Toyota 1HZ-T Overheating Issues

(Research and testing by Brandon Peltz and Brett Harth, Engine Australia)

May 2021

The Background

There is a persistent stream of reports in online forums of overheating problems with newly rebuilt Toyota 1HZ engines that have had performance upgrades with turbochargers fitted. In most cases, the engines have had a complete rebuild with quality parts and in many cases, all new cooling system components, typically from the aftermarket. In particular, the radiators are often upgraded to four core brass/copper 'performance' variations. An upgrade like this can see the power output of the 1HZ engine go from 52kW RWHP for the original naturally aspirated engine, anywhere up to 230kW RWHP for a full performance build. There is no question that the more power the engine produces, the more heat the engine cooling system must extract. The question is, what heat can be pulled out of a 1HZ-T engine?

Engine Australia decided to conduct a range of back-to-back, highway and dyno tests with varying components and settings to see what affects the engine temperature the most what gives the best cooling results. The bulk of the testing was conducted on a real world 'problem' engine, a couple of year old 1HZ to 1HZ-T rebuild with the classical overheating problems (HZJ79 Ute 103kW RWHP), then the findings were applied to a new inhouse 1HZ to 1HZ-T build with low HP (HZJ75 98kW RWHP) and then to an new inhouse 1HZ to 1HZ-T build with high HP (HZJ80 Wagon 230kW RWHP). All horsepower and torque readings made on our Dyno Dynamics 4WD 450DS dynamometer. The tests were made in mid to late January 2021 at Dalby Queensland.

Note: Testing of the Toyota temperature gauge showed the needle sat at just under the halfway mark while the engine was operating in the 50°C to 110°C range. It then typically rises very quickly if the temperature climbs above 110°C.

The Testing

The main test vehicle was a **HZJ79 farm ute** that was rebuilt a couple of years ago and ever since has had overheating issues, especially when towing a loaded 5th wheel horse float. It was so bad, that the owner had basically given up using it anymore. Any run in the vehicle at 100 kph was reading over 90°C on his new aftermarket water temperature gauge. A trailer and hill was 90 km/h absolute maximum and in excess 100°C. The engine was rebuilt by a reputable engine conditioner, with 1HDT conrods, 1HZ-T ceramic pistons, new cylinder head etc. When the reconditioned engine was installed, a DTS turbocharger kit, a well-known 4 core copper/brass radiator and a well-known thermostat were also fitted. The engine was running 11.5 psi (could peak at 13.5 psi) boost and no intercooler.

The first test was the installed water temperature gauge against a calibrated mercury thermometer.

Aftermarket Temp. Gauge °C	Mercury Temp. Gauge °C
70	80
80	90
90	100

This showed the engine had in fact been running even hotter than the owner believed it was – temperatures that could well have been detrimental to the engine.

It was decided to use Davies Craig EWP electronic controllers during the testing, and they were also tested.

Davies Craig EWP Temp. Gauge °C	Mercury Temp. Gauge °C
80	78
90	88
100	98

An EGT gauge was fitted post-turbo and a boost gauge in the turbo to intake manifold cross-over pipe. The first test run was a 20 km circuit at 10:00 am in the morning. The engine temperature reached 98°C on the DC EWP Controller. The following readings were recorded:

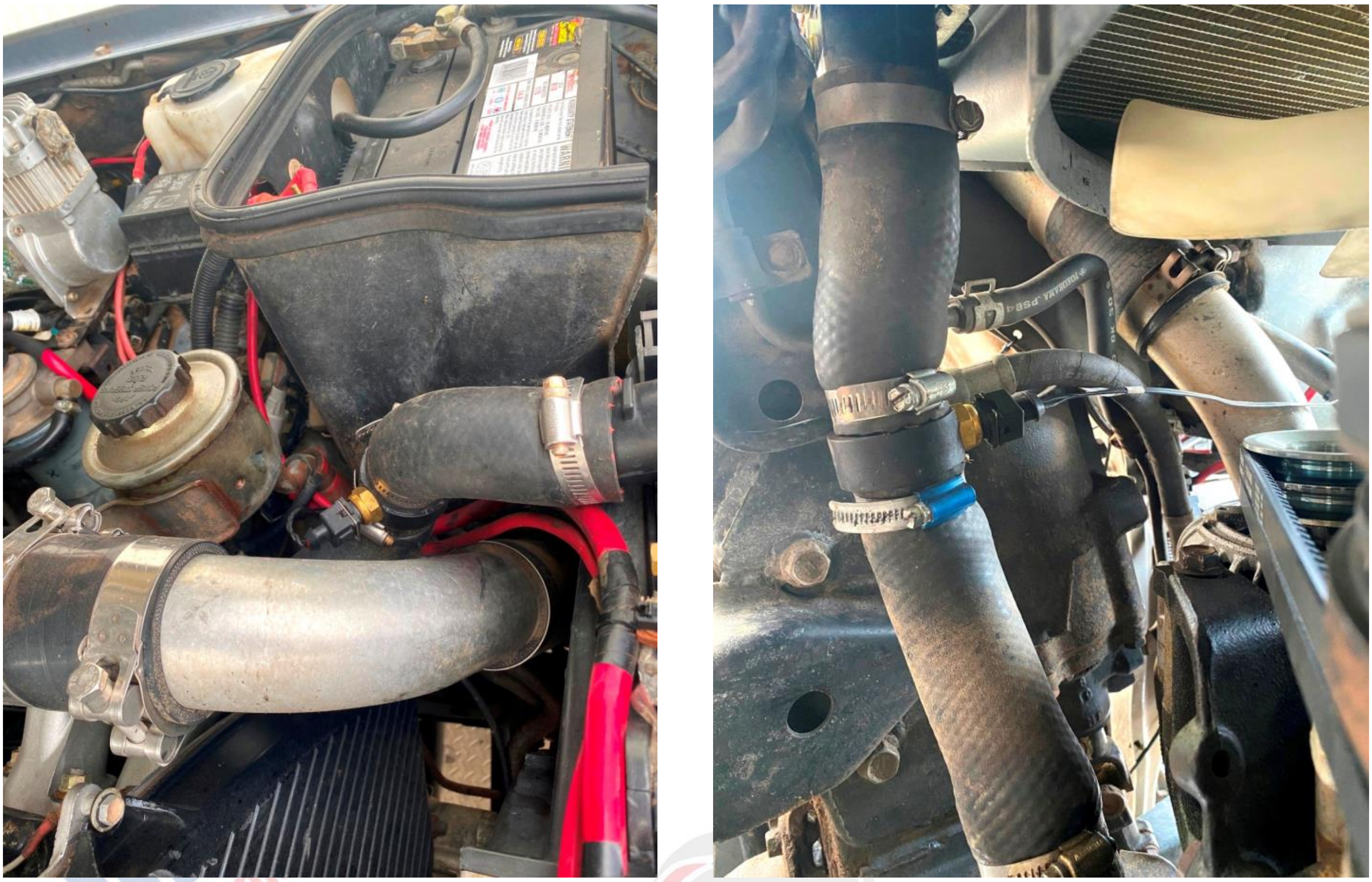
Speed (km/h)	EGT (°C)	Boost (psi)
80	250	2
90	270	3.5
100	320	6
110	350	8
120	400	11.5

There were obviously variations in road surface, gradient, wind direction etc., but in the most part, conditions were reasonably constant.

A second Davies Craig EWP Controller sensor was installed in the lower radiator hose to measure the temperature drop across the radiator. A second run in the afternoon saw temperatures of 102 - 103°C at 100 km/h and a temperature drop across the radiator of 4 - 6°C.

A cooling system flow test was then made to check the water flow. This was made using a calibrated Macnaught flow gauge fitted into the top radiator hose. The following flow recordings were made in the workshop with the engine operating at 85 - 90°C.

RPM	Flow rate (L/min)
1500	60.8
2000	69.5
2500	82.0
3000	98.5
3500	125
4000	148



Radiator inlet and outlet temperature sensors for measuring temperature drop across the radiator in real time.

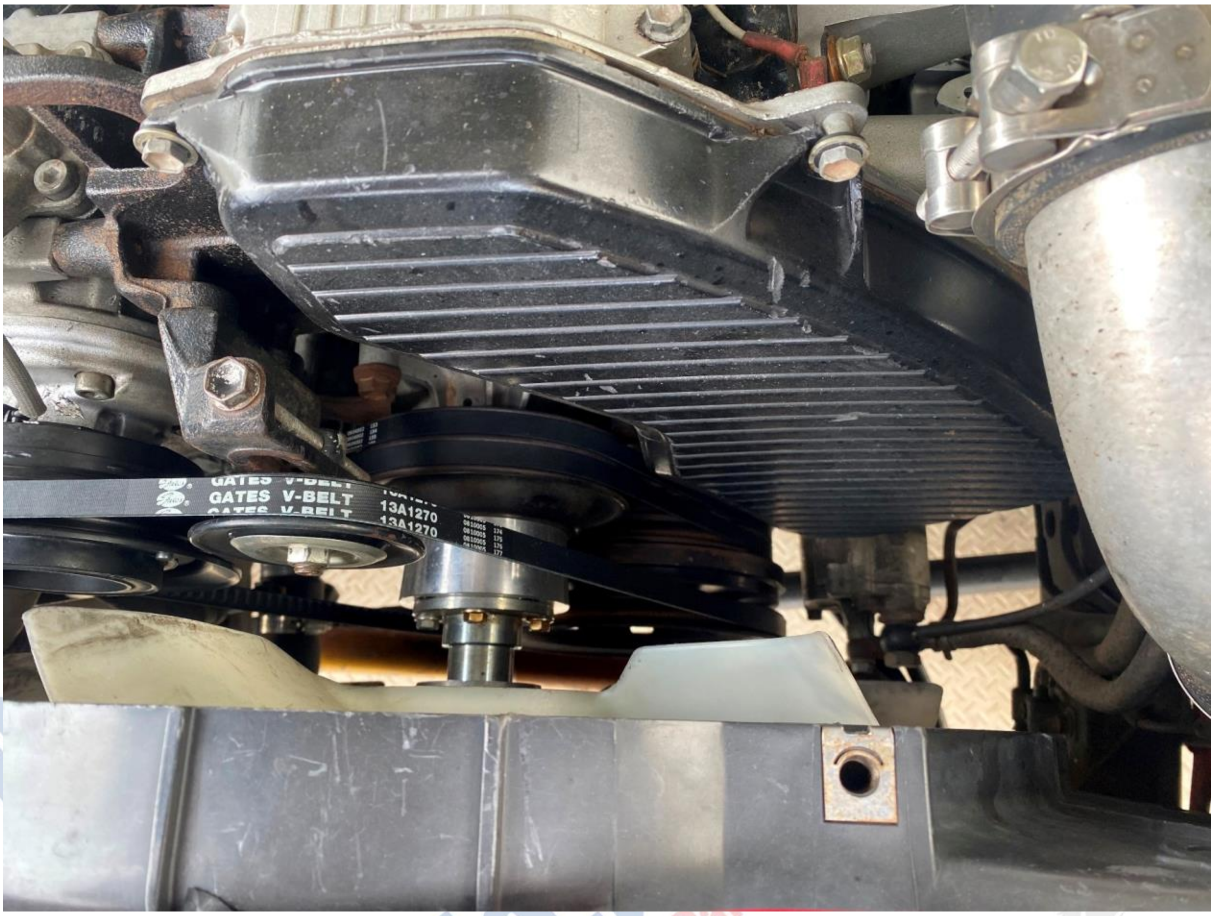
The engine was fitted with an NPW water pump and these flow readings were comparable with previous flow tests conducted by Engine Australia on an O.E. and various aftermarket water pumps. The radiator cap on the 4-core radiator had a different pressure rating to an O.E. cap, so an O.E. radiator cap was fitted and the vehicle taken for a test run. This made no difference to the cooling system temperatures.

The **thermostat** was removed and found to be a popular replacement brand. It and a new O.E. thermostat were placed in Pyrex dish filled with water, over a gas burner, with a mercury thermometer. The O.E. thermostat started to open at 76°C and the aftermarket one at 77°C. Both openings measured 40 mm ± 0.5 mm in diameter. The O.E. thermostat was fully open at 92 - 93°C and approximately 13 – 14 mm lift. The aftermarket thermostat was fully open at 87 - 88°C and approximately 12 mm lift.

The O.E. thermostat was fitted to the vehicle and taken for a test run at 9:30 am and 25°C ambient temperature. The water temperature stabilised noticeably quicker at 92°C and the temperature drop across the radiator a constant 5°C at 100 km/h. Slight head winds saw the temperature rise to 95 – 96°C after overtaking and they did not recover quickly.

A **new O.E. radiator** was fitted to the vehicle and taken for a test run at 11:30 am. The engine was first run without the air conditioning (A/C) for 10 – 15 km/h at 100 km/h. Water temperature was consistent at 82°C with a 10 - 12°C drop across the radiator. The A/C was then turned on and the temperature rose to 86°C and then steadied to 82 - 83°C. The vehicle speed was increased to 110 km/h and the temperature rose to 88°C and then steadied to 85 - 86°C.

A **Diesel Performance Parts Hi-Flow Viscous Hub and Fan Kit** was fitted to the engine and taken for a test run at 2:45 pm and 30°C. The water temperature at 100 km/h and the A/C on was 82°C. Temperature drop across the radiator was 14 – 16°C. At 110 km/h the temperature rose to 83 - 84°C, with across radiator drop of 12 - 14°C. Temperature recovery when slowing was noticeably quicker.



Diesel Performance Parts Hi-Flow Viscous Hub and Fan Kit installed to engine.

An Adrad aluminium 2-core radiator with plastic tanks was fitted. This is slightly thinner than the O.E. radiator. The hi-flow fan was still fitted, and the vehicle taken for a run at 5:00 pm. The water temperature at 100 km/h and the A/C on was 82°C. Temperature drop across the radiator was 12 – 14°C. At 110 km/h the temperature rose to 86°C, with across radiator drop of 11 - 12°C. Recovery was just a little slower than with the O.E. radiator.

The following day a **temporary air dam was fitted under the front of the vehicle** to redirect air under the front differential. The idea was to create a low-pressure zone to help draw the hot air coming out of the radiator under the vehicle rather than into the engine bay. A run at 9:00 am and 25°C ambient temperature recorded 81 - 82°C water temperature at 100 km/h and a temperature drop across radiator of 14 – 16°C. At 110 km/h the temperature stabilised at 81 - 82°C and 12 - 14°C drop across radiator. The dam appears to have made some slight improvement, but questionable if it is worth the effort. **Cardboard cut-outs of large spotlights** were placed into the bulbar to simulate having spotlights fitted to the vehicle. A run at 9:30 am and 26°C ambient temperature recorded 86°C water temperature at 100 km/h, steadying to 82 - 83°C and a temperature drop across radiator of 10°C. At 110 km/h the temperature rose to 86°C, stabilised at 86°C and 10°C drop across radiator.

The vehicle was run on the **Dyno and recorded 100kW, 360 Nm and AFRs of 20:1**. The genuine radiator was swapped back in and the spotlight cut-outs and air dam left in place and at 3:00 pm and 32 - 33°C ambient was taken for a run. It recorded 88°C water temperature at 100 km/h, steadying at that and a temperature drop across radiator of 10°C. At 110 km/h the temperature rose to 90 - 91°C, stabilised at that and 10°C drop across radiator.

Air dam fitted under front of vehicle to see if would help extract hot air from the engine bay.

Cardboard cut-outs fitted to simulate spotlights.

O.E. fan, radiator, thermostat, and red coolant, plus the air dam and spotlight cut-outs are fitted. A run made at 12:00 pm and 35°C ambient recorded 87 - 88°C water temperature at 100 km/h, steadying at that and a temperature drop across radiator of 8°C. At 110 km/h the temperature rose to 92°C, stabilised at that and 8 - 9°C drop across radiator. Removing the spotlight cut-outs did not make any difference to the temperatures. The air dam was removed, and this also made little difference. **The high ambient temperature seemed to be the governing factor at this stage.**

At several times through these tests the A/C was turned on and off and was shown to make a 2°C change in water temperature, while turning the heater on and off made a 2 – 3°C difference.

At 2:30 pm and 37°C ambient a run was made with a horse float attached with 600 lt (650 kg) water drum inside and some 150 – 200 kg of camping gear in the vehicle. Overall trailer weight estimated at 1600 kg. In 5th gear, 95 -100 km/h, the temperature sat steady at 95°C with 8 - 9°C temperature drop. EGT'S 420 - 450°C post turbo. In 4th gear, 95 -100 km/h, the temperature dropped and sat steady at 93 - 94°C with 8 - 9°C temperature drop. EGT'S came down to 380 - 400°C post turbo.

At 3:45pm and 36°C ambient a run was made through some hilly country. The coolant temperature ran 92°C with a tailwind on the outward leg. Going up the first hill the temperature rose to 98°C and 4th gear selected to maintain speed. The throttle had to be adjusted to limit EGTs to 500°C post turbo. The temperature recovered well coming off the hill and would go through this pattern going up and down hills. Heading back to the workshop with a head wind, the temperature slowly climbed to and settled at 97°C.

A new day and the unloaded vehicle was taken for a 25 – 30 km run at 8:30 am and 26°C ambient. It returned results comparable to an equivalent run the week before. The horse float was loaded up and an extra adult passenger on board, with a run through the hills at 9:00 am recording 92 – 93°C through the hills. Throttle was adjusted to control EGTs. **A boost 'T' was fitted, and the boost increased from 13.5 psi to 16.5 – 17 psi.** A run was then made at 12:00 pm and 33°C. This resulted in decreased EGTs maxing at 480 - 500°C while accelerating up to and holding 100 km/h up hills. Water temperature maxed at 94°C and recovered quickly to sit at 90 - 92°C on the flat.

The coolant and **water pump** were removed and **all internal steps or sharp edges in the water flow path between the water pump and the block were removed with a Dremel**. The impellor was raised on the shaft to leave a clearance between it and the block of 0.5 mm. A run with loaded trailer at 9:00 am and 27°C ambient saw 87°C on the flats and 92°C in the hills. There appeared to be no variance in operating temperatures, but recovery was noticeably quicker.

A 'T' piece joined length of hose and ball valve were fitted between the inlet and outlet heater hoses. At 12:00 pm and 32°C ambient with the tap closed and the heater off, 100 km/h saw steady 86°C. With the heater turned on, no significant temperature change was observed. Nor was any significant change observed with the ball valve open and heater closed or with the ball valve and heater open.

It was decided to apply some the principles learnt from these tests to the **HZJ75 98kW RWHP** 'Troopy'. It has the 1HDT conrods, the Diesel Performance Parts ceramic coated, oil-gallery cooled crown 1HZ-T pistons, the standard 1HZ fuel pump, Garret CT26 equivalent turbocharger, Eclipse stainless steel exhaust manifold, O.E. thermostat, same make aftermarket 4-core radiator as the previous vehicle but no intercooler. The engine was only recently fully rebuilt and the customer added the radiator at that time. The vehicle was experiencing some heating issues, but not as severe as the ute. It should be noted it was not towing the loads of the ute either.

The radiator was replaced with an **Adrad 2-core radiator**, it had an O.E. thermostat and Toyota red coolant added. The vehicle was test run at 30°C ambient and 65% humidity. At 100 km/h and the A/C on, the highest coolant temperature was 90°C, stabilising at 88°C, with a temperature drop across the radiator of 9 - 10°C. A **Diesel Performance Parts Hi-Flow Viscous Hub and Fan kit** was fitted with 70% of the blade width in the shroud and 30% out. On the same test circuit at 100 km/h and the A/C on, the highest coolant temperature was 86°C, stabilising at 84 - 85°C, with a temperature drop across the radiator of 12 - 13°C.

A 10.5 mm wider adaptor was fitted to the hi-flow viscous hub and fan, placing the fan blade width 100% in the shroud. A test run at 28°C ambient and 80% humidity made no difference to temperatures.

The water pump impellor was raised on the shaft to give 0.3 mm clearance to the block. The hi-flow viscous hub and fan were still installed but the shorter 32 mm wide adaptor was re-fitted. The vehicle was test run at 36°C ambient and 35% humidity. With the A/C on and 100 km/h, the highest coolant temperature was 90°C, stabilising at 86 - 87°C, with a temperature drop across the radiator of 10 - 11°C.

The Results

These results are based on tests on Toyota 1HZ-T engines. There are no guarantees that they apply to all 1HZ-T and 1HD-T engines and certainly not to any other make or model engine. The best measure for radiator and fan efficiency is pre and post radiator temperature gauges. Two gauges allows you to monitor the temperature of the coolant coming out of the engine (what your engine is doing) and the temperature coming out of the radiator (what your radiator and fan are doing). You should be able to obtain a drop of 10 - 12°C – less on hot days and low humidity and more on cooler days and high humidity – if you have an efficient radiator and fan.

To achieve the best results, we recommend:

- The old radiator is flushed, and the fins unblocked and checked for corrosion.
- The engine block and cylinder head are cleaned in a caustic tank to remove scale and sediments. The block must be well flushed to ensure no caustic remains, as this can affect coolant and cooling.
- Fit an O.E. Toyota or O.E.M. aftermarket thermostat.
- Fit an O.E. or Adrad 2-core radiator and radiator cap. There may be other brands as efficient also – but be sure to test them to see how well they work.
- Use Toyota red coolant additive.
- Fit a Diesel Performance Parts Hi-Flow Viscous Hub and Fan Kit – EMPTO330B (32 mm adaptor) or EMPTO330C (42.5 mm adaptor).
- Install two quality temperature gauges – pre and post radiator.

Note:

As a footnote, some time after these tests were conducted, we evaluated the effect of the air conditioner condenser on the cooling system on two vehicles. In both cases the condenser was full of seeds, grass, insects etc. and the fins were bent and damaged after 25+ years operation. Fitting new O.E. condensers saw a 4°C drop in peak cooling system temperatures under load on the dyno and a significant increase in air conditioner efficiency.

Obviously, the condenser sits in front of the radiator and affects the volume and temperature of air passing through a significant surface area of the radiator. As far as air conditioner efficiency goes, an even larger improvement was from the removal and cleaning or replacement of the evaporator. Years of built up 'crud' had almost completely block them off in both vehicles. With new condensers, cleaned inside and out evaporators and a re-gas, the air conditioner systems are working incredibly well. The difference is significant.

Available from:

Engine Australia Phone: 1300 364 463