2017 Yamaha Sidewinder Genesis 998 Turbo Engine

“Sidewinder” is a great name for the first production snowmobile to make over 200 CHP at DTR. A “sidewinder” is, among other things, a rattlesnake that can travel 18 mph (terrifyingly fast for a poisonous snake), a nasty military missile, and a powerful Pratt & Whitney radial aircraft engine with two compound superchargers—the second of which is gear driven perpendicular to the crankshaft. Thanks to Kevin Cameron for that last tidbit!

This preproduction (900 miles) Sidewinder was brought to DTR by Yamaha for an independent dyno evaluation on its way to the Snow Fest (grass fest this year) in Old Forge, NY. Yamaha techs/ test riders/ great guys Dan Miller and Brian Ehmann helped wrench and dyno test this new engine.

The engine is a 998cc four stroke triple (the same configuration as used in Yamaha’s high performance SxS), reengineered in Japan for reliability with boost. Here are some features highlighted in Yamaha’s 2017 brochure:

- Side mounted high tech IHI turbo—low friction ceramic ball bearings and light weight turbine wheel = instant boost and throttle response.
- Forged low compression turbo pistons (cooled from the bottom side by oil jets)
- Forged steel turbo-specific con rods
- Triple throttle bodies
- Cast steel exhaust manifold
- Front mounted intercooler
- Mitsubishi ECU with detonation protection.

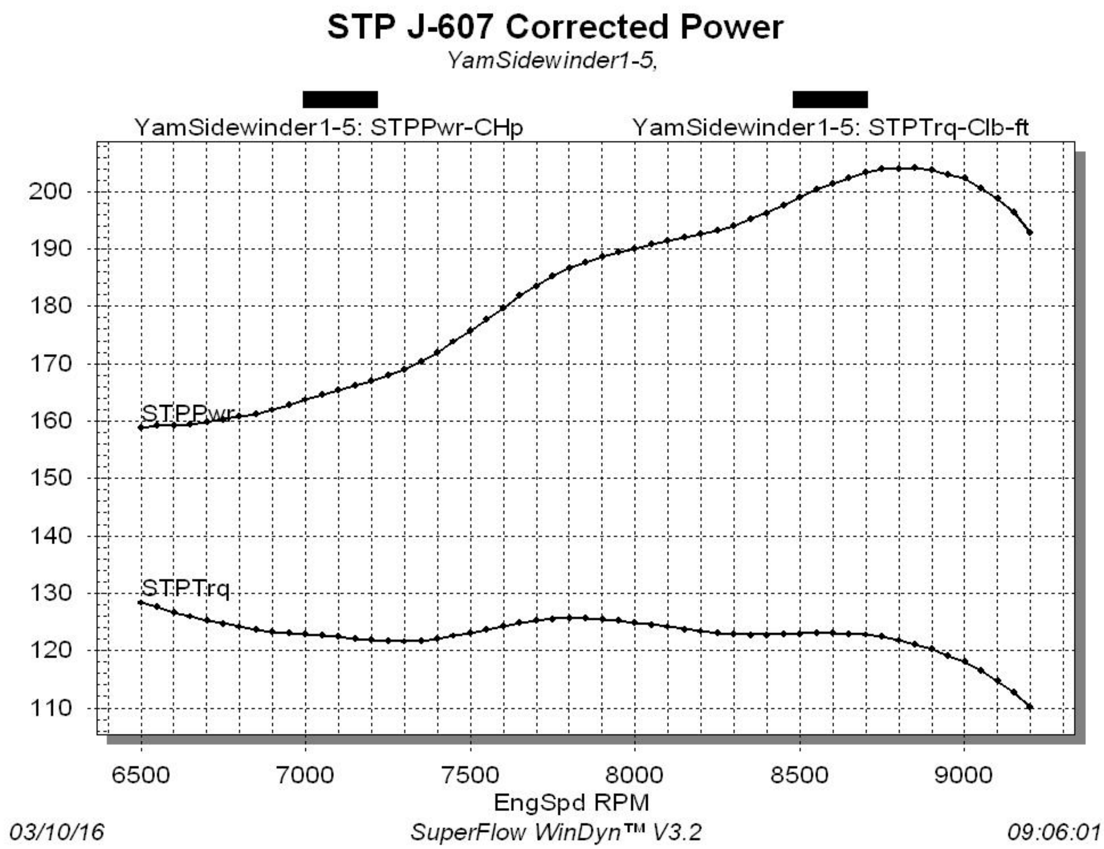
This has been a bad winter thanks to El Nino, and this day was the warmest March 9 on record (@70 F). We did six dyno tests with ambient air—test one was just over 200 CHP and once the oil temp was optimal, this test was typical. The fuel in the tank was tested on our Zeltex 101C near infrared octane analyzer—91.1 R+M/2 octane and 0% ethanol. And note in this test data that our LamAF1 wideband A/F ratio reading (from exhaust gas measured at the muffler outlet) mirrors the mechanically measured AFRA_B A/F ratio (pounds of air based upon measured CFH and air density and bypassed fuel from regulator beck to tank lb/hr B subtracted from gross flow A from pump to rail lb/hr). Turbo engines usually give us excellent airflow and exhaust outlet wideband readings due to the smooth, pulse-free air inlet and reversion-free exhaust outlet. One of the two outside air blower ducts was placed directly in front of the intercooler, blowing 80 mph 70 degree F air through the core.

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA_B lb/hph	FulA_B lbs/hr	LamAF1 Ratio	AFRA_B Ratio	Air_1c CFM	BoostP psig
6500	158.8	128.3	0.470	69.3	12.00	11.49	185.4	8.1
6550	159.2	127.6	0.470	69.5	11.96	11.50	186.1	8.1
6600	159.2	126.7	0.473	69.9	11.89	11.48	186.9	8.2
6650	159.4	125.9	0.474	70.3	11.83	11.46	187.5	8.2
6700	159.8	125.3	0.475	70.5	11.78	11.45	188.0	8.1
6750	160.3	124.7	0.475	70.7	11.75	11.45	188.5	8.2

6800	160.7	124.1	0.476	71.1	11.73	11.43	189.2	8.2
6850	161.2	123.6	0.477	71.4	11.72	11.43	190.0	8.2
6900	161.9	123.2	0.477	71.7	11.72	11.43	190.9	8.2
6950	162.8	123.1	0.476	72.0	11.72	11.44	191.8	8.3
7000	163.7	122.8	0.477	72.4	11.72	11.44	193.0	8.3
7050	164.6	122.6	0.477	72.9	11.70	11.44	194.2	8.3
7100	165.4	122.4	0.478	73.3	11.68	11.42	195.2	8.4
7150	166.2	122.1	0.481	74.1	11.66	11.38	196.5	8.4
7200	167.0	121.8	0.484	74.9	11.64	11.34	197.9	8.5
7250	167.9	121.7	0.486	75.6	11.63	11.31	199.5	8.6
7300	169.0	121.6	0.488	76.5	11.63	11.29	201.3	8.7
7350	170.3	121.7	0.490	77.4	11.64	11.27	203.3	8.9
7400	172.0	122.0	0.491	78.2	11.65	11.27	205.5	9.1
7450	173.8	122.5	0.491	79.1	11.66	11.27	207.8	9.2
7500	175.8	123.1	0.491	80.0	11.66	11.26	210.2	9.3
7550	177.8	123.7	0.491	80.8	11.66	11.27	212.4	9.5
7600	179.7	124.2	0.490	81.5	11.66	11.28	214.5	9.6
7650	181.8	124.8	0.490	82.5	11.64	11.27	217.1	9.7
7700	183.6	125.2	0.490	83.3	11.62	11.27	219.1	9.7
7750	185.2	125.5	0.491	84.1	11.59	11.25	221.0	9.8
7800	186.6	125.6	0.491	84.7	11.56	11.26	222.7	9.8
7850	187.7	125.6	0.492	85.4	11.53	11.25	224.5	9.8
7900	188.7	125.5	0.493	86.0	11.50	11.26	226.2	9.8
7950	189.5	125.2	0.496	86.9	11.45	11.24	228.2	9.8
8000	190.0	124.8	0.500	87.8	11.41	11.22	230.2	9.8
8050	190.9	124.5	0.501	88.4	11.39	11.20	231.4	9.8
8100	191.5	124.1	0.504	89.1	11.36	11.17	232.7	9.8
8150	192.0	123.7	0.506	89.7	11.35	11.16	234.0	9.8
8200	192.6	123.3	0.506	90.0	11.35	11.18	235.3	9.9
8250	193.3	123.1	0.504	90.0	11.36	11.23	236.6	9.9
8300	194.1	122.8	0.502	90.0	11.40	11.30	237.8	9.9
8350	195.1	122.7	0.499	89.9	11.47	11.37	239.2	9.9
8400	196.3	122.7	0.496	89.8	11.57	11.46	240.7	9.9
8450	197.6	122.8	0.492	89.8	11.68	11.53	242.2	9.8
8500	199.0	123.0	0.490	89.9	11.76	11.57	243.4	9.8
8550	200.3	123.0	0.487	89.9	11.84	11.62	244.7	9.8
8600	201.4	123.0	0.483	89.8	11.91	11.71	246.2	9.9
8650	202.4	122.9	0.480	89.6	11.95	11.78	247.1	9.9
8700	203.4	122.8	0.477	89.4	11.97	11.84	247.8	9.9
8750	203.9	122.4	0.475	89.3	11.99	11.90	248.8	9.9
8800	204.0	121.8	0.478	89.8	11.97	11.88	249.9	10.0
8850	204.1	121.1	0.480	90.3	11.93	11.85	250.6	10.0
8900	203.8	120.3	0.483	90.8	11.91	11.83	251.3	10.0
8950	203.0	119.1	0.485	90.6	11.93	11.88	252.1	10.0
9000	202.3	118.1	0.484	90.1	12.00	11.97	252.7	10.0
9050	200.6	116.4	0.482	88.9	12.18	12.18	253.6	10.1
9100	198.7	114.7	0.476	87.0	12.46	12.48	254.6	10.2
9150	196.5	112.8	0.469	84.7	12.84	12.87	255.4	10.2

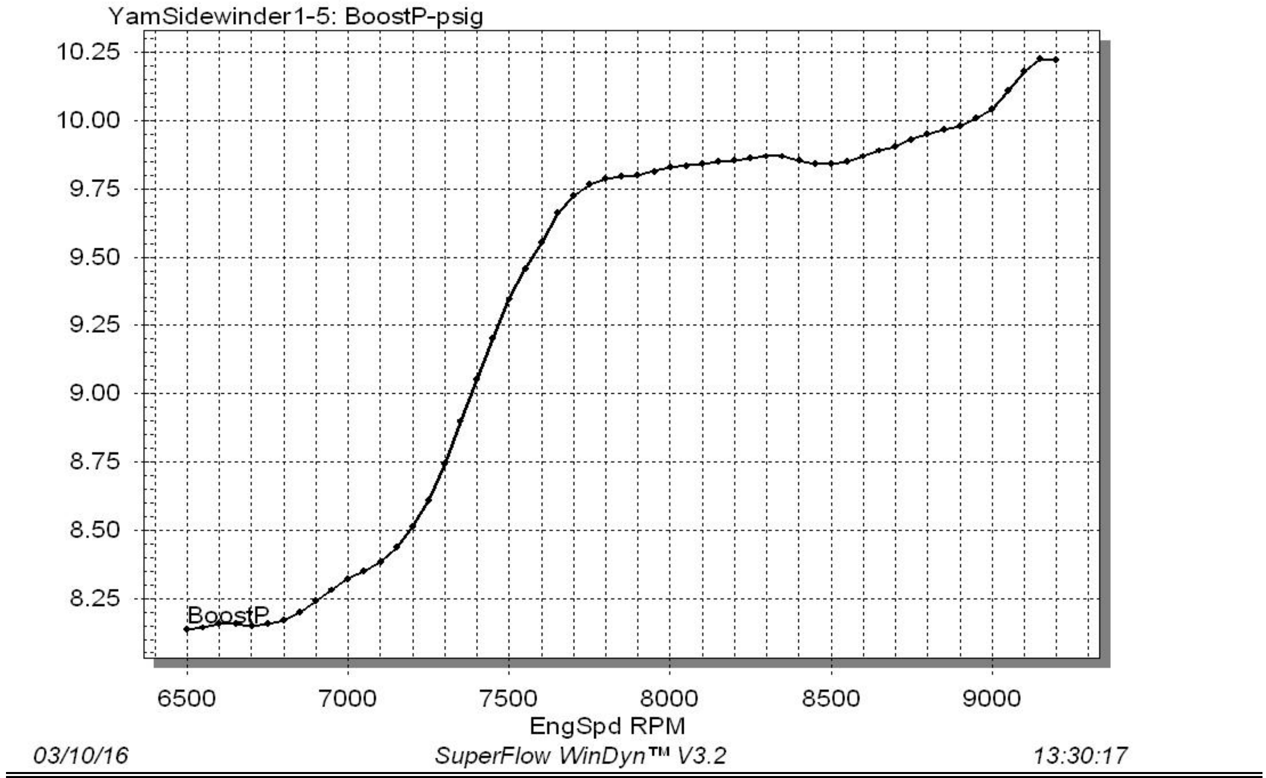
9200	192.8	110.0	0.459	81.3	13.23	13.37	254.9	10.2

Here's a graph of the above torque and HP curves. Note that peak torque is at the start of the test at 6500 then declines steadily, except for a slight hump in the middle. This is where the ECU controlled boost is allowed to rise, as shown in the second graph. Those who continue to think, wrongly, that snowmobiles accelerate best when clutches are tuned to shift initially at peak torque RPM need to look at this torque curve and reconsider! And, imagine what the torque curve would look like if boost were allowed to be full in at 6500, and if test was begun at 5500!

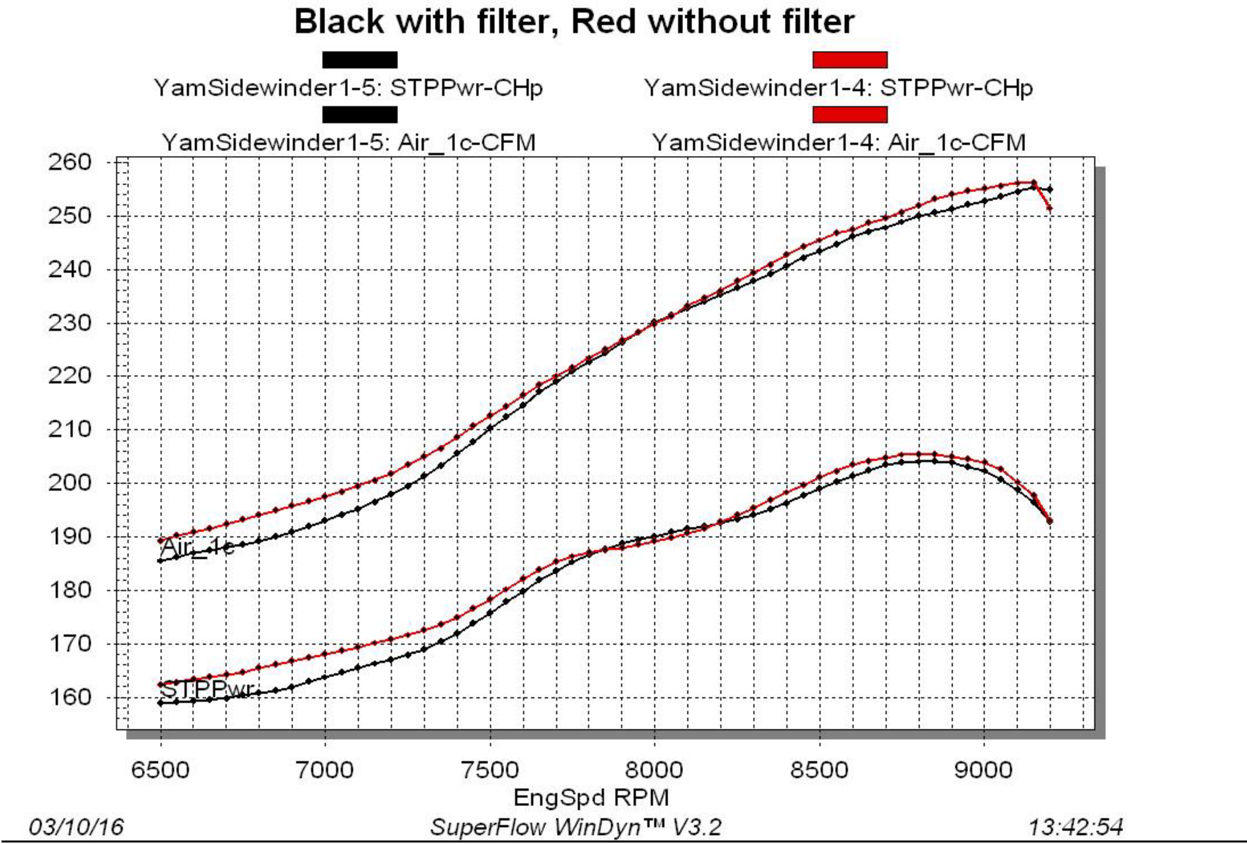


boost rise as controlled by the ECU

[redacted]



We also tested the engine without the oiled foam filter, and picked up a bit of airflow CFM one HP at peak (and a few more in midrange as shown in this graph. Note how the airflow increase mirrors the HP increase. If I owned one of these I would leave the filter in place. Any small piece of debris—even plastic—will dance around on a spinning compressor wheel, like the ball on a spinning roulette wheel, and bend or break the thin blades!



And, speaking of data here's more to study from our stock dyno test. Columns two and three are OBSERVED (actual uncorrected) HP and TQ. Column four is fuel A pump to rail, and column five is return fuel. Return fuel is critical, because that tells us how many more OBSERVED HP the stock fuel system will support. 66 lb/hr bypassed @.50 lb/hphr BSFC will cover maybe another 100 OBSERVED HP (fuel needed for a combo of colder, denser air AND added boost once the tuners figure out how to crack the ECU and crank things up!). But note how the pump flow (A) drops as fuel pressure rises. Increasing the boost pressure will drop flow A even more, which reduces B as well. Be cautious! Column five is fuel pressure PSI (idle pressure is 44 psi, and is boost referenced 1/1), six is air intake temperature, and seven is the Brake Specific Air Consumption (lb of air per HP per hour). This turbo engine matches the lowest boosted BSAC that we've seen to date (FPP turbocharged 4tec)—indicating great design, tuning and efficiency. Finally, column eight is STP correction factor at each RPM. Note how the air intake temp/ STP correction changes as revs climb. It took modifying the standard SuperFlow air temp/ humidity sensor to react more quickly—something very necessary, especially when using refrigerated intake air, for near-perfect repeatability. On this test, a standard SF air intake temp sensor would likely have indicated 71.5 for the complete sweep test, resulting in .004 reduction in STP correction factor. On this test, it would have cost us .75 HP—not a huge deal, but what if the STP HP was 199.5? We need every tenth of a HP!

You can’t have too much data:

EngSpd RPM	EngPwr Hp	EngTrq lbs-ft	FuelA lbs/hr	FuelB lbs/hr	FulPrA psig	AirInT degF	BSAC lb/hph	STPCor Factor
6500	147.60	119.26	160.6	91.3	52.9	71.5	5.40	1.068
6550	147.89	118.59	160.5	91.0	52.9	71.5	5.41	1.068
6600	147.90	117.70	160.7	90.8	52.9	71.6	5.43	1.068
6650	148.10	116.97	160.9	90.6	52.9	71.7	5.44	1.068
6700	148.42	116.35	161.0	90.5	52.9	71.7	5.44	1.068
6750	148.87	115.83	161.1	90.4	53.0	71.7	5.44	1.068
6800	149.24	115.27	161.4	90.3	53.0	71.7	5.44	1.068
6850	149.67	114.76	161.7	90.3	53.0	71.7	5.45	1.068
6900	150.31	114.41	162.0	90.3	53.1	71.7	5.45	1.068
6950	151.15	114.22	162.1	90.1	53.1	71.8	5.45	1.068
7000	151.92	113.98	162.1	89.7	53.1	71.8	5.46	1.068
7050	152.70	113.76	162.0	89.1	53.2	71.9	5.46	1.069
7100	153.48	113.53	161.7	88.3	53.2	72.0	5.46	1.069
7150	154.18	113.25	161.5	87.4	53.2	72.0	5.47	1.069
7200	154.87	112.97	161.4	86.5	53.3	72.1	5.48	1.069
7250	155.71	112.80	161.5	85.9	53.4	72.2	5.50	1.069
7300	156.64	112.69	161.6	85.2	53.5	72.3	5.51	1.069
7350	157.87	112.81	161.9	84.6	53.7	72.4	5.52	1.069
7400	159.34	113.09	162.1	83.9	53.8	72.5	5.53	1.069
7450	161.06	113.54	162.2	83.1	54.0	72.6	5.53	1.070
7500	162.86	114.04	162.1	82.1	54.1	72.6	5.53	1.070
7550	164.65	114.54	162.0	81.2	54.2	72.7	5.53	1.070
7600	166.46	115.03	161.8	80.2	54.2	72.8	5.52	1.070
7650	168.35	115.58	161.5	79.0	54.3	72.9	5.53	1.070
7700	169.94	115.91	161.4	78.1	54.4	73.0	5.52	1.070
7750	171.45	116.19	161.4	77.3	54.4	73.1	5.52	1.070
7800	172.68	116.27	161.2	76.5	54.4	73.1	5.52	1.071
7850	173.67	116.19	160.9	75.5	54.4	73.2	5.53	1.071
7900	174.57	116.06	160.5	74.4	54.4	73.3	5.55	1.071
7950	175.21	115.75	160.0	73.1	54.4	73.5	5.57	1.071
8000	175.68	115.34	159.6	71.8	54.4	73.6	5.61	1.071
8050	176.43	115.11	159.6	71.2	54.4	73.7	5.61	1.071
8100	176.92	114.71	159.6	70.6	54.3	73.8	5.63	1.072
8150	177.40	114.32	159.7	70.0	54.3	73.9	5.64	1.072
8200	177.86	113.92	159.5	69.5	54.3	73.9	5.66	1.072
8250	178.50	113.63	159.2	69.2	54.3	74.0	5.67	1.072
8300	179.18	113.38	158.9	68.9	54.3	74.1	5.67	1.072
8350	180.13	113.30	158.5	68.6	54.3	74.1	5.68	1.072
8400	181.16	113.27	158.2	68.4	54.3	74.2	5.68	1.072
8450	182.37	113.35	157.9	68.1	54.3	74.3	5.67	1.072
8500	183.59	113.44	157.8	67.9	54.3	74.3	5.66	1.072
8550	184.75	113.49	157.6	67.7	54.3	74.4	5.66	1.073
8600	185.73	113.43	157.3	67.5	54.4	74.4	5.66	1.073
8650	186.62	113.31	157.0	67.4	54.4	74.5	5.66	1.073

8700	187.50	113.19	156.8	67.4	54.4	74.5	5.64	1.073
8750	188.01	112.85	156.6	67.3	54.4	74.5	5.65	1.073
8800	188.04	112.22	156.5	66.7	54.4	74.6	5.68	1.073
8850	188.05	111.60	156.6	66.3	54.4	74.6	5.69	1.073
8900	187.76	110.80	156.8	66.1	54.4	74.7	5.72	1.073
8950	186.97	109.72	156.8	66.2	54.5	74.7	5.76	1.073
9000	186.25	108.69	156.7	66.6	54.5	74.8	5.79	1.073
9050	184.64	107.15	156.6	67.7	54.6	74.9	5.86	1.073
9100	182.79	105.50	156.3	69.3	54.7	75.0	5.94	1.073
9150	180.61	103.67	156.0	71.4	54.8	75.2	6.03	1.074
9200	177.09	101.09	156.2	74.8	54.8	75.4	6.14	1.074

After the base testing was done, we wanted to see how the tuning of the Sidewinder would be in winter air. We have an insulated cold room next door, where 1000 cubic feet of 20 degreeF dry air is created by three walk-in freezer compressors and condensers, stored and then fed to the engine's intake. We had four gallons of 92.9 R+M/2 octane 7.7% ethanol fuel to try, and Dan Miller (a former Indy 500 crew chief for the likes of Arie Luyendyk and currently Robby Gordon's race truck crew chief) suggested early on while we were planning our session that we should chill the fuel to be equally cold (they used to *really* chill their fuel for qualifying), so early in the day I put the steel fuel can in the circulating air of the cold room so it would match the temp of the intake air. Great idea!

But the problem we had was a typically slow to respond engine air intake temp sensor that failed to recognize the quick change in intake temperature from 70+ F resting on the dyno table to winter air as the dyno test begins. That's no problem in the field where temperature changes are gradual, but on the dyno the refrigerated air system creates instant swings in temperature. What was happening was, the cold air made HP rise by one, then the cold fuel added another HP. But then we noticed that the A/F ratio had leaned itself out to 12.6/1 because the fuel flow was identical to the 70+F tests. So we surmised that the ECU was thinking 70+, not winter temp. So we really learned nothing from that cold air test. *I had that same issue with Etec air temp sensors that are totally plastic coated. By monitoring BUDS air intake temp during summer testing, we could see that the dyno cold intake air temp was 20F, and for a full test the Etec was thinking warm, causing leaner than optimal A/F ratio. I purchased an Etec air intake temp sensor and ground the plastic off of the metal thermocouple. Now it's as quick acting as my modded dyno temp sensor. I'll have to do that with a Yamaha air temp sensor.*

This is the first 200+ HP production snowmobile engine, used by both Yamaha and Arctic Cat for their highest performance models. It's said that this new Mitsubishi ECU will be difficult for hacker hotrodders to break into. The Arctic Cat Suzuki turbo tuners lucked out, because the motorcycle tuners had early on figured out how to tweak the Huyabusa motorcycle ECU's—identical to what was used on the Arctic Cat Suzuki turbo engine. So outfits like Turbo Dynamics and others just had to buy a license and some hardware from some smart motorcycle guy on the west coast, and it was "game on". Let's see who can best use their customers as guinea pigs to create the highest HP with the lowest octane fuel! Why are we on version 57 of the "gonzo HP pump gas extreme fuel mileage tune"? Is that because there were 56 lifted heads/

popped pistons? Probably. But no one can argue that this new 998 triple has a distinct advantage when it comes to making big HP on pump gas. Smaller bore diameter = less ignition timing advance and less time for deto to happen. Deto protection is factory tuned all the way to 9200. And, since detonation is a time-based phenomenon, high revs and reduced torque (lower deto producing peak cylinder pressure) are your friends.

Most wise tuners consider the Suzuki twin Arctic Cat turbo, tuned optimally, reasonably OK on pump gas up to 250 HP. But this new Yamaha turbo, once the ECU is hacked, should be good for even more. How much more will depend on the skill of the tuners. 275? 300? Let the hacking and tuning begin!

Brian Ehmann (sleeping standing up because he drove the big rig all night from WI to DTR) and Dan Miller, great Yamaha guys.

Check out the dirt burnout in the DTR parking lot, from driving the Sidewinder up on the loading ramp! 204 HP!

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