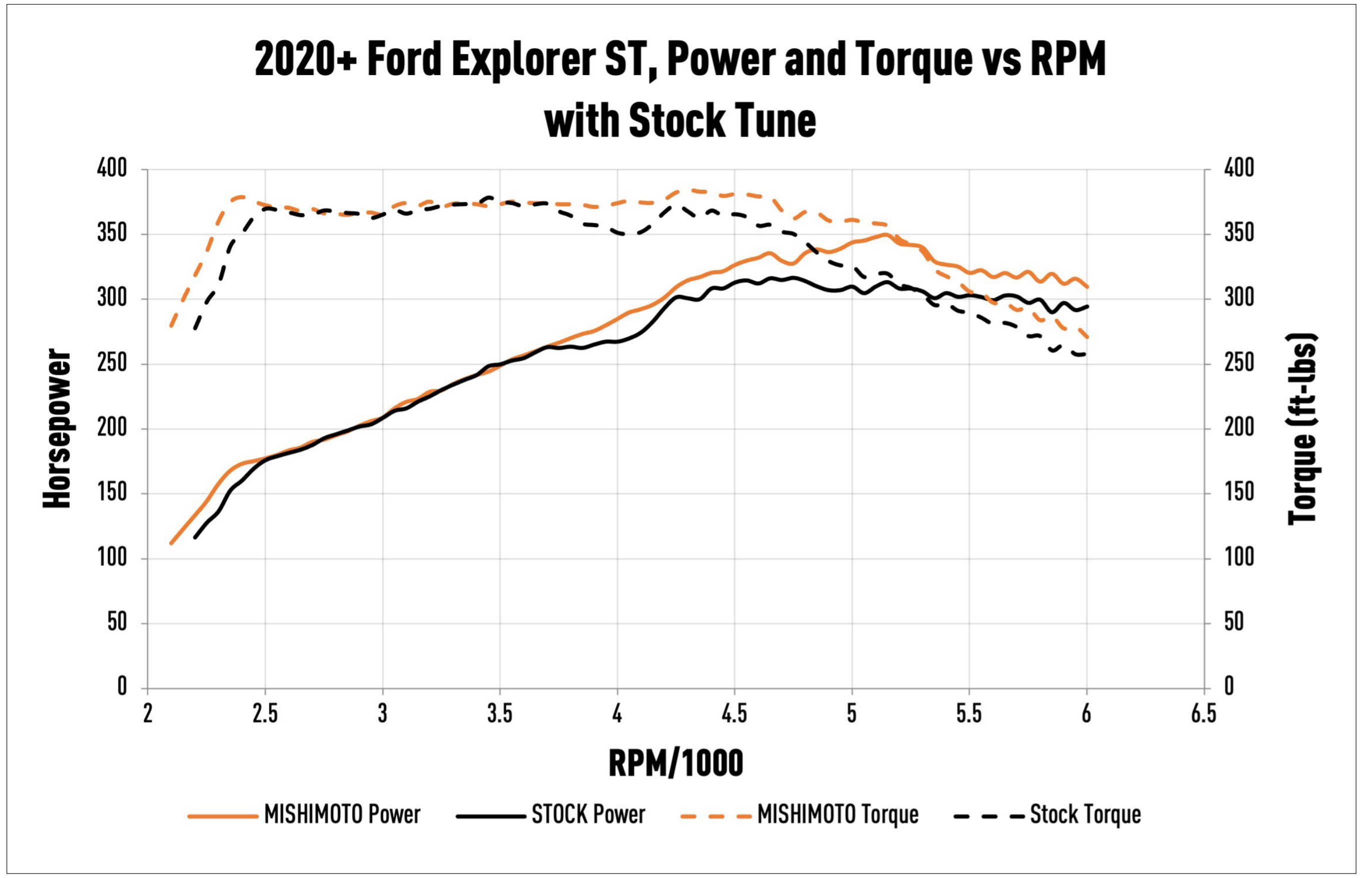

FIGURE 10: *Dyno Results with factory Calibration.*

Generally, in these tests, we like to perform heat soak runs to replicate the heavy repeated loads put onto the cooling system and intercooler during high-performance driving scenarios, such as drag or circuit racing. After performing power runs with the factory intercooler, we decided that it would be dangerous to the vehicle to perform this test without the Mishimoto intercooler installed as the charge air temperatures were extreme. However, we still performed a heat soak test on the Mishimoto intercooler with the aftermarket calibration to ensure our intercooler was up to the task. We performed three back-to-back power runs to see how the intercooler would perform under stress, and it managed to keep the outlet temperatures in control, with minimal temperature rise.

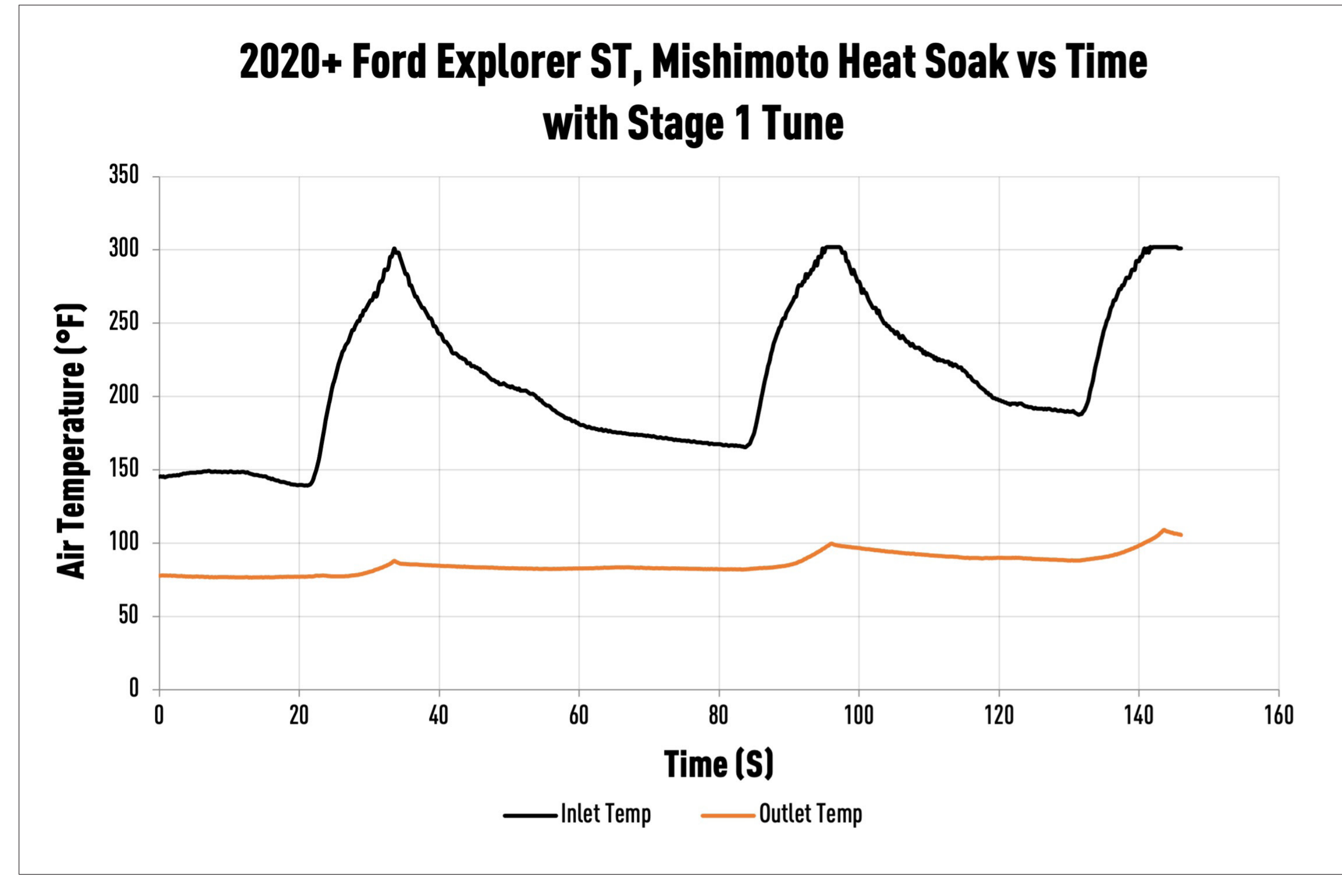

FIGURE 11: *Heat Soak Test Results.*

An important factor we look at when evaluating our intercooler performance is pressure drop across the intercooler. On a turbocharged application, the more pressure drops from the turbocharger to the throttle body, the more the turbocharger must put work and energy into the air to create the same boost pressure in the intake manifold. This, in turn, is less efficient and creates more heat. As part of our performance testing, we measured the pressure drop between the inlet and outlet of the intercooler to compare to stock and the results were excellent.

The Mishimoto intercooler had an average pressure drop across the run of 0.7psi vs. 1.9psi on the factory unit. This is one of the contributing factors to the large increase in horsepower achieved with the Mishimoto intercooler. In some applications, we must create a slightly more restrictive system in order to achieve significantly better charge air cooling, but in this application, we are pleased that the Mishimoto intercooler increased cooling and decreased restriction through the system.

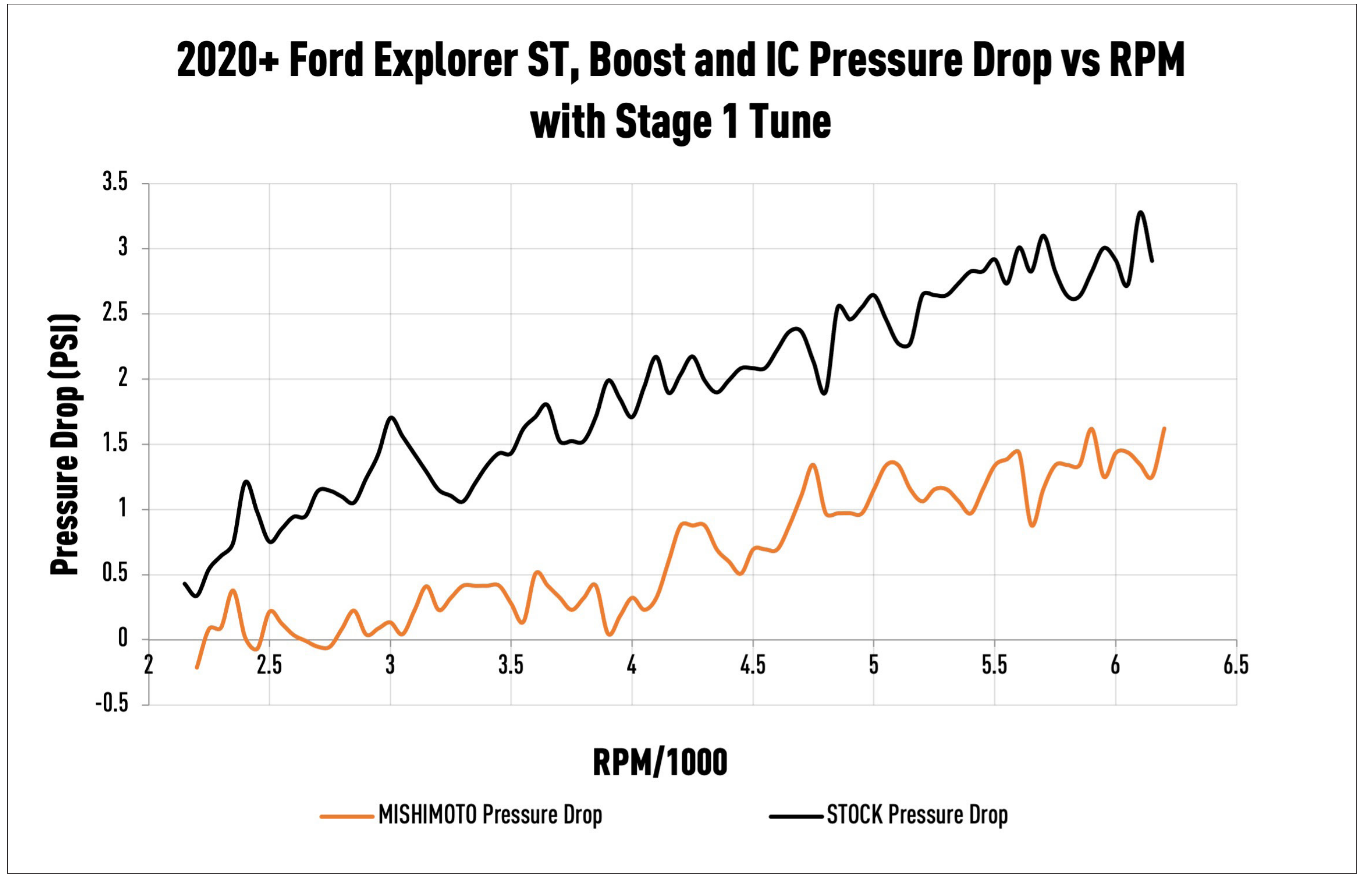

FIGURE 12: *Pressure Drop Test Results.*

The pressure drop test results confirmed the data that was seen during flow bench testing which showed approximately a 19% decrease in restriction in the Mishimoto intercooler compared to the factory intercooler.

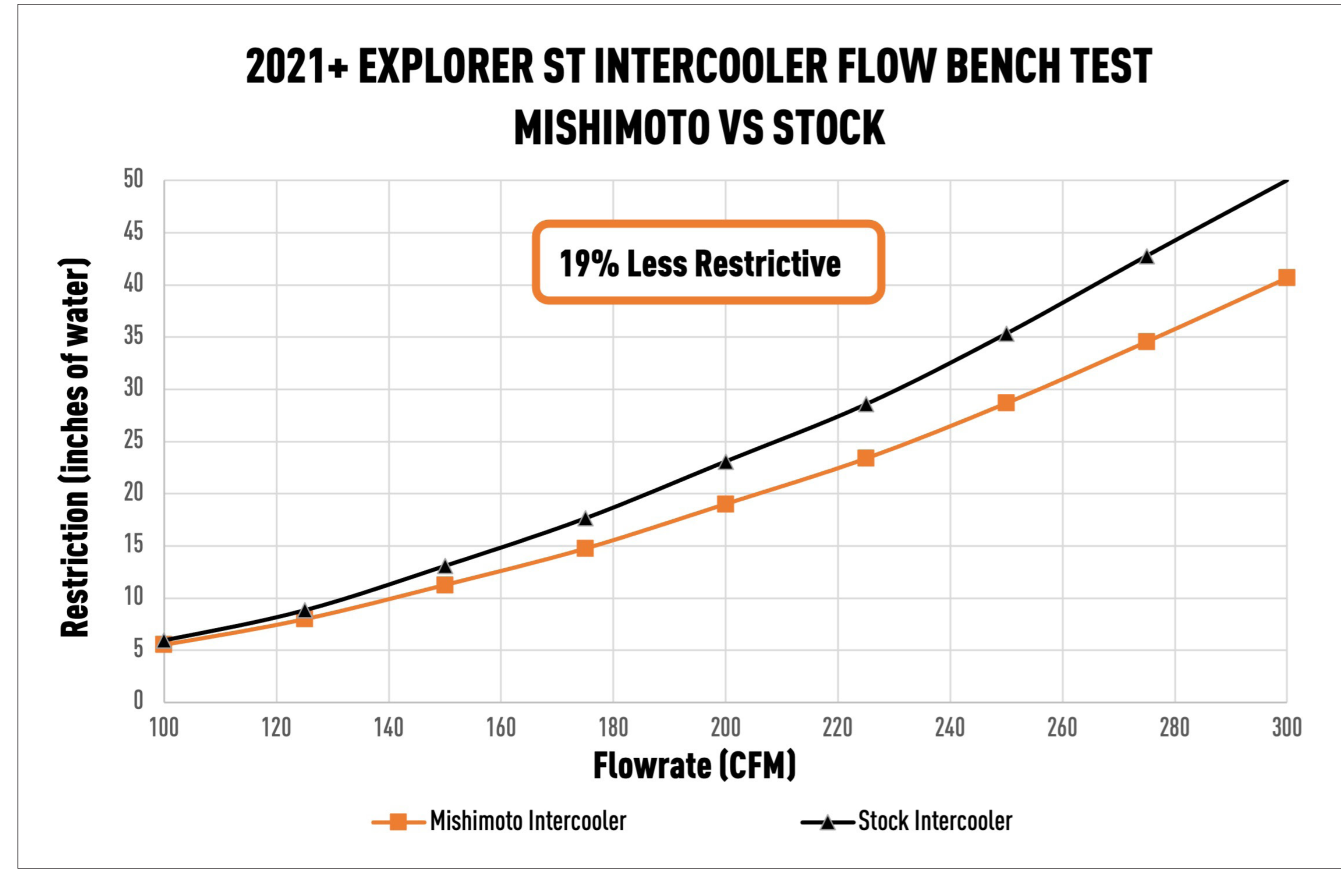

FIGURE 13: *Flow Bench Test Results.*

CONCLUSION

The Mishimoto Intercooler is what should have been on the Explorer ST from the factory. The factory intercooler is undersized and will hinder the performance, while the Mishimoto Intercooler boosts performance with no increase in restriction. The Mishimoto intercooler will work great on a stock vehicle and should be able to support future upgrades such as larger turbochargers and increased boost pressures.

FOLLOW US

Mishimoto is very active on social media so we can be in constant contact with our customers. Our Social Media Team is a available via Facebook, Instagram, YouTube, our Engineering Blog, and forums. We sponsor contests and promotional events, so be sure to follow us.

GoMishimoto

MishimOtO

Mishimoto

Engineering.
Mishimoto.com

CONTACT US

EMAIL

For sales and technical questions please contact support@mishimoto.com

BY PHONE

USA: 877.466.4744
International: +1.302.762.4501
Fax: 302.762.4503

MAIL

Mishimoto
7 Boulden Circle
New Castle, DE 19720

VISIT

Mishimoto.com
Mishimoto.co.uk
Mishimoto.eu
Mishimoto.com.au

MISHIMOTO