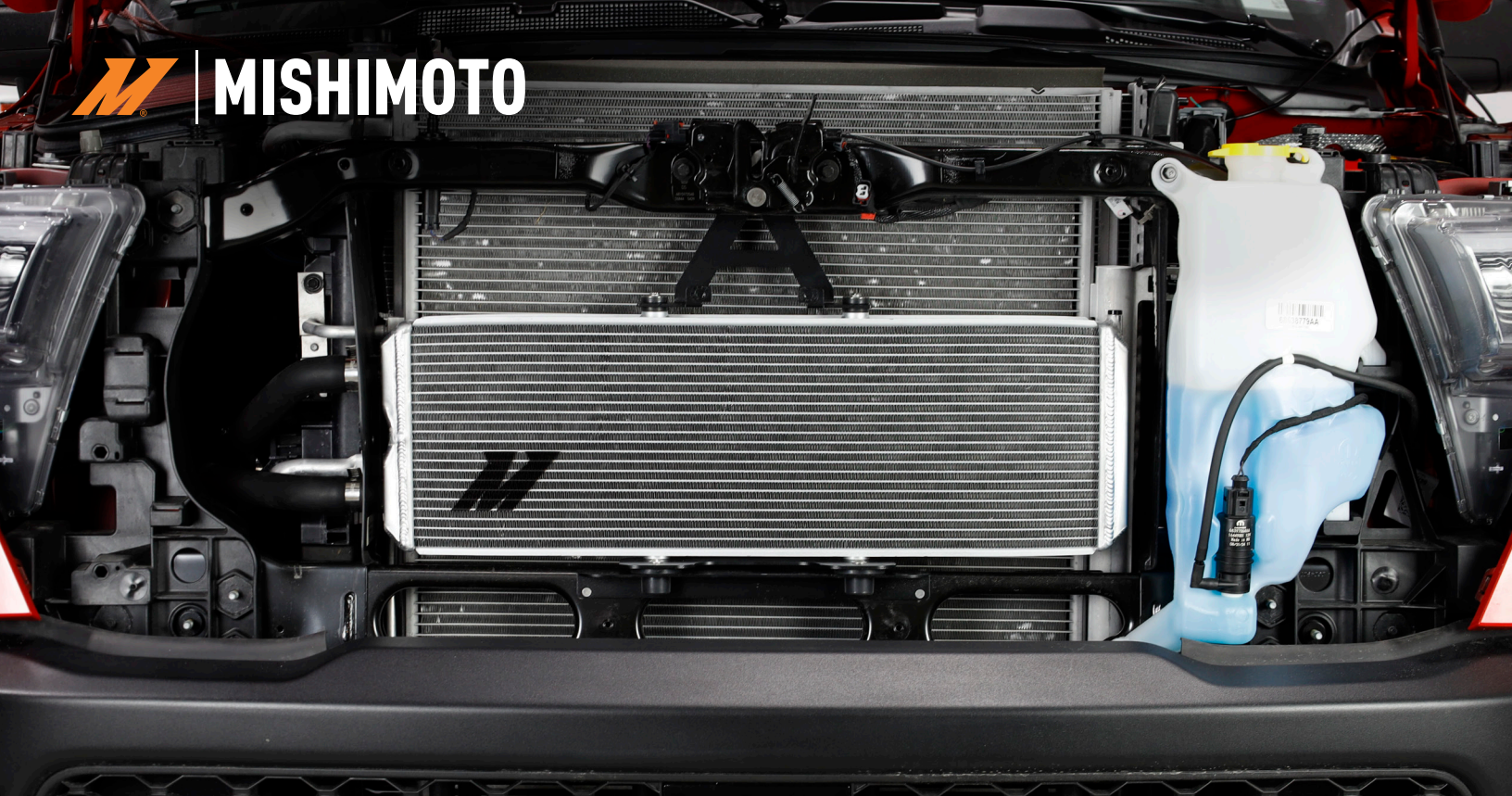




MISHIMOTO



ENGINEERING REPORT

2025+ Ram RHO Heat Exchanger | SKU: MMHE-RHO-25

By: Mitch Levy, Mishimoto Product Engineer

REPORT AT A GLANCE

Goal: Create a direct fit heat exchanger upgrade for the 2025+ Ram 1500 with high output Hurricane 3.0L twin turbo engine. Heat exchanger should be the largest possible size that can fit with all other stock components for a bolt on, easy installation experience with maximized performance. Measurable horsepower gains and/or drop in engine air charge temperatures vs stock.

Results: The Mishimoto heat exchanger lowered peak heat exchanger outlet temperatures by 9.8°F which in turn lowered the peak charge-air temperature by 9°F for an increase in peak power of 11 horsepower. The added heat exchanger has no significant negative effects on coolant flow in the heat exchanger circuit or airflow to the rest of the cooling stack.

Conclusion: The Mishimoto heat exchanger system is a great addition to the Ram RHO to improve the performance of the factory air to water intercooler system to help increase the vehicle performance and consistency.

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STOCK SYSTEM OVERVIEW AND PRELIMINARY TESTING

To achieve our goal of improving upon the factory system, we must first understand the inner workings and capabilities of the system. The factory Hurricane High Output T6 3.0 twin turbo engine utilizes an air-to-water intercooler system, something we have plenty of experience with. The system utilizes a large but thin factory heat exchanger, located in the vehicle’s front mounted cooling stack, between the A/C condenser and radiator. We noted that the heat exchanger does not have priority over the air coming into the grille; the air going through the heat exchanger has already been through the A/C condenser which means that it will be above ambient temperature as it hits the front face of the heat exchanger. The coolant goes through the heat exchanger, into the electric water pump (which is controlled by the Engine Control Unit), into the air to water intercooler on the side of the engine, and then back into the heat exchanger.

We loaded the vehicle onto our Mustang Dyne MD-AWD-500 dyno and performed some test runs on a fully stock vehicle to determine a baseline for the intercooler system performance. We determined that the factory system is impressive, with peak charge air temperatures of 104°F with an ambient temperature of 79°F, while cooling 540hp worth of air coming into the intercooler at a peak temperature near 300°F. The coolant leaving the factory heat exchanger (going into

the pump and then the intercooler) reached a peak temperature of 94°F. Theoretically, this leaves about 14°F of improvement to reach the theoretical minimum coolant temperature, which is the ambient testing temperature of 79°F.

In addition, four wide-open throttle pulls were performed back-to-back to simulate worst case scenario thermal conditions, in order to stress test the factory cooling system. The peak charge air temperature was 133°F and the peak coolant temperature out of the heat exchanger was 123°F. Both tests showed that there was room for performance improvement as well as a strong correlation between peak coolant temperatures and charge air temperature.

DESIGN AND FITMENT

The factory heat exchanger is a large but thin dual pass design, 625mm wide, 580mm tall, and 16mm thick. Its location, sandwiched between the A/C condenser and radiator, does not allow for easy removal and replacement of the factory unit as the full radiator must be removed for access. In addition, there is very little room to make the factory unit larger, as it is already as tall and wide as the factory radiator behind it with very little room to make it thicker. We decided to take a new approach to the heat exchanger upgrade by adding a second heat exchanger in front of the A/C condenser, instead of replacing the factory unit.

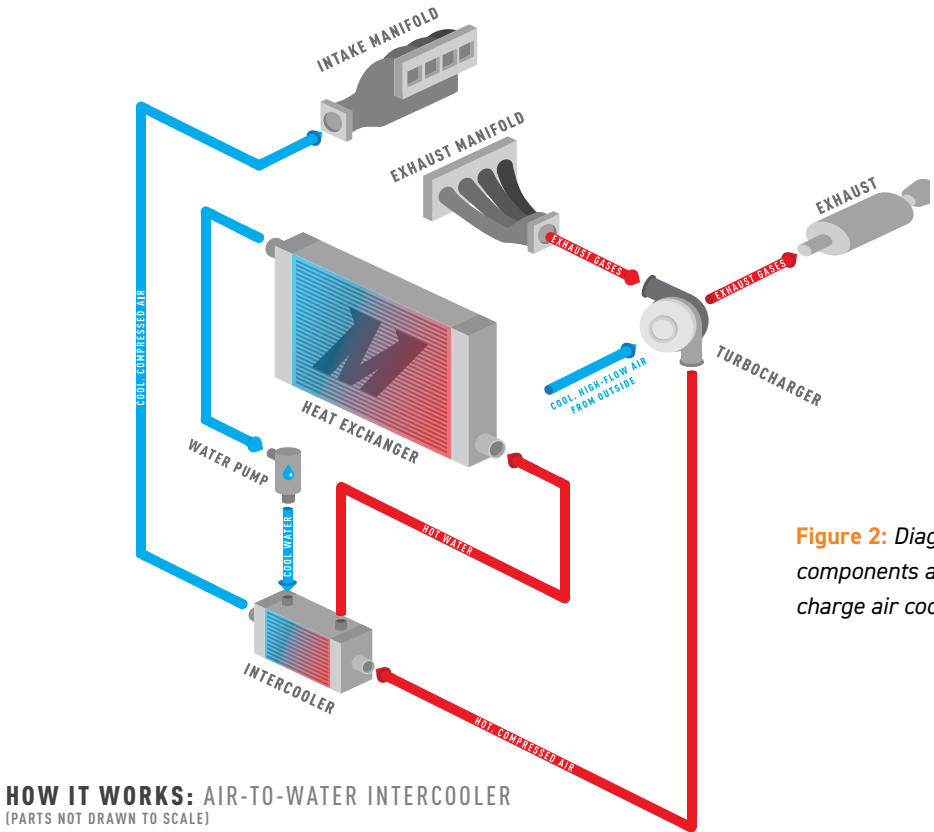


Figure 2: Diagram shows the basic components and routing of an air-to-water charge air cooling system

HOW IT WORKS: AIR-TO-WATER INTERCOOLER (PARTS NOT DRAWN TO SCALE)

This new (to us) method has several advantages. First, there’s plenty of room for it, which gave us plenty of design freedom to fit an ideal heat exchanger behind the front grill of the car, allowing for a simple, bolt-on installation. Next, putting the second heat exchanger in front of the cooling stack gives it first priority over the incoming air, allowing the coolant to get as close to the ideal temperature (ambient) as possible. To achieve this, the coolant will first go through the factory heat exchanger to cool down to factory levels, and then into the Mishimoto unit to further cool the coolant down. In addition, the additional cooler will add additional coolant capacity which will have a capacitive effect on the cooling system, meaning it will take longer to fully heat up all the coolant in the system, giving better transient and overall performance.

There were a few design constraints that must be worked around in order to ensure a higher level of performance. First, the intercooler cooling system relies on an electric water pump to move the coolant through the system. The performance of this pump is vital to the performance of the full system. Governed by the basic heat exchange equation $Q=\dot{m}C\Delta T$, the flow rate of the coolant is directly proportional to the cooling power of the system. Electric water pumps tend to suffer from lower flow rates when they have to push against higher pressures. The RHO uses a Bosch pump similar to the Bosch PCE line water pump which we were able to acquire flow data for. Since we are running the system in series, the second cooler must be designed so that it causes a minimal drop in pressure as the coolant flows through it, as this pressure drop is added to the pressure drop of the original

cooler. This was achieved by keeping the coolant loop short and maximizing the flow area through the cooler itself. A wide core with a tall tube was chosen to maintain as much water flow area through the core as possible. A dual pass cooler was designed to keep all the hoses as short as possible. The inlet and outlet of the cooler are on the same side of the cooling stack as the factory heat exchanger outlet, which will feed the system.

Technical Data and performance curve

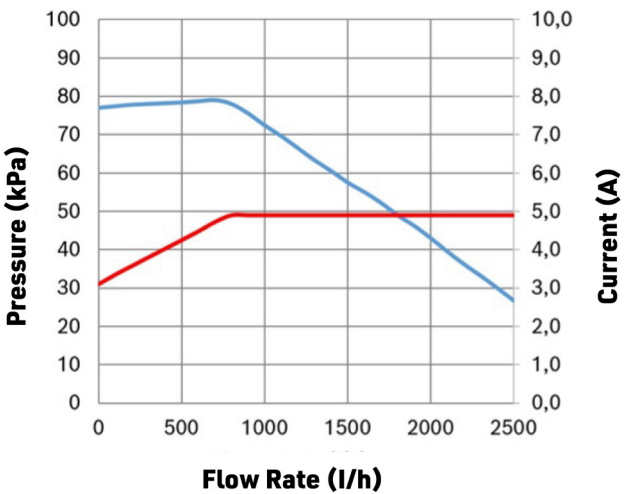


Figure 3: Factory data for the Bosch PCE line electric water pump shows that as pressure increases, the flow rate

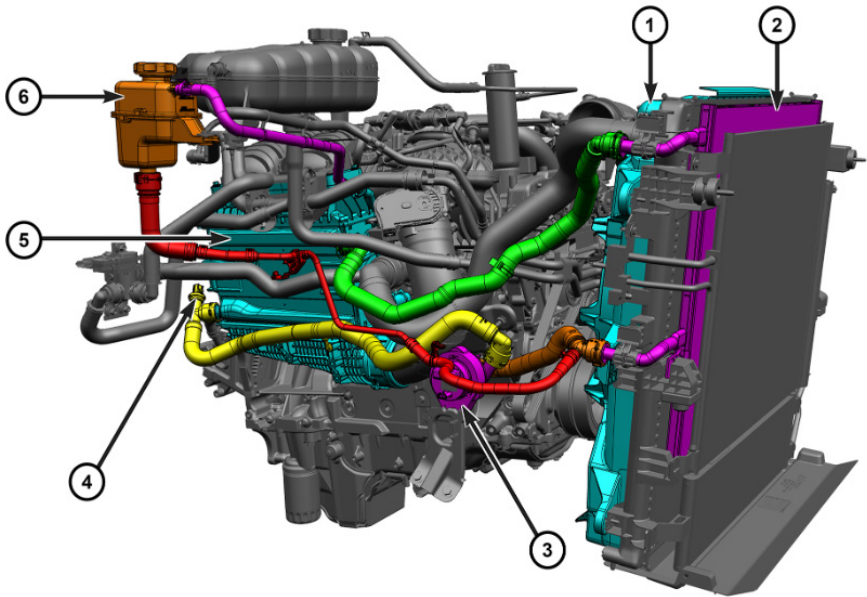


Figure 1: Diagram shows the factory cooling system components and the location of the factory heat exchanger. Note: This diagram shows the standard output engine cooling system, which has the same layout as the high output engine cooling system.

- 1 - Cooling Fan

2 - Low Temperature Radiator

3 - Low Temperature Water Pump
- 4 - Charge Air Cooler Coolant Temperature Sensor

5 - Charge Air Cooler

6 - Low Temperature Pressurized Coolant Bottle

Another consideration is that the new core will be in front of the factory cooling stack. As a result, the air going through the Mishimoto heat exchanger will pick up heat and have less cooling power as it flows through the rest of the cooling stack. However, the temperature of the water as it enters the Mishimoto cooler is already pretty low (especially compared to the coolant in the main cooling system for the engine) as the water has already gone through the factory heat exchanger. If the Mishimoto heat exchanger heats up the air going through it, or slows it down too much, it could, theoretically hurt the performance of the factory heat exchanger and have less of a positive effect on the system as a whole. To help negate this effect, the core was specified to have a tall external fin with a relatively loose fin pitch to allow the air to flow through it without much disruption. In addition, the back of the heat exchanger was fit with foam to seal against the A/C condenser, making sure that the air flowing through the cooling stack goes through it and not around it.

The result is effectively doubling the amount of core volume as the factory system (99% increase in core volume) as well as a 33% increase in frontal area. Theoretically, the heat exchanger coolant outlet temperature should be close to the temperature of the air hitting the front of the vehicle.

The new heat exchanger is mounted using factory bolt hole locations. The top bracket replaces the factory horn bracket and doubles as a horn mount and heat exchanger mounting bracket. The heat exchanger is mounted with rubber bushings at both the top and bottom, allowing for both a secure fitment as well as isolating the heat exchanger from chassis flex and vibrations that can damage the core over time. The kit also includes two custom molded hoses with pre-installed quick

connect fittings. This allows a quick and easy installation of the hoses – simply disconnect the factory heat exchanger outlet and install the Mishimoto hoses into the factory coolant line and heat exchanger outlet, for an OEM-like fitment. The hoses pass through a factory cooling shroud. A cutting template is supplied to allow easy accurate cutting of the factory plastic cooling shroud. The heat exchanger also includes a bleed screw at the highest point to allow any air trapped in the tank to escape after the system is initially filled with coolant.

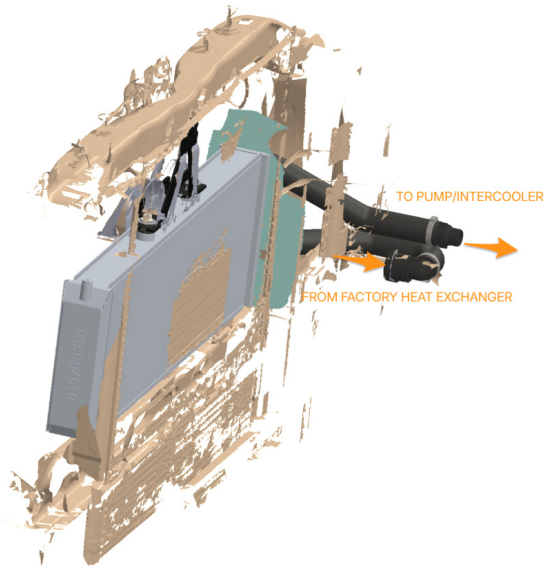


Figure 5: The 3D scan of the front of the vehicle shows the 3D model of the heat exchanger in the vehicle and the new routing of the coolant hoses

Core Volume

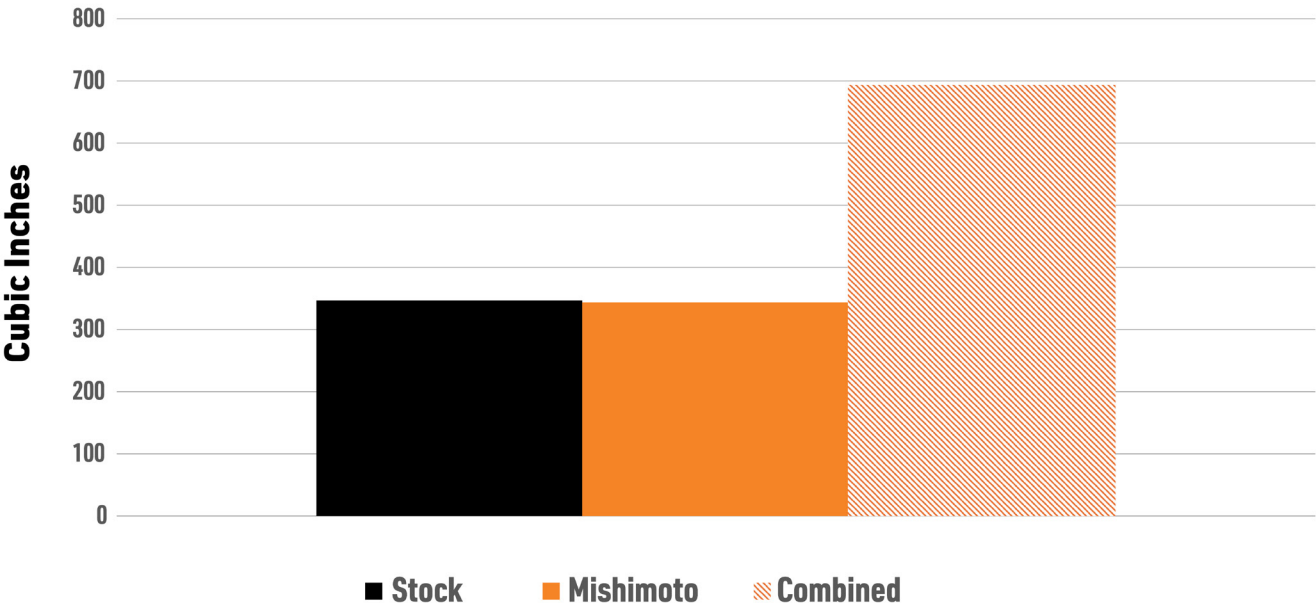


Figure 4: The Mishimoto heat exchanger core is about the same volume as the factory heat exchanger. Since they are both being utilized, the effective core volume doubles.

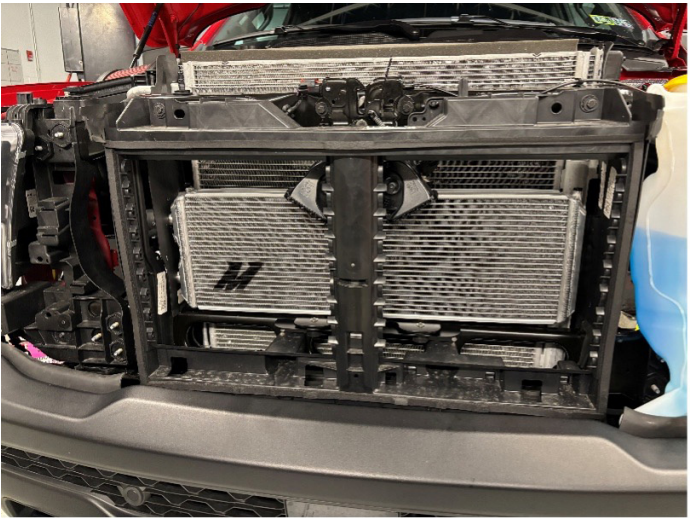


Figure 6: The Mishimoto heat exchanger upgrade installed on a 2025 Ram RHO

TESTING APPARATUS

For testing the intercooler, we installed Rife temperature sensors in the charge pipes and coolant hoses before and after the intercooler. These sensors were monitored and logged via the AEM AQ-1 datalogging system. In addition, OBD-II parameters were monitored via the AQ-1 datalogger. Ambient conditions were logged via the Powerdyne Software on our Mustang Dyno MD-500XL-AWD dyno, utilizing the Mustang Dyno data acquisition system, JBOX. The front driveshaft was removed as the RHO does not have a dedicated rear wheel drive mode. In addition, we replaced the rear all-terrain tires with passenger truck tires to maximize the accuracy of the dyno. The coolant hose was also fitted with a Hedland in-line flow gauge, both to determine when the electric water pump was running and to compare flow rates with and without the Mishimoto heat exchanger upgrade. We also made sure to data log the coolant temperatures to make sure that adding the heat exchanger had no meaningful effect on radiator performance.



Figure 7: Mishimoto's 2025 Ram RHO loaded onto the MD-500XL-AWD chassis dyno. The vehicle must be run rear-wheel-drive as it is too long to fit on the dyno.

PERFORMANCE TESTING

Testing consisted of two different tests: single runs to measure the difference between two dyno runs in ideal conditions, and heat soak testing, where the vehicle must perform back-to-back dyno pulls with no opportunity to cool down. This simulates some of the harder performance driving that the vehicle may perform in the real-world environment. In addition to datalogging the vehicle output and sensor, we also attached an action camera to the front passenger wheel well to monitor the in-line flow meter that was installed in the line between the water pump and intercooler. This in-line flow meter was able to show us if the electric water pump was running and when it was not. We found that putting the vehicle into sport mode kept the pump on 100% all the time, so, for the sake of consistency, we performed testing in sport mode.

The single run testing resulted in a drop in peak heat exchanger outlet temperature drop of about 10°F, from 88.2° to 78.0°F. The 78°F temperature was only 2-3 degrees above ambient, which means that the system is running at peak efficiency, near its theoretical limit. This drop in coolant temperature, in turn, caused a drop in peak charge air temperature of 9°F, from 100.4°F to 91.4°F. This difference was significant enough for the vehicle to pick up 9 ft-lbs of torque and 12 horsepower at their peak. The difference was most pronounced from 4500-5800 rpm, where the increased temperature of the air coming into the intercooler and the higher mass flow of air (which generally increases with engine speed) put a higher heat load on the system and the increased cooling capacity of the added Mishimoto heat exchanger showed its' superior cooling power over the stock system.

In addition, we concluded that the increased coolant backpressure in the cooling system caused by the extra heat exchanger did not cause a large enough drop in flow to negatively impact the cooling system. This is evident based on the direct readings from the flow meter, which showed an approximate 10-15% decrease in flow with the Mishimoto heat exchanger installed (Note: the graduations on the flow meter gauge were not steady and exact enough to get a precise flow number. Approximate readings were taken from the video camera focused on the flow meter during testing). The test data also spoke for itself, as the flow of coolant and the lower temperature were able to take more heat away from the intercooler with the addition of the Mishimoto heat exchanger. The overall goal of removing more heat from the intercooler was achieved with the additional cooler and the small drop in flow did not seem to have a negative effect on cooling performance.

For the heat soak testing, we looked at both the peak and average charge air temperatures across the three back-to-back runs that were performed. For the coolant outlet temperature, we saw an approximately 9°F drop in both the peak and average coolant temperature across the three runs, and as a result the maximum charge air temperature dropped by 11°F while maintaining an average charge air temperature of 6.5°F lower. This shows a consistent, significant improvement in cooling in the system through repeated high heat loads, which will translate into better performance in real world conditions.

2025 Ram 1500 RHO, Heat Exchanger Testing, Heat Exchanger Outlet Temperature vs RPM

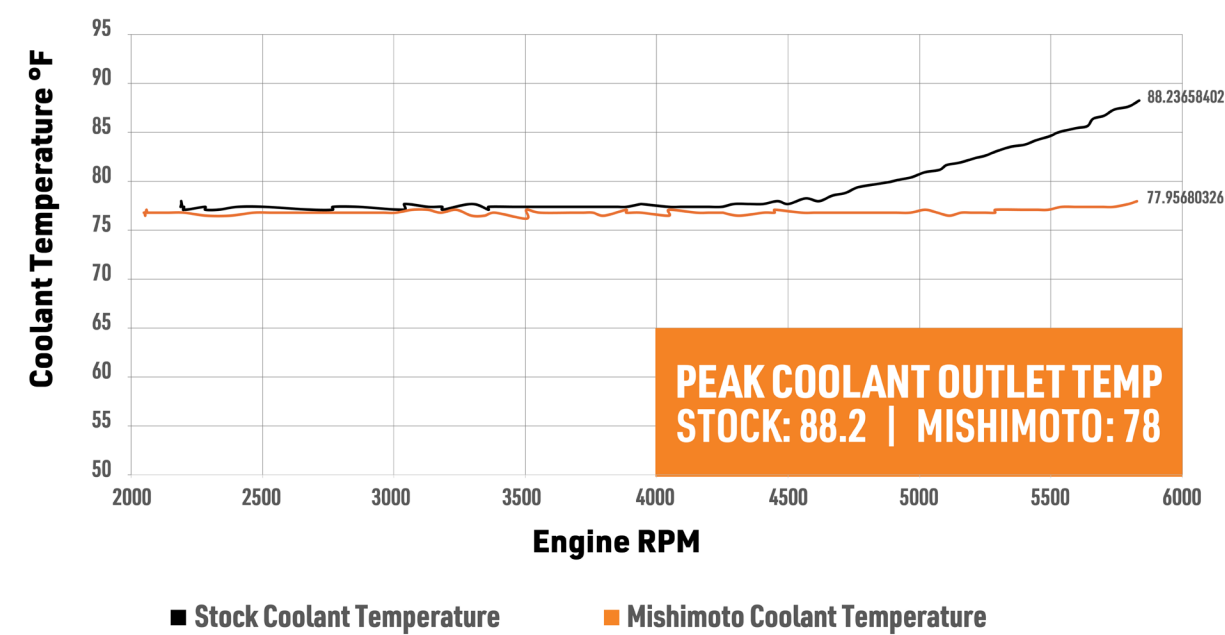


Figure 8: Chart shows the temperature of the coolant exiting the heat exchanger on its way to the during a single dyno pull. The Mishimoto heat exchanger significantly reduced the coolant temperature, especially at higher RPMs

2025 Ram 1500 RHO, Heat Exchanger Testing, Charge Air Temperature vs RPM

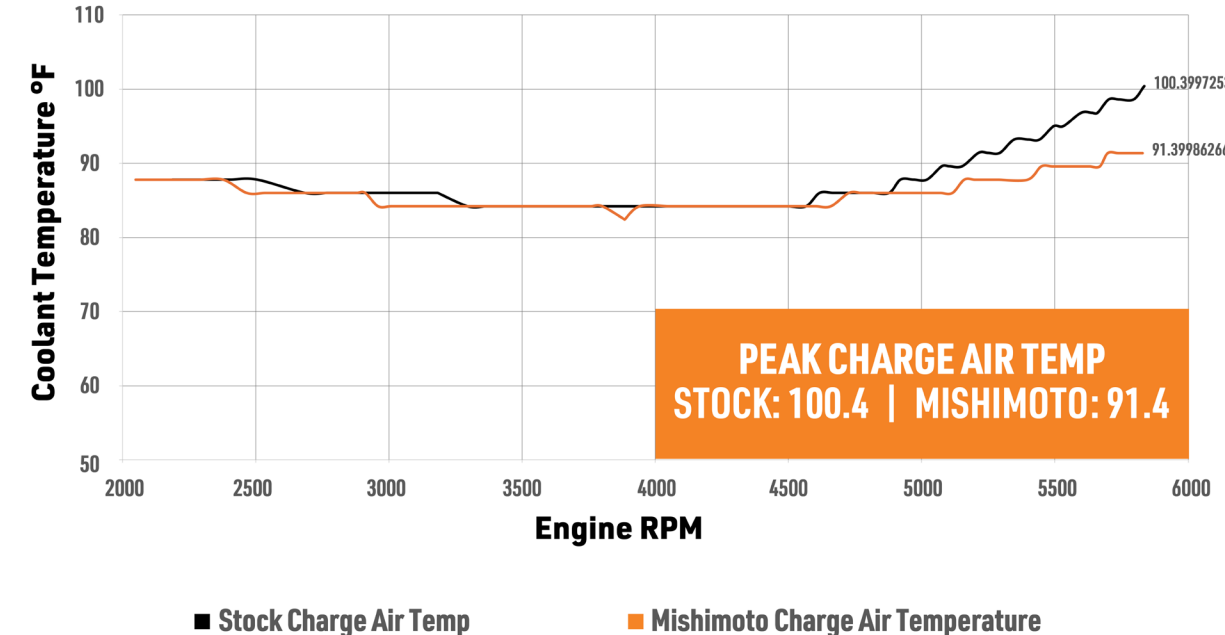


Figure 9: The lower coolant temperatures shown in figure 3 were able to pull more heat out of the intercooler, especially in at high RPMs for a 9 degree drop in peak charge air temperature.

2025 Ram 1500 RHO, Heat Exchanger Testing, Horsepower and Torque vs RPM

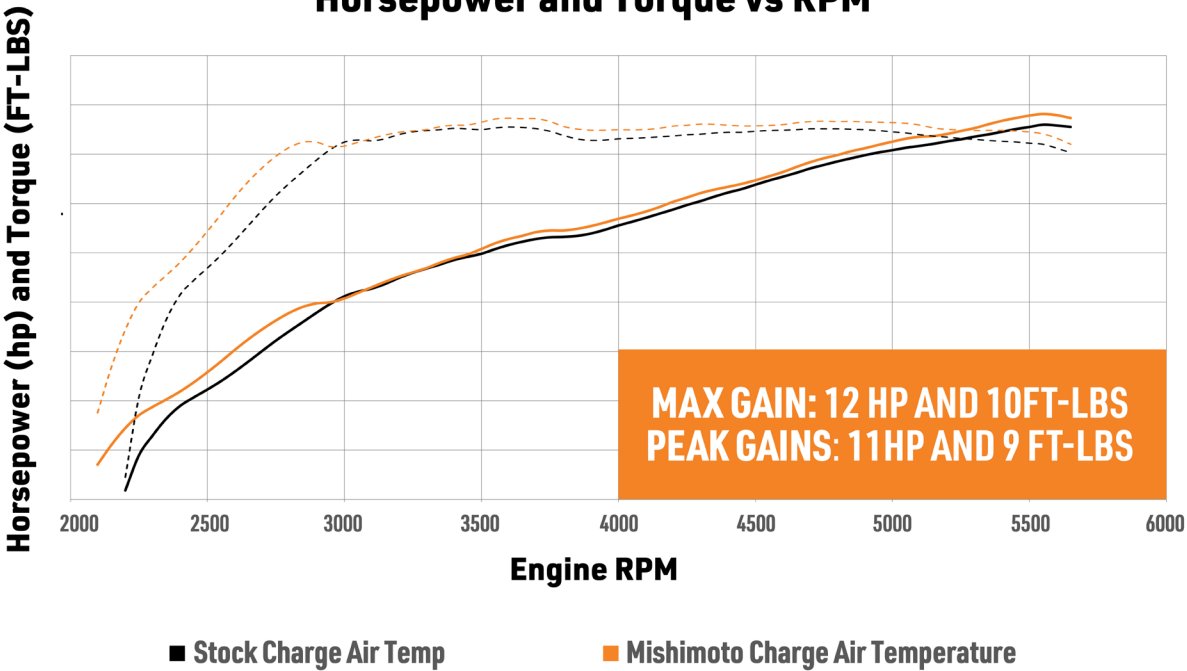


Figure 10: Lower charge air temperatures allowed the vehicle to pick up 11HP and 9ft-lbs peak and 12HP and 10ft-lbs max

The main radiator (which cools the engine in a separate circuit) coolant temperature also stayed consistent across both the single runs as well as the heat soak back-to-back runs. The peak coolant temperature was only 1°F higher while running the Mishimoto heat exchanger during the heat soak test, which is not a significant difference. We concluded that the additional heat exchanger in front of the cooling stack does not affect the rest of the cooling system, while the increased intercooler system performance seen in the single pulls was replicated in the heat soak testing.

output by 11 horsepower. The increased intercooler system’s cooling capacity increases performance and consistency and adds headroom to accommodate future modifications that may put additional load on the intercooler cooling system as well as different vehicle use cases that may put a high demand on the air-to-water intercooler system. The heat exchanger upgrade will also pair well with an upgraded intercooler, as the two systems work together to cool the charge air. The Mishimoto heat exchanger is an easy to install performance modification that will get the most out of the High Output Hurricane engine.

CONCLUSION

We were able to add significant performance by adding a second, heat exchanger in series with the factory heat exchanger which was able to lower heat exchanger coolant temperatures by about 10°F, which in turn lowered the peak charge-air temperature by 9°F and increased peak power

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CONTACT US

Email

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

By Phone

USA: 877.466.4744
International:
+1.302.762.4501

Mail

Mishimoto
1515 Garnet Mine road,
Garnet Valley, PA 19060

Visit

Mishimoto.com
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