ENGINEERING REPORT

2019+ RAM Cummins 6.7L Intercooler Kit | SKU: MMINT-RAM-19K

By: Ye Liu, *Mishimoto Product Engineer*

REPORT AT A GLANCE

- **Goal:** Create a direct-fit intercooler kit that outperforms the stock intercooler system.
- **Results:** The Mishimoto intercooler kit reduced outlet temperatures by 20F°, system restriction by 1.6 psi, and increased efficiency by 7.2% compared to the stock intercooler system, resulting in increased charged air density by 237% from the turbo inlet to the intake manifold, compared to stock system's 162.6%.
- **Conclusion:** The Mishimoto intercooler is a well-rounded upgrade for Cummins 6.7L owners seeking to maximize core volume and gain more cooling capacity and efficiency.

CONTENTS

DESIGN OBJECTIVES

- Create an intercooler that outperforms the stock intercooler in power, torque, and charged-air temperature reduction.
- A direct-fit design with minimal modification required for installation
- A bar-and-plate style core
- Include oversized intercooler pipes
- Integrated air diverter plates for optimum airflow

DESIGN AND FITMENT

We first set out to evaluate the stock intercooler system for improvement. The stock intercooler mounts at an angle in front of the condenser. The intercooler seals against the lower bumper fascia and the radiator with plastic deflectors on all four sides so that air is forced through the opening on the bumper, passes through the intercooler and the rest of the cooling stack without escaping by the gaps between these components.

The stock intercooler has a 25-row, tube-and-fin core of 25" x16" x3.5" in dimension. By reducing the gap between the intercooler to the bumper and the cooling stack, we were able to increase the core size to 25" x 17" x 5.3", a 63% core volume increase over stock. The Mishimoto intercooler also uses the more robust bar-and-plate style core. With this construction, solid aluminum bars and plates stack together to form the internal and external air passages instead of thin extruded aluminum tubes. Bar-and-plate cores can support much higher boost pressure without leaking and are much less susceptible to damage caused by road debris or long-term deterioration from heat cycles. Bar-and-plate designs allow engineers to use almost any core dimensions and choose from various fin combinations to achieve the best overall performance. In contrast, tube-and-fin core designs are constrained by the limited tube dimensions available for manufacturing.

The Mishimoto intercooler also incorporated two internal air diverter plates inside the end tanks. These diverter plates help to guide charged air evenly across the intercooler core instead of taking a shortcut through the center rows to reach the other side. These diverter plates also reduce turbulence inside the end tank, which causes pressure loss.

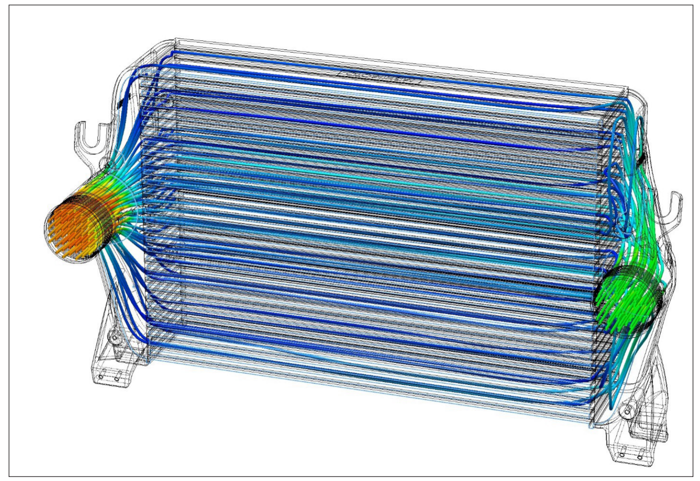

Figure 2: *CFD Analysis*

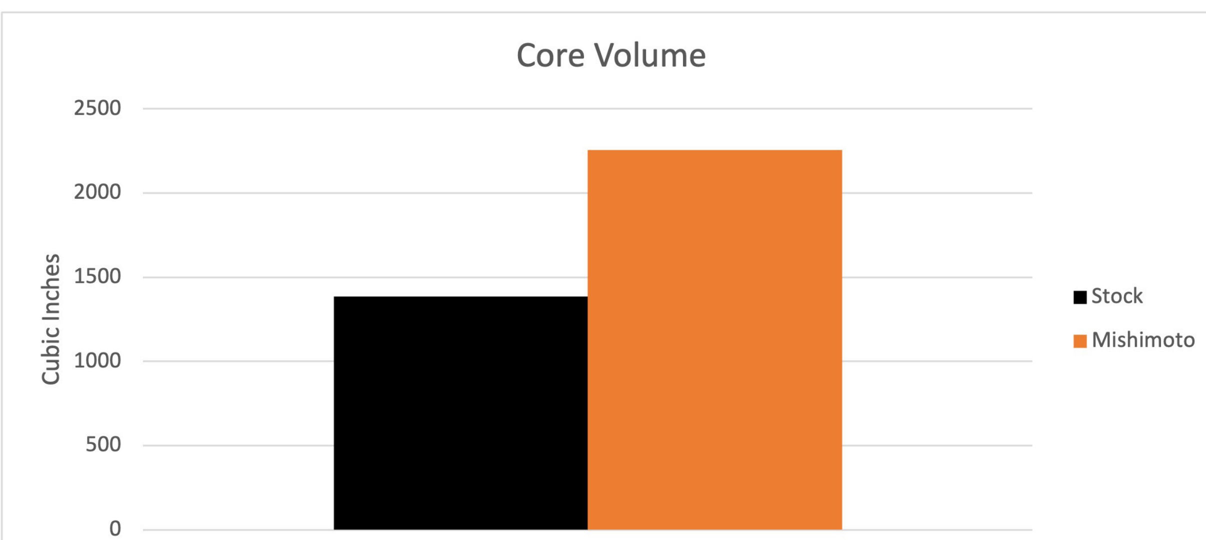

Figure 1: *Mishimoto intercooler core volume compared to stock*

With the significant increase in core thickness, we also redesigned the deflector pieces to seal the smaller gaps between the intercooler core and bumper, maintaining optimum airflow through the core same as stock. While the mounting points are the same as the stock intercooler, due to the increased weight of a bar-and-plate construction, a pair of heavy-duty rubber isolators are provided with the Mishimoto intercooler to replace the stock ones to ensure a robust installation.

Figure 3: *Mishimoto Intake Production Sample Installed*

PERFORMANCE TESTING

Extensive dyno tests are conducted in-house on our DynoJet dynamometer. We use the AEM AQ-1 data acquisition system to gather data from two temperature sensors and four pressure sensors installed on the intercooler system. We also monitor all relevant OBD-II channels to ensure reliable and consistent results. Once the vehicle was warmed to operating temperatures, we performed a series of heat soak tests on the stock and Mishimoto intercooler systems.

An intercooler heat soak test is used to evaluate an intercooler's thermal performance and efficiency under conditions that simulate prolonged exposure to high temperatures. This test is important for understanding how well an intercooler can dissipate heat and maintain optimal engine performance, especially under continuous heavy load or high ambient temperatures. To perform the heat soak test, a cluster of 5-6 RPM sweeps were conducted back to back in quick succession without allowing the system to cool down. This procedure mimics a heat-saturated environment that will stress the intercooler system to its maximum thermal capacity. During the test, similar inlet temperatures were maintained for both the stock and Mishimoto intercooler systems, and the Mishimoto intercooler showed a 20F reduction in outlet temperatures by the fifth run, as shown in Figure 4.

Four pressure sensors are installed on the intercooler system to monitor pressure drop across the core and the full system. With the widened internal flow path of the core and oversized pipes, the Mishimoto kit reduced system pressure drop by 1.6psi at the 4th run compared to the stock system, as shown in Figure 5. The reduction in restriction is further supported by flow bench testing, which removed air density change as a factor, as shown in Figure 8, where the Mishimoto system showed 44.7% less restriction than the stock system.

Next, with mathematical computations of data gathered during heat soak testing, we plotted intercooler efficiency and charged air density change chart to understand the intercooler performance better. Intercooler efficiency is a measure of how effectively an intercooler cools the air passing through it. It is defined as the ratio of the actual temperature drop achieved by the intercooler to the maximum possible temperature drop. The maximum possible temperature drop is the difference between the inlet air temperature and the ambient (or cooling medium) temperature. Rather than simply comparing the outlet temperatures, IC efficiency takes into account the variance in inlet temperature and ambient temperature when tests are performed. Plotting IC efficiency over time also provides a more intuitive picture of how the cooling performance drops once the heat soak process begins. It can be observed from Figure 6 that the Mishimoto intercooler system demonstrated higher efficiency consistently and maintained the high-efficiency numbers after the 3rd run when the thermal load became too high for the stock system to maintain its efficiency numbers.

Charged air density change is another intuitive index to measure the intercooler system's ability to cool charged air, which directly translates to engine performance. Everything else being equal, the denser the air, the more oxygen is delivered to the combustion chamber to burn, which means the engine can produce more power. Charged air density is calculated with existing temperature and pressure data at the turbo outlet and intake elbow, and the percentage change across the intercooler system is plotted in Figure 7. The Mishimoto intercooler system increased charged air density by a maximum of 237%, compared to the stock system's 162.6%.

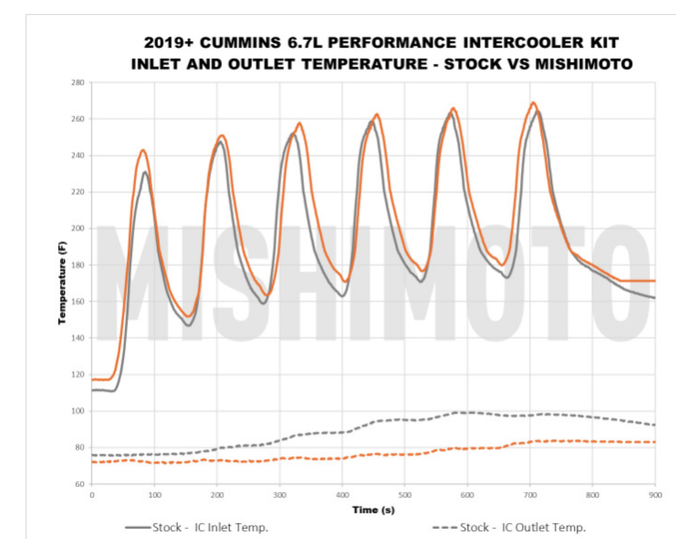

Figure 4: *Inlet and Outlet Temperature Plot*

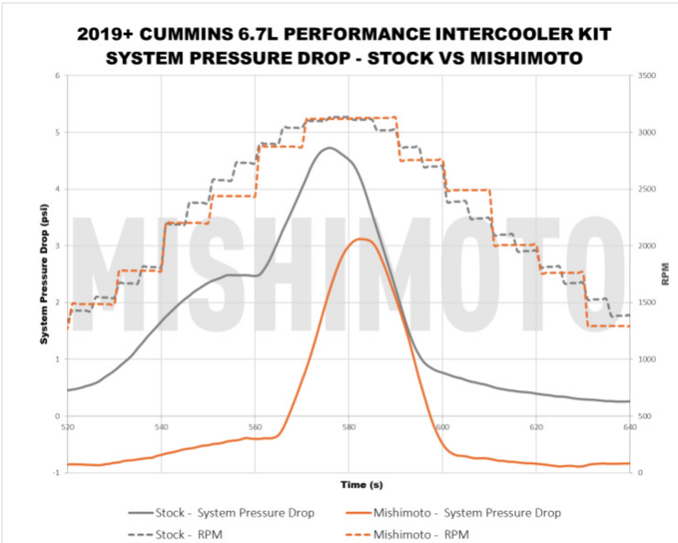

Figure 5: *System Pressure Drop Plot*

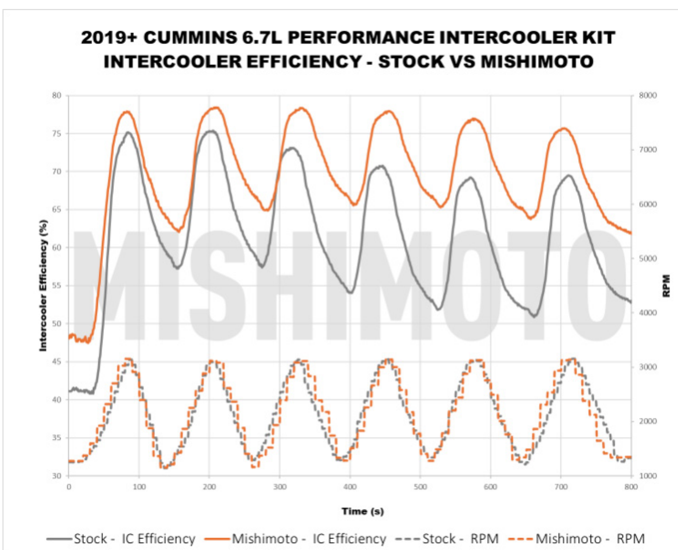

Figure 6: *Intercooler Efficiency Plot*

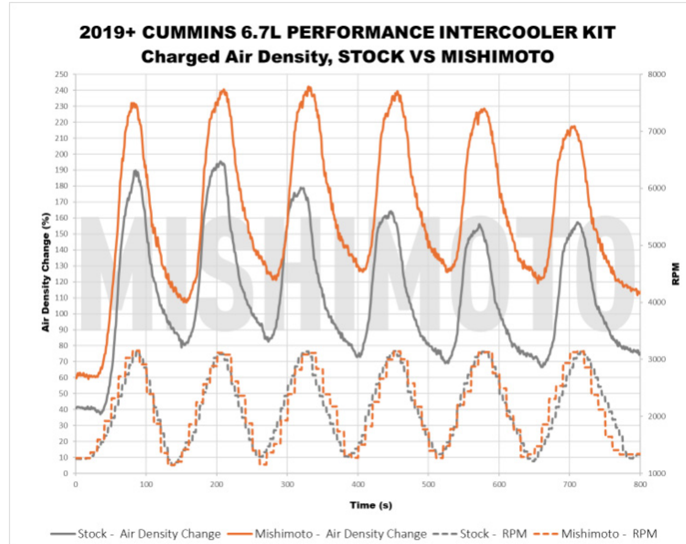

Figure 7: *Charged Air Density Plot*

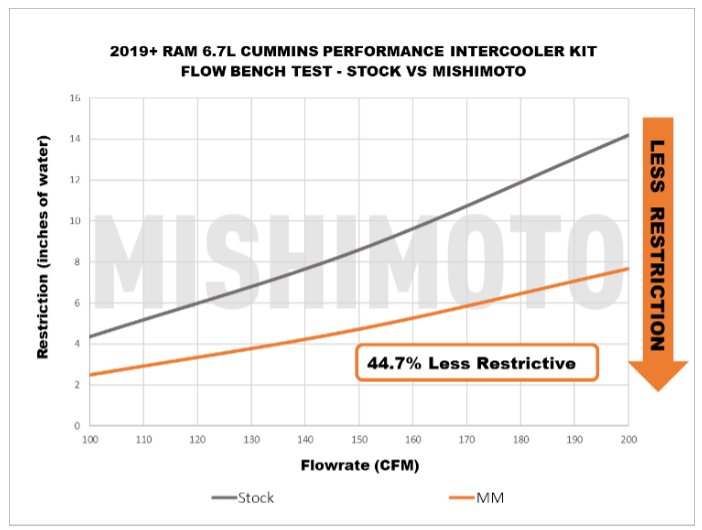

Figure 8: *Flowbench Results*

INSTALLATION NOTES

Some modification to the fan shroud is required to install this intercooler kit.

TESTING DONE BY:

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