Pontiac Solstice Header Comparison
January, 2008

On January 4th, 2008, and January 18th, 2008, Trifecta Performance, Clear Image Automotive, and Meridian Performance Services together performed a series of chassis dynamometer tests involving 5 different exhaust headers on a 2006 Pontiac Solstice, outside of Lynden, WA. This article will discuss the test methodology, approach and the results. The primary objective was to determine which of the four exhaust headers made the most power, both with stock programming, and custom programming. The effects of fuel grade on the outcome of some of the tests were evaluated as well.

The conclusion was that the "shortie" style four-into-one manifold replacement header had the broadest torque and horsepower gains both with stock programming, and custom programming. However, the four-into-one long tube style header made the most peak power and torque. Out of the two tri-y designs tested, the tri-y with cylinders #1 and #4 and cylinders #2 and #3 tied together made the most peak power with custom programming, and the tri-y with cylinder #1 and #3 tied together, along with cylinders #2 and #4 tied together made the most peak power with stock programming.

The Vehicle

The vehicle used in the testing was a 2006 Pontiac Solstice. This vehicle is equipped with General Motors' "Ecotec" 2.4L, which is an inline 4 cylinder engine, with dual overhead camshafts, and electronic camshaft phasing. The vehicle has a 5 speed manual transmission, and other than the exhaust modifications, was completely stock.

The Gasoline

On January 4th, the testing was performed with regular unleaded fuel, rated at 87 octane. On January 18th, the testing was performed with supreme unleaded fuel, rated at 92 octane. It was determined supreme unleaded added an averaged 1.03% of horsepower and torque with stock programming, and an averaged 1.02% horsepower and torque with custom programming.

The Headers

Five exhaust headers were tested – two "tri-y" headers (of differing design), a "shortie" style four-into-one header, a long tube style four-into-one header and the stock exhaust manifold. The first "tri-y" had cylinders #1 and #4 joining together into one of the primary collectors, and cylinders #2 and #3 joining together into the other primary collector. The second "tri-y" header had cylinders #1 and #3 joining together into one primary collectors, and cylinders #2 and #4 joining together into the other primary collector.

The "shortie" style four-into-one is essentially a manifold replacement part. The stock manifold is a cast iron manifold.

The Testing

Each header was installed on the vehicle, and the vehicle was subjected to a "baselining" procedure with the stock tune in the ECM. The baselining involved repeated "dyno" pulls until the recorded power output from the vehicle was consistent. This approach eliminates biased or incorrect data due to things such as carbon deposits that had built up in the combustion chamber, or dyno-pulling an engine that had not reached operating temperature.

The chassis dynamometer used was a Dynojet "above ground" model.

Once the baseline was established, custom tuning of the ECM was performed as outlined in the custom tuning approach section below.

Dynamometer Operation

All "dyno pulls" were performed in 4^{th} gear, which is the vehicle's 1:1 transmission ratio. The vehicle was at operating temperature for each pull, and engine temperature was controlled by an external 2' diameter cooling fan. The vehicle was brought up to speed gradually, and dyno pulls began at the 2400-2800 RPM range. The pull was continued until the engine control module (ECM) cut the fuel due to reaching the upper RPM limit of 6800 RPM. All dyno results are reported as "uncorrected".

Wideband exhaust gas analysis was performed by the installation of a post-catalyst wideband oxygen sensor.

All horsepower and torque measurements were evaluated using SAE correction factor, which takes into account the environmental conditions at the time of the test.

Custom Tuning Approach

Generally speaking, GM engines are tuned too rich during wide open throttle operation, known as PE mode (power enrichment mode) from the factory. It is widely believed this is the case because GM wanted to be either (or both) conservative in their tune, and/or create opportunity for the aftermarket to add power via fine-tuning.

PE mode (wide open throttle) fuel ratio tuning

The factory tune had a delayed PE mode onset, which caused the engine to run at the closed-loop AFR (air to fuel ratio) of about 14.6 to 1 until 3200 RPM. This is not the ideal AFR for maximum power. Once PE mode came on, the AFR gradually enrichened, passing under 12.5:1 at about 4500 RPM, eventually bottoming out at 10:1 at 6000 RPM, continuing until the redline of 6800 RPM. This is a poor fuel curve for top performance, hence most of the tuning effort was spent correcting this curve.

It was found maximum power and torque came at a leaner fuel mixture using supreme unleaded than when using regular unleaded.

Spark advance timing curve

The factory "high octane" timing table caused 2-4 degrees of "spark knock retard" in the 2800-3400 RPM range, and 1-2 degrees of "spark knock retard" in the 6000 and above RPM range with 87 octane fuel. Some effort was spent on assessing whether any additional power gains could be found via spark map tuning, but with 87 octane fuel, the gains were negligible. With supreme unleaded, however, most of the additional power gains came from being able to employ a more aggressive spark advance curve.

Catalyst Over-temperature Protection (COT)

It was discovered that the "crashing" of the AFR at the 6000 RPM point on the stock tune was caused by the ECM's catalyst over-temperature (COT) protection feature. This feature is designed to enrichen the fuel mixture when the catalytic converter temperature gets too high. The ECM doesn't actually have a temperature sensor in the catalytic converter, rather, it uses heuristics to estimate the catalyst temperature. Extended, full throttle operation is sure to cause the heuristics to determine the catalyst is overheating.

Disabling the COT feature corrected the "crashing" of the AFR and for the purposes of the custom tuning, it was left disabled. It is not believed COT will pose a major issue on the street as sustained wide open throttle operation in 4th gear will rarely be experienced.

Charts, Notes and Observations

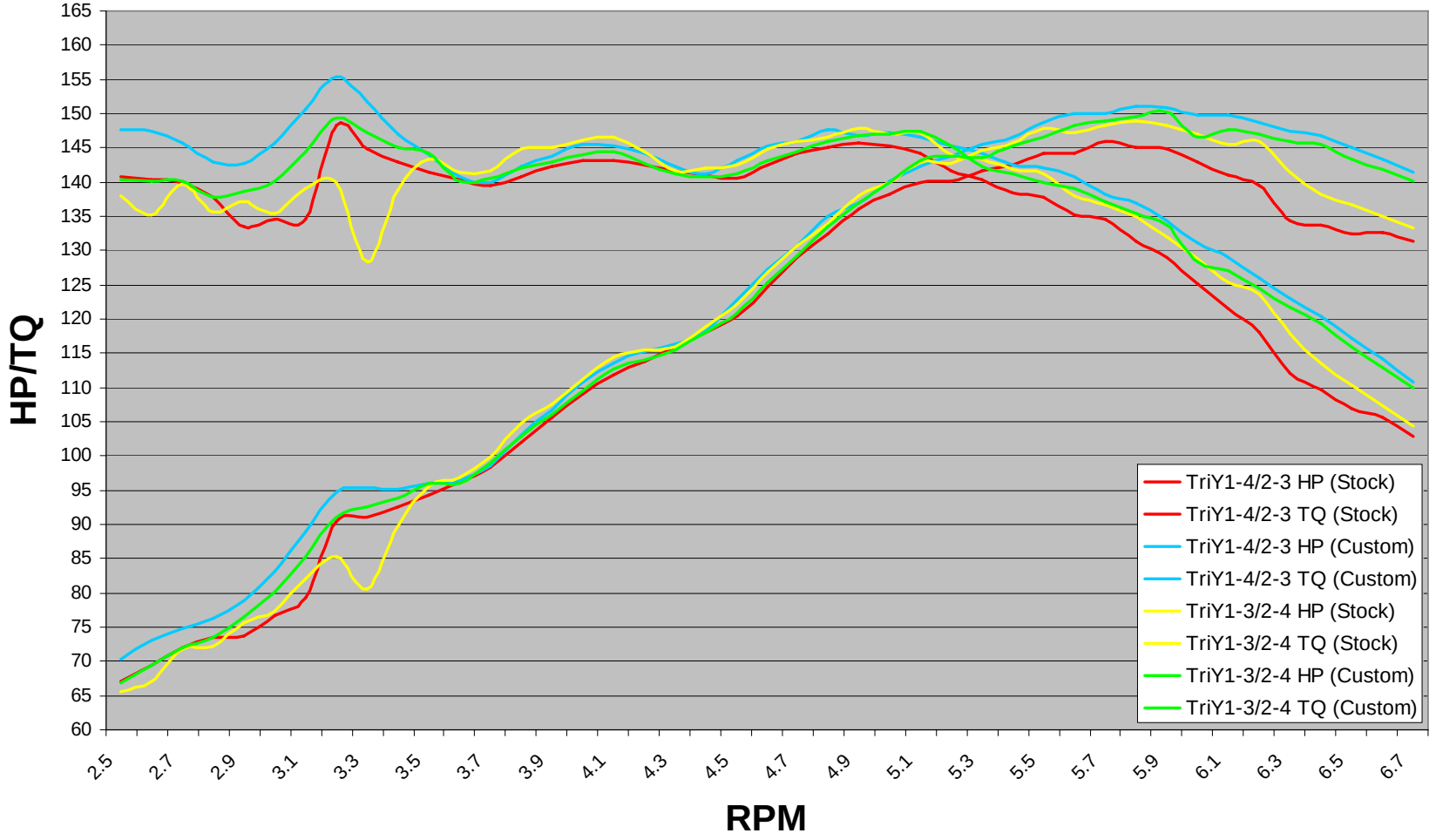
Below are selected charts comparing the results of the various dyno runs. The following was observed:

- Each of the headers, by themselves, added power over the stock manifold.
- In each case, custom programming added additional gains
- In each case, the addition of headers and custom programming were synergistic, or added more power than either of these items by themselves
- Supreme unleaded added additional power in both the case of stock programming, and custom programming
- The four-into-one long tube design made the most peak power overall, however, it should be noted that this header was never tested with 87 octane fuel, so the comparisons are slightly unfair.

The Tri-Y Face Off: Cyl 1-4/2-3 vs Clear Image Tri-Y

Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune

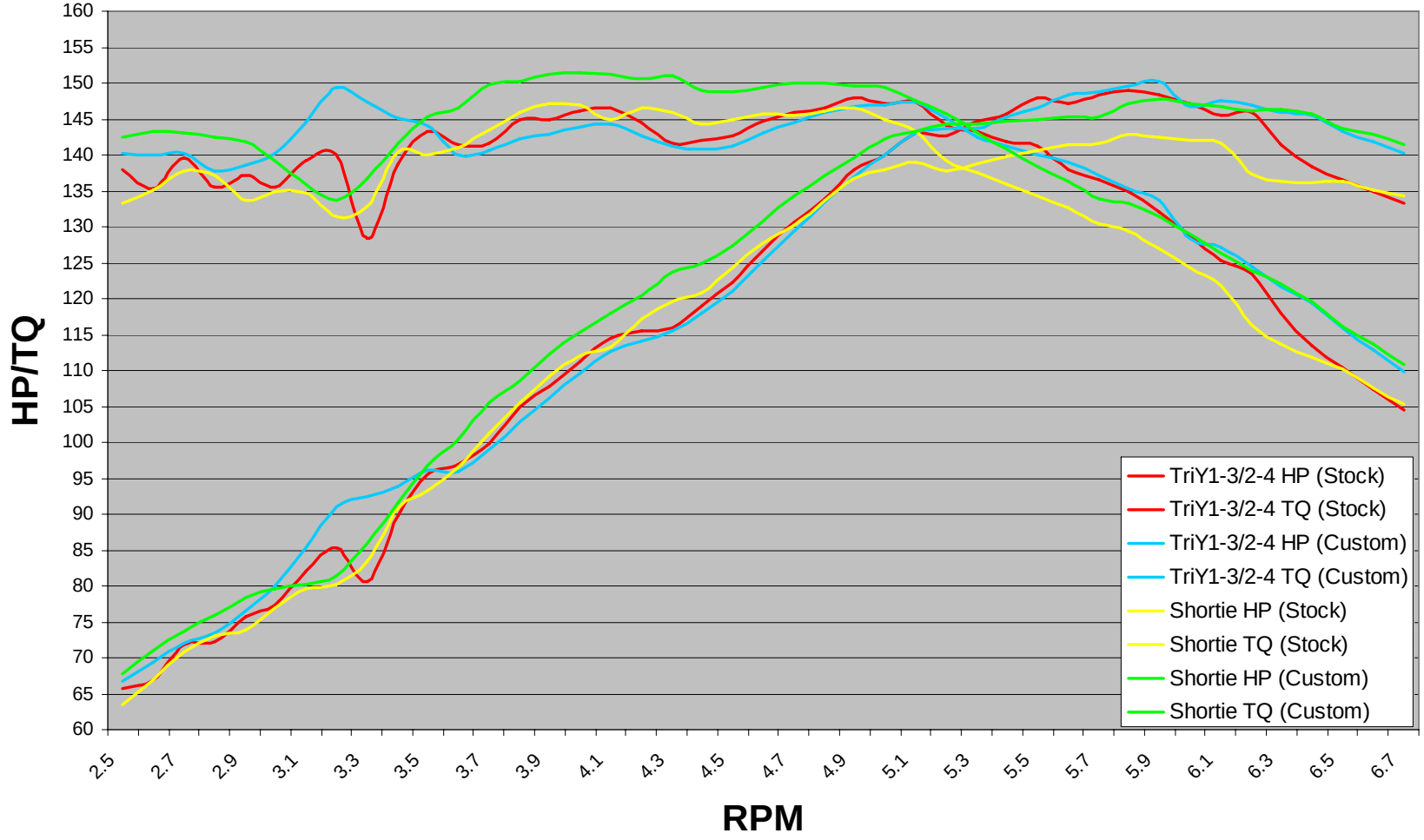
Tests were performed with regular unleaded fuel (87 octane) on 2006 Pontiac Solstice w/ 5sp



Clear Image Tri-Y vs Clear Image 4 into 1 "shortie"

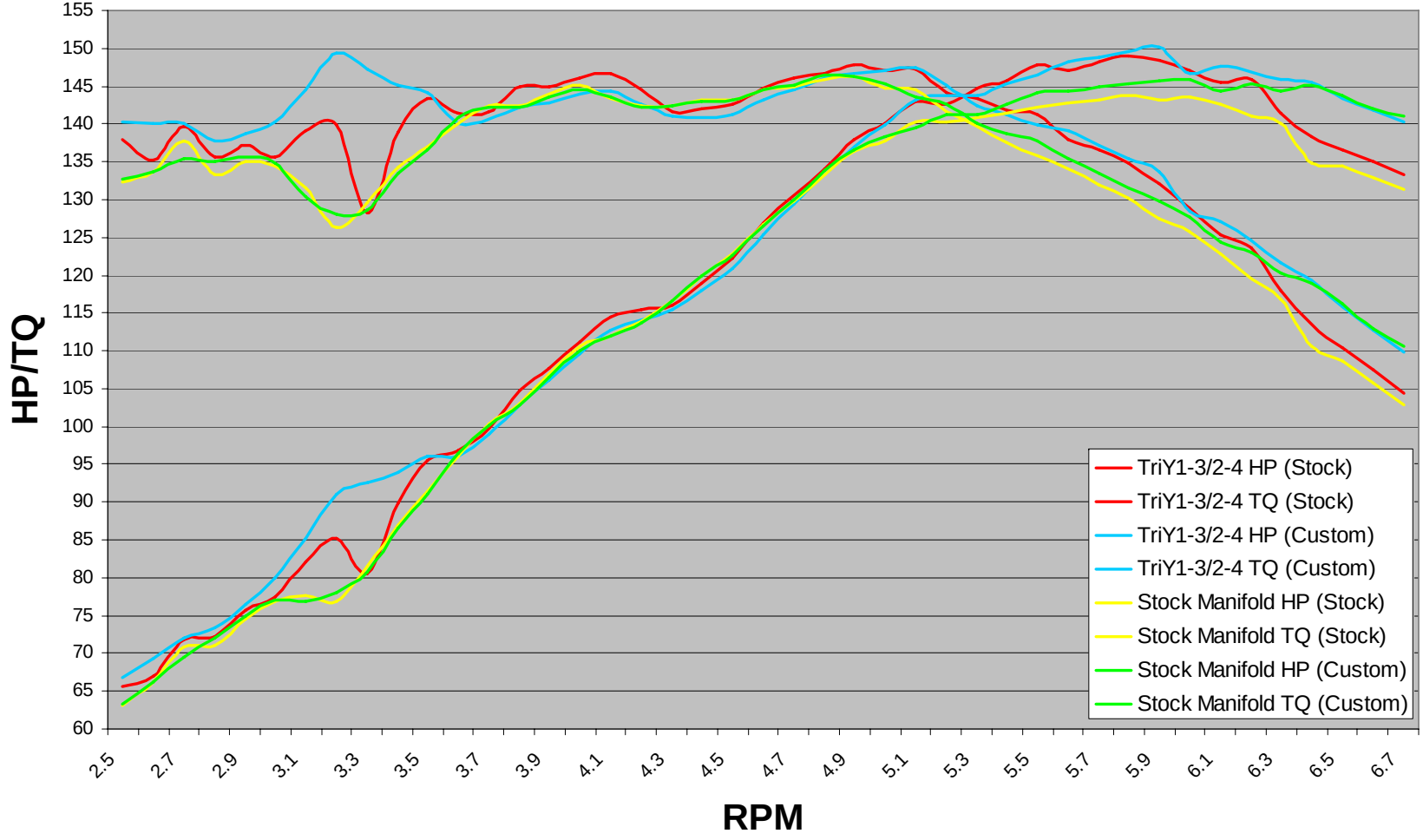
Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune

Tests were performed with regular unleaded fuel (87 octane) on 2006 Pontiac Solstice w/ 5sp



Clear Image Tri-Y vs Stock Manifold

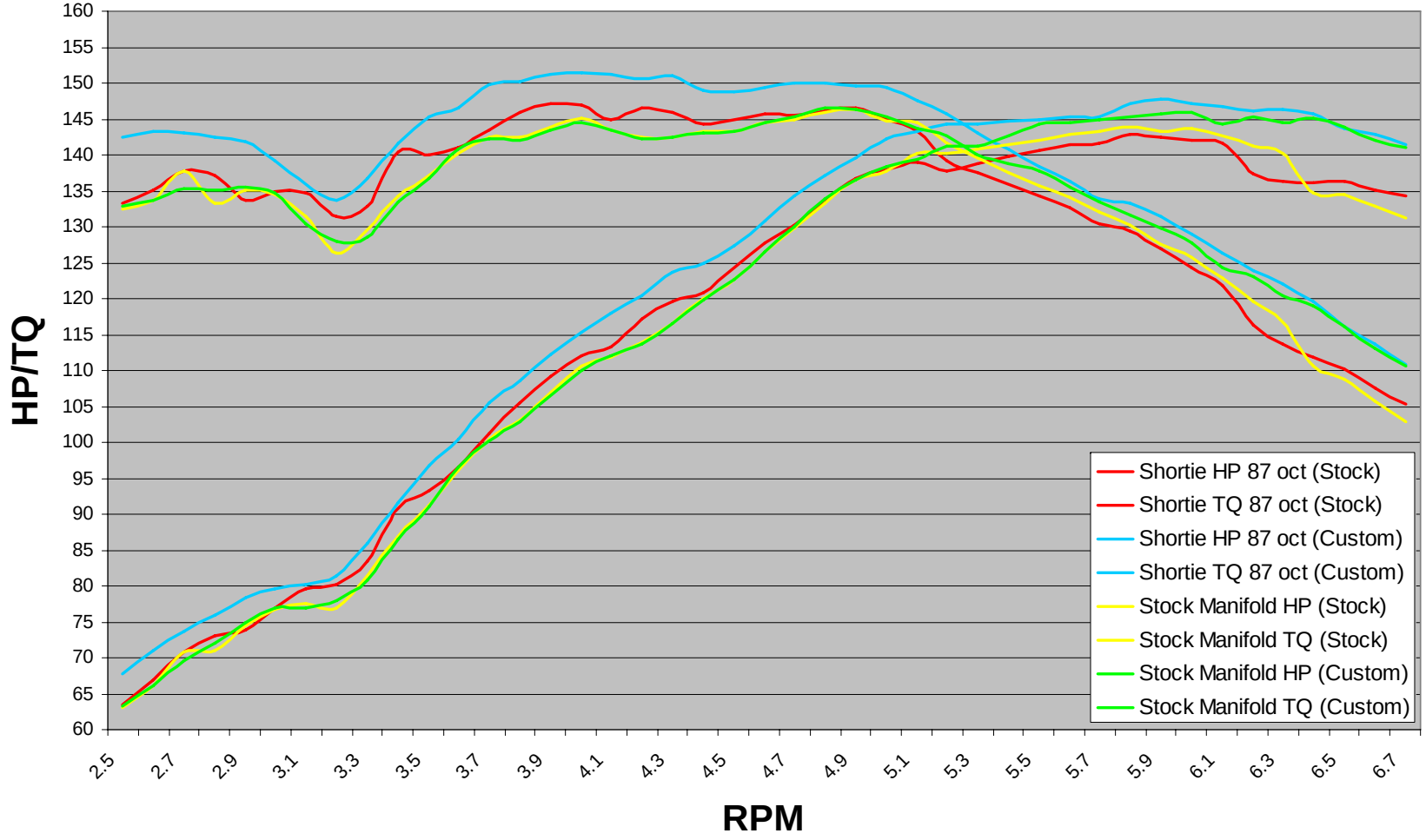
Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune
Tests were performed with regular unleaded fuel (87 octane) on 2006 Pontiac Solstice w/ 5sp



Clear Image 4 into 1 "shortie" vs Stock Manifold

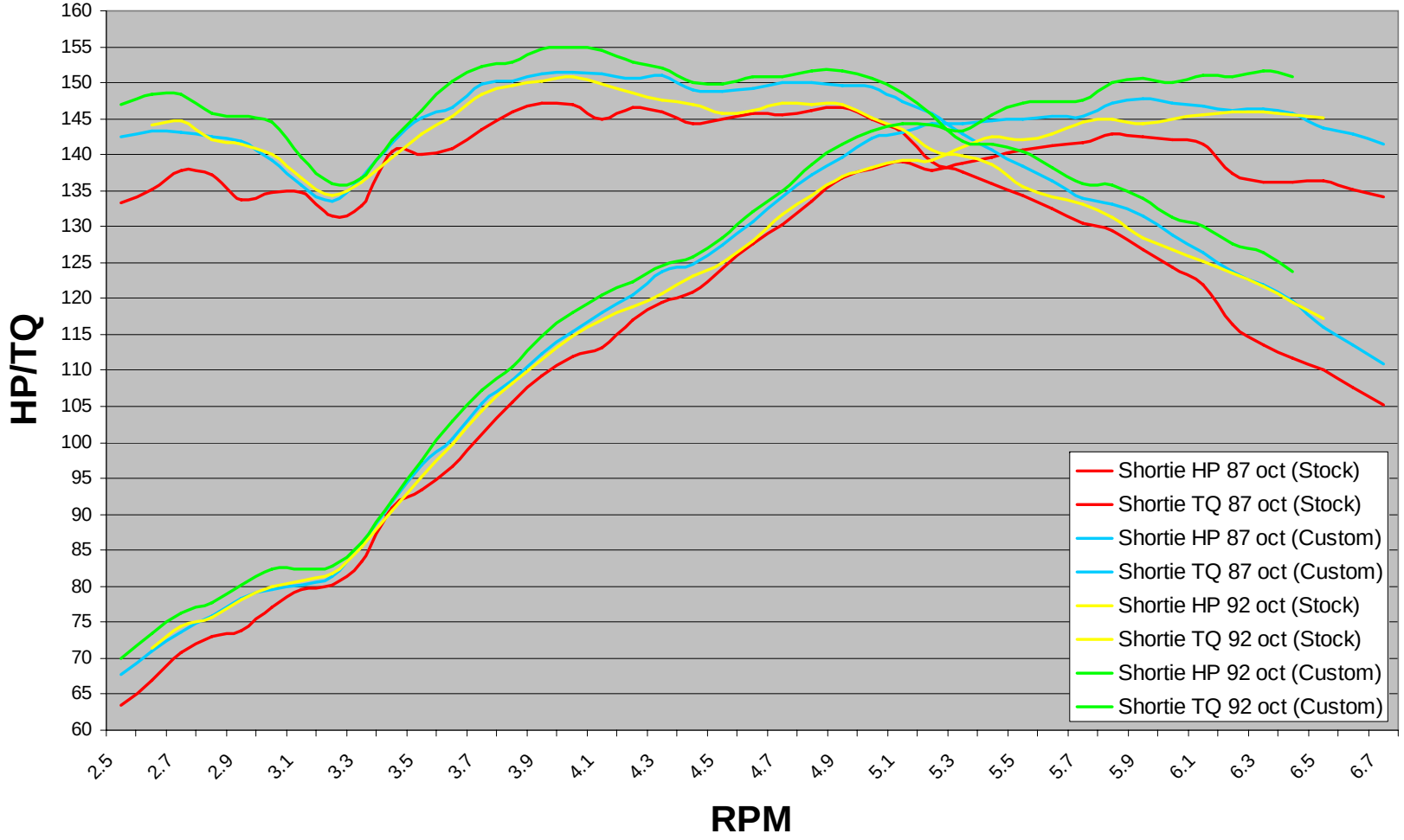
Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune

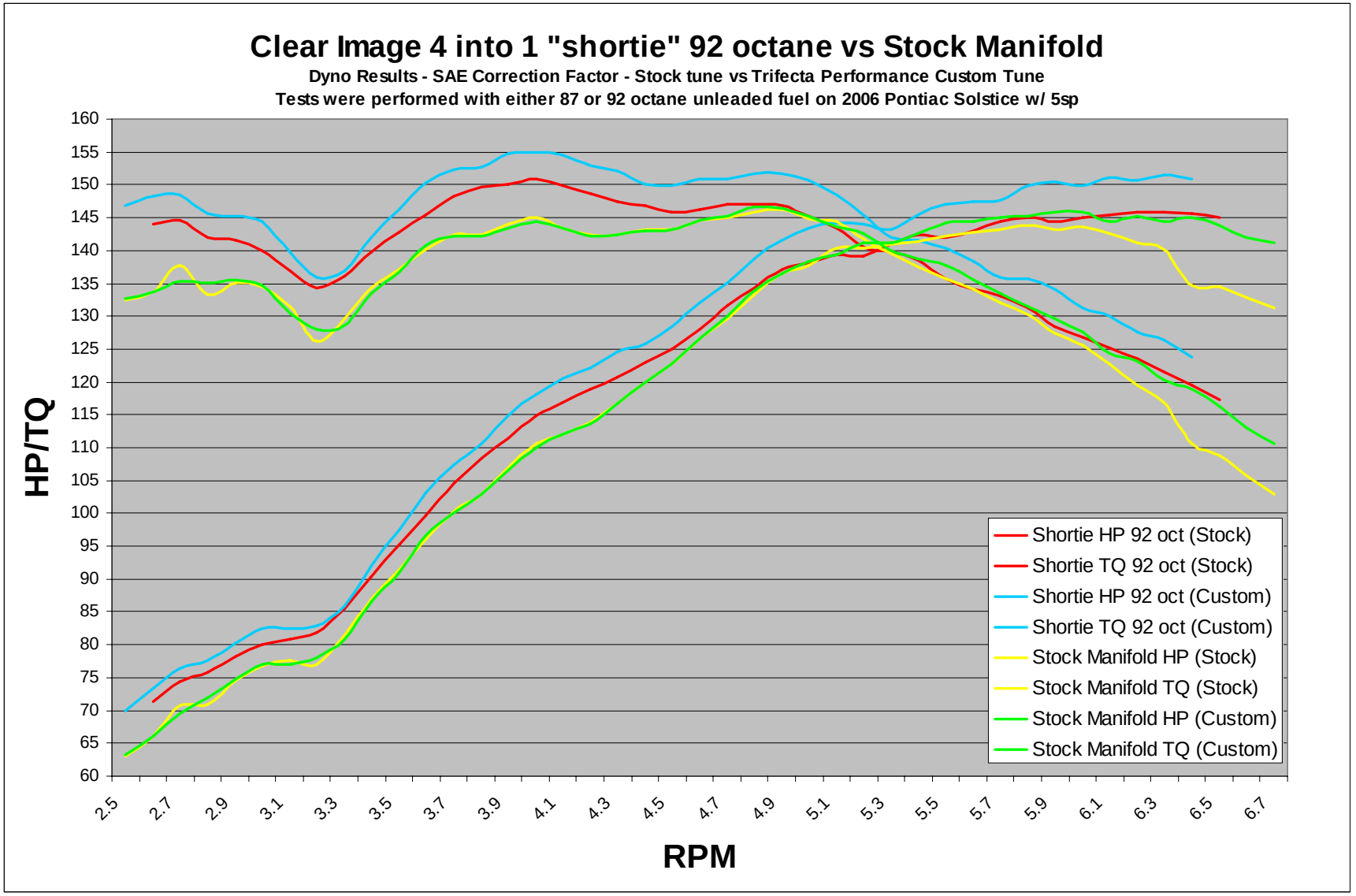
Tests were performed with regular unleaded fuel (87 octane) on 2006 Pontiac Solstice w/ 5sp

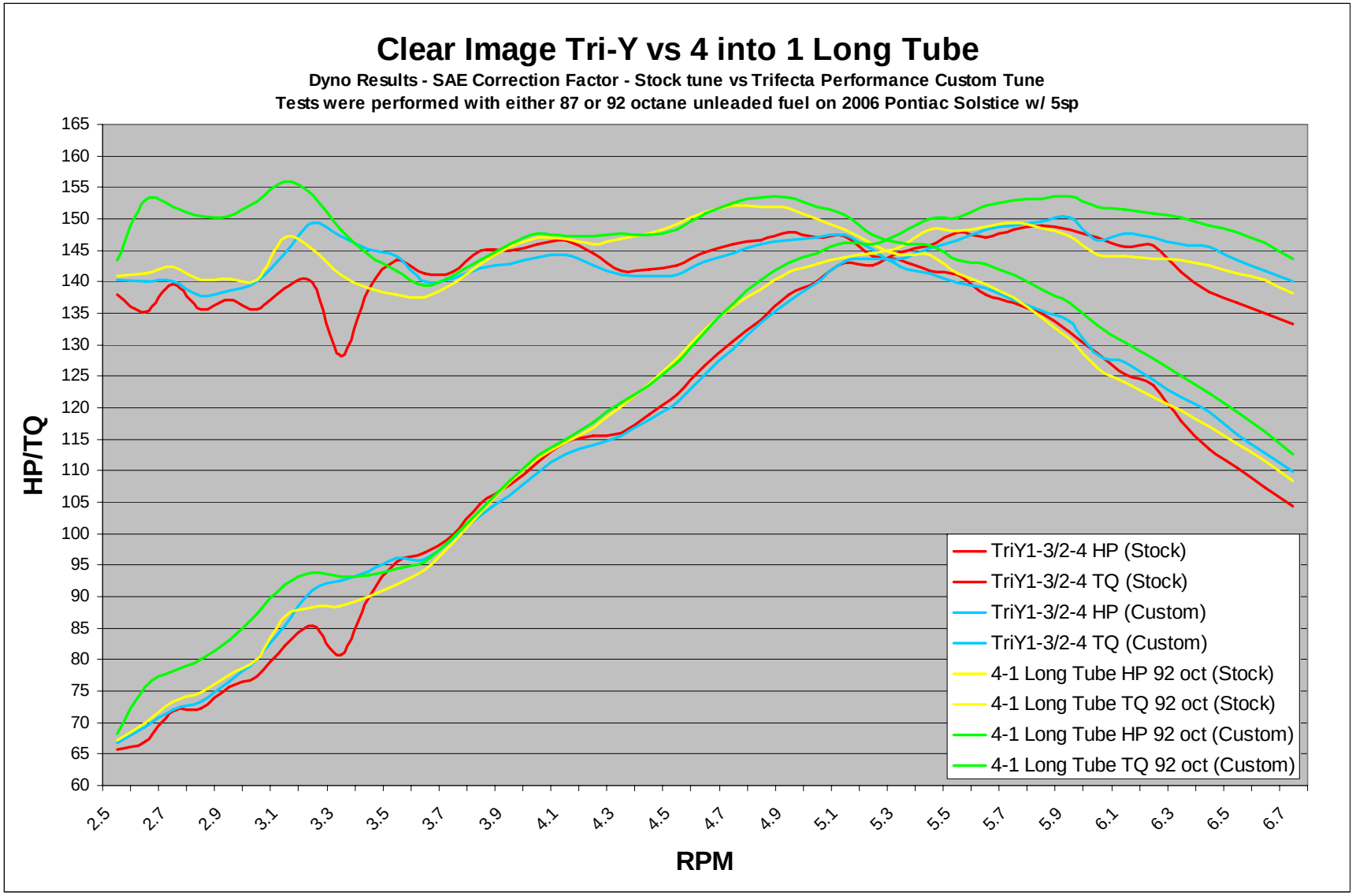


Clear Image 4 into 1 "shortie" 87 octane vs 92 octane

Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune
Tests were performed with either 87 or 92 octane unleaded fuel on 2006 Pontiac Solstice w/ 5sp



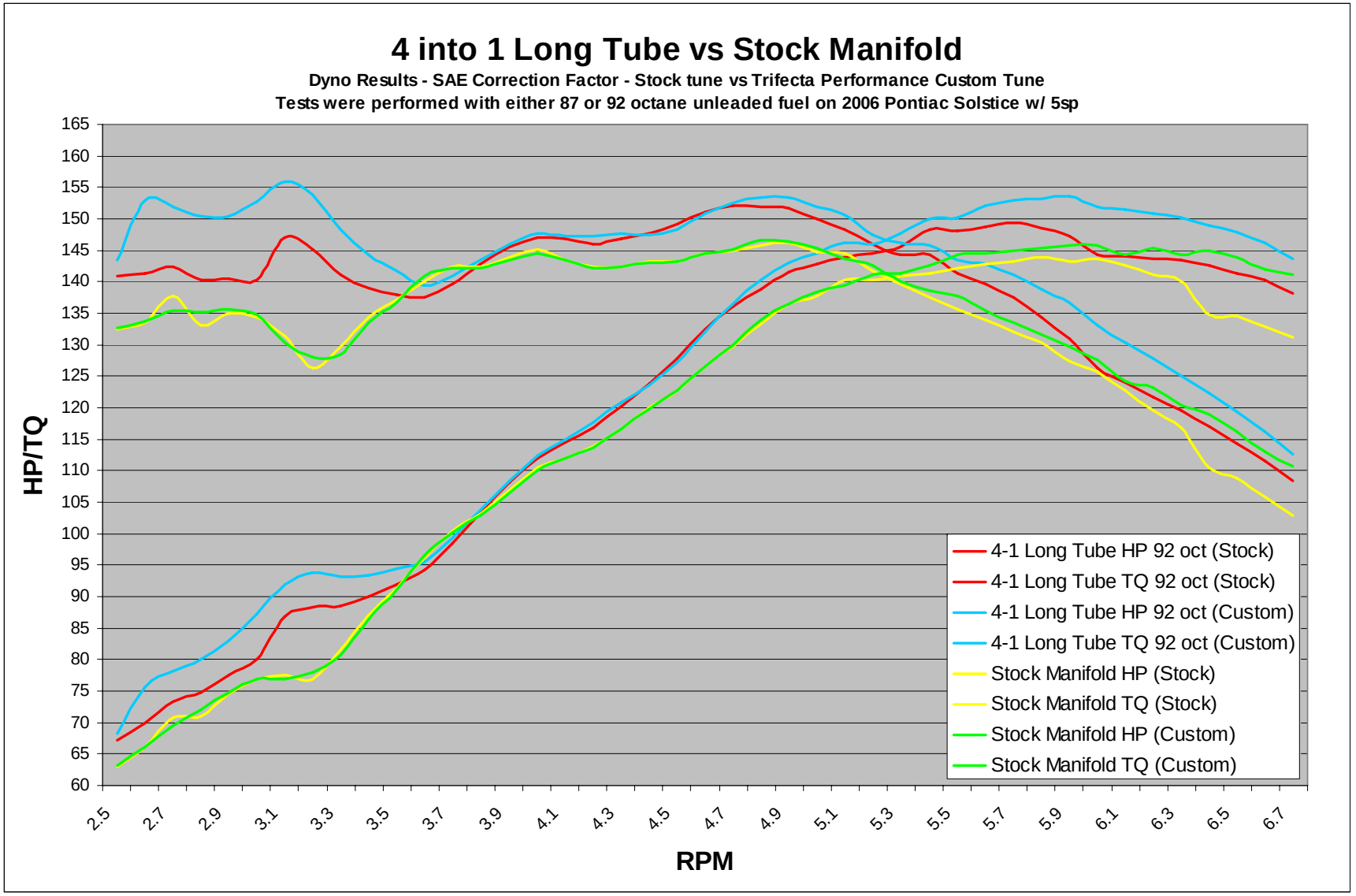

Clear Image 4 into 1 "shortie" 92 octane vs Stock Manifold
Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune
Tests were performed with either 87 or 92 octane unleaded fuel on 2006 Pontiac Solstice w/ 5sp
HP/TQ
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
RPM
Shortie HP 92 oct (Stock)
Shortie TQ 92 oct (Stock)
Shortie HP 92 oct (Custom)
Shortie TQ 92 oct (Custom)
Stock Manifold HP (Stock)
Stock Manifold TQ (Stock)
Stock Manifold HP (Custom)
Stock Manifold TQ (Custom)


Clear Image Tri-Y vs 4 into 1 Long Tube
Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune
Tests were performed with either 87 or 92 octane unleaded fuel on 2006 Pontiac Solstice w/ 5sp
HP/TQ
RPM
TriY1-3/2-4 HP (Stock)
TriY1-3/2-4 TQ (Stock)
TriY1-3/2-4 HP (Custom)
TriY1-3/2-4 TQ (Custom)
4-1 Long Tube HP 92 oct (Stock)
4-1 Long Tube TQ 92 oct (Stock)
4-1 Long Tube HP 92 oct (Custom)
4-1 Long Tube TQ 92 oct (Custom)

4 into 1 Long Tube vs Stock Manifold

Dyno Results - SAE Correction Factor - Stock tune vs Trifecta Performance Custom Tune

Tests were performed with either 87 or 92 octane unleaded fuel on 2006 Pontiac Solstice w/ 5sp



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