2015 Arctic Cat Crossfire 800 cheap mods

Al Sledzeiski (AKA ALSLED on the forums) is a DTR member/ customer who first came here 10ish years ago to see why his then-new high buck Polaris PSI [out of business now] 1155cc stroker/ big bore twin was not much faster then the stock 800 engine it replaced. Al and a pal of his had bought two of these for about $10,000, adding twin pipes, Big Air carbs, case work—all the options to get 210+ HP claimed by PSI. They had opted to pay the extra few hundred bucks to get just one of the two engines dyno tuned at PSI and got a photocopy of some generic SuperFlow dyno sheet, with no test/ engine description, showing just that—210 HP. Good enough. But Al is a savvy clutch/ engine/ chassis tuner and he couldn't find a combo that would make either sled run much better than a stocker. So, expecting that his intuition was correct, he opted to spend another $250 at DTR to see what was going on.

The day the Al arrived, I was just finishing dyno tuning a stock Firecat F7 EFI with pipe mod, 2 degree key, and a tiny main jet stuck in the fuel line between pump and fuel rail to drop fuel pressure and lean the engine out properly at high revs (there were no Boondockers or Power Commanders then), making 150+ HP. After the Cat customer left, we put Al's PSI engine on the dyno and with jetting optimised made 151 HP (or therabouts). Very depressing. We wound up cranking the stator plate fully counterclockwise and wound up with 158 HP. But that hardly matched the 210 HP dyno sheet. The dyno is not magic, but it will help us find every HP there is, what RPM it peaks at, and tell you where you stand. Al accepted the bad news unhappily but graciously. Some displeased dyno tuners have resorted to screaming, throwing wrenches, and using my rotary dial phone to call the builder to complain and threaten loudly. That sort of unpleasant dyno session wasn't uncommon in the early days, but Al was good about it, sold the engine for low bucks, and has riding lightly tuned stockers ever since.

Now Al is riding a 2015 Arctic Cat 800 twin, and when he talked about doing a low-buck hopup with just cheap stuff and tuning to provide better HP for himself and good info for his HardCoreSledder pals, I was all for it. Expecting that his stocker was in the low-mid 150's HP, he was targeting 160+ with more midrange HP. So after reviewing past DTR info regarding the twin plug Cat 800s, he had some $5 exhaust resrictors made at a local muffler shop that would drop into the muffler inlet. Then he purchased a D&D Y pipe which is advertised to add 4 HP. I always have Power Commander 5 fuel and ignition timing tuners on hand for testing (and selling to sledders and dealers), in case we want to see what fuel and ignition timing adjustments might do for engine performance. A few clicks of the computer keyboard = a half hour of flywheel popping and offeset key swapping.

Our plan was to take Al's 600 mile stocker and:

- optimise stock muffler backpressure to try to match the best 2010 stock muffler
- increase airflow and HP with a D&D Y pipe
- tweak timing and fuel flow, if necessary, to max HP on pump gas
- test with hot engine to listen for deto and see how HP would be maintained

Today, we had 4.2% ethanol 91.8 R+M/2 octane fuel. The airflow SCFM number is a bit low due to either less than perfect fit from airbox to throttle bodies, imperfect seal from airflowmeter to airbox due to cold duct tape and cold rubber (or maybe a combo of both) because the mechanical A/F readings were noticably lower than the wideband. So we're just showing the wideband A/F readings. But the airflow readings were consistent, and useful to see the change in SCFM from test to test.

As expected, this engine made 153+ HP with 100F+ coolant temps on its second dyno test (warm crankcase, crankshaft, rods and pistons).

AL'S STOCK 2015 800

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6400	112.0	91.9	0.611	67.6	43.7	16.02	197.8
6500	112.8	91.2	0.606	67.5	43.7	15.96	198.6
6600	113.6	90.4	0.603	67.7	43.6	15.88	200.4
6700	115.2	90.3	0.604	68.7	43.4	15.82	204.2
6800	117.6	90.8	0.609	70.7	43.0	15.71	210.3
6900	120.8	92.0	0.614	73.3	42.7	15.55	217.0
7000	123.8	92.9	0.619	75.7	42.6	15.41	222.9
7100	125.9	93.1	0.634	78.7	42.4	15.27	228.3
7200	127.7	93.2	0.648	81.7	42.2	15.14	233.1
7300	130.1	93.6	0.664	85.3	42.1	14.94	238.3
7400	134.4	95.4	0.686	91.0	42.3	14.54	245.6
7500	139.0	97.4	0.687	94.4	42.6	14.22	249.9
7600	143.5	99.2	0.682	96.7	42.9	13.94	253.5
7700	147.2	100.4	0.675	98.2	42.9	13.71	256.2
7800	150.0	101.0	0.667	98.8	42.9	13.54	258.2
7900	152.1	101.1	0.660	99.1	42.8	13.43	259.5
8000	153.4	100.7	0.658	99.6	42.5	13.33	260.1
8100	152.2	98.7	0.673	101.1	42.2	13.20	259.9
8200	145.9	93.5	0.713	102.7	42.2	13.16	258.2
8300	131.5	83.2	0.778	101.0	42.8	13.30	242.0

Next, Al installed a 3" long 1 7/8" OD (1 ¾" ID) restrictor—bought for $5 at a muffler shop, flared on one end to roughly match the donut on the tuned pipe outlet—dropped down into the inlet of the stock muffler.

INSERT 1 7/8" RESTRICTOR

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6400	111.3	91.3	0.606	66.3	43.3	15.65	193.9
6500	112.3	90.7	0.597	65.9	43.3	15.59	195.0
6600	113.1	90.0	0.594	66.1	43.2	15.49	197.2

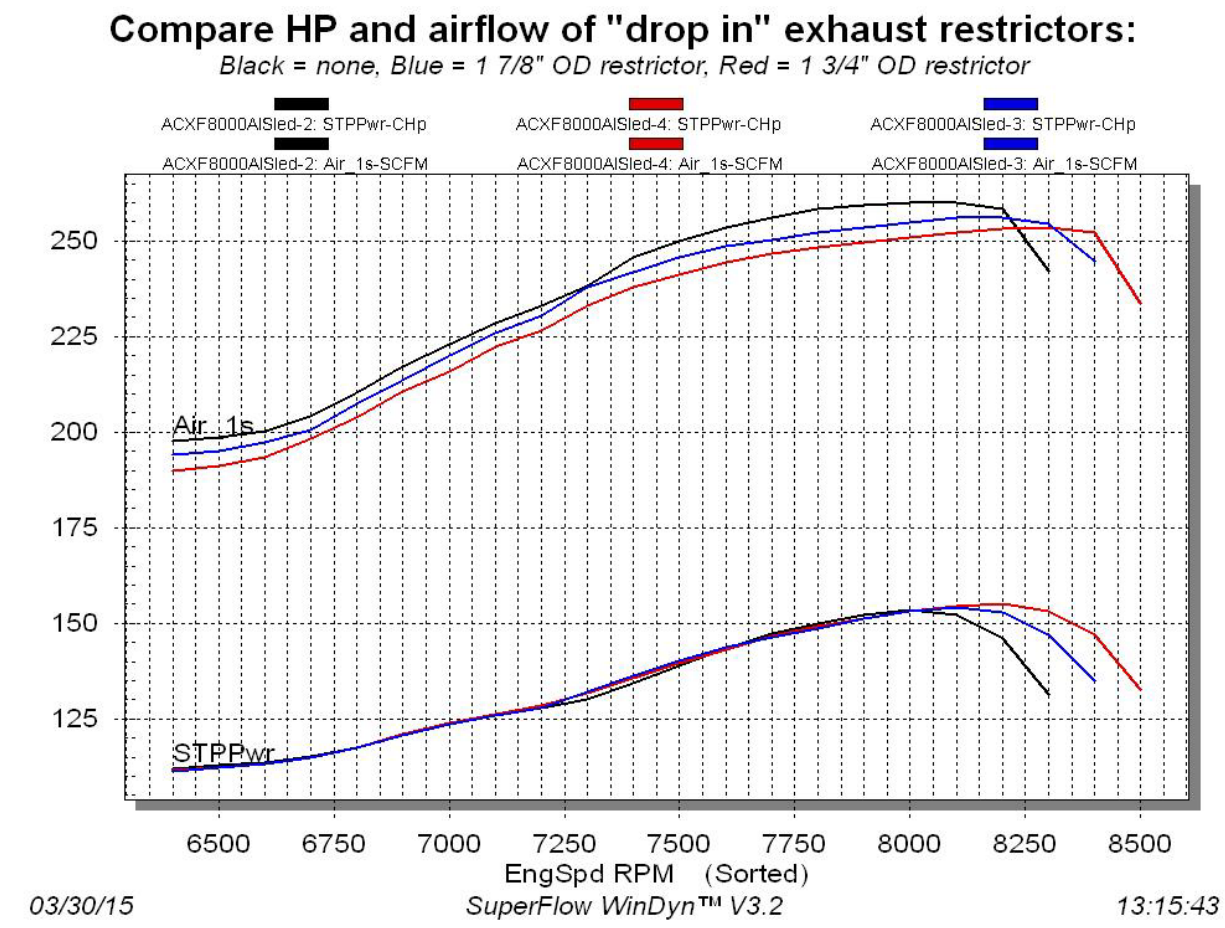
6700	114.7	89.9	0.592	66.8	43.0	15.43	200.7
6800	117.4	90.7	0.594	68.6	42.3	15.32	207.5
6900	120.7	91.9	0.597	70.9	41.9	15.23	213.4
7000	123.7	92.8	0.603	73.4	41.6	15.17	220.1
7100	125.8	93.0	0.613	75.9	41.3	15.07	225.8
7200	128.0	93.4	0.623	78.4	41.1	14.92	230.3
7300	132.1	95.0	0.644	83.6	40.7	14.57	237.9
7400	136.4	96.8	0.649	87.0	40.7	14.32	241.9
7500	140.3	98.3	0.653	90.2	40.8	14.06	245.5
7600	143.7	99.3	0.654	92.5	40.9	13.79	248.7
7700	146.2	99.7	0.649	93.3	40.9	13.66	250.4
7800	148.8	100.2	0.644	94.2	40.9	13.53	252.1
7900	151.2	100.5	0.638	94.9	40.9	13.44	253.7
8000	153.1	100.5	0.632	95.2	40.9	13.41	255.0
8100	154.1	99.9	0.632	95.7	41.0	13.38	256.0
8200	152.9	98.0	0.645	97.1	41.0	13.26	256.0
8300	146.9	92.9	0.677	97.8	41.3	13.20	254.3
8400	135.0	84.4	0.730	96.8	42.0	13.35	244.8

Next, Al dropped in the tighter 1 ¾" OD (1 5/8" ID), 2 7/8" overall length flanged restrictor. This one choked airflow a bit more, increased pipe pressure and average ex temp in the pipe and extended the HP curve to higher revs. Because airflow dropped at high revs, A/F was enrichened due to the EFI's constant fuel flow.

INSERT 1 ¾" RESTRICTOR

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6400	111.6	91.6	0.595	65.6	42.7	15.02	189.8
6500	112.3	90.7	0.593	65.6	42.7	15.17	191.1
6600	113.2	90.1	0.589	65.8	42.7	15.13	193.5
6700	114.8	90.0	0.591	66.9	42.4	15.09	198.1
6800	117.4	90.7	0.596	69.0	42.1	15.01	203.8
6900	121.1	92.2	0.600	71.7	41.8	14.88	210.6
7000	124.0	93.0	0.601	73.5	41.7	14.78	215.8
7100	126.4	93.5	0.609	76.0	41.4	14.66	222.3
7200	128.5	93.8	0.616	78.2	41.2	14.56	226.4
7300	131.7	94.7	0.636	82.6	40.8	14.33	232.9
7400	135.7	96.3	0.649	86.9	40.8	14.04	237.9
7500	139.5	97.7	0.650	89.5	40.8	13.80	241.2
7600	143.2	99.0	0.649	91.7	40.8	13.53	244.3
7700	146.6	100.0	0.647	93.6	40.8	13.30	246.6
7800	149.2	100.5	0.645	94.9	40.8	13.19	248.2
7900	151.2	100.5	0.640	95.5	40.9	13.13	249.6

8000	153.0	100.5	0.633	95.6	41.1	13.09	251.0
8100	154.6	100.2	0.628	95.8	41.2	13.06	252.2
8200	155.0	99.3	0.630	96.2	41.2	13.00	253.2
8300	153.2	96.9	0.638	96.3	41.2	12.95	253.4
8400	146.9	91.9	0.664	96.2	41.6	13.02	252.1
8500	132.9	82.1	0.716	93.8	42.3	13.21	233.8



Now, Al removed the stock Ypipe and installed the new D&D Ypipe—this time with no restrictor in the muffler. That would come next

D&D Ypipe, no restrictor

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6400	114.1	93.6	0.603	67.3	43.7	16.06	200.2
6500	115.1	93.0	0.594	66.9	43.7	15.98	201.5
6600	116.4	92.6	0.592	67.5	43.6	15.89	204.9
6700	118.5	92.9	0.599	69.5	43.3	15.77	210.4
6800	121.9	94.1	0.607	72.4	43.1	15.64	216.3
6900	125.6	95.6	0.608	74.8	43.1	15.52	222.1
7000	128.4	96.3	0.609	76.6	43.0	15.42	227.8

7100	130.5	96.6	0.617	78.9	42.8	15.33	232.8
7200	133.1	97.1	0.630	82.1	42.6	15.15	238.2
7300	137.6	99.0	0.649	87.5	42.5	14.78	245.5
7400	142.7	101.3	0.652	91.0	42.7	14.43	250.1
7500	146.8	102.8	0.648	93.2	42.8	14.18	253.1
7600	150.1	103.7	0.646	94.9	42.8	13.96	255.4
7700	153.0	104.4	0.643	96.3	42.6	13.77	257.2
7800	155.1	104.4	0.638	96.9	42.6	13.67	258.5
7900	156.4	104.0	0.633	97.0	42.7	13.64	259.2
8000	156.6	102.8	0.633	97.0	42.8	13.64	259.8
8100	155.5	100.8	0.641	97.5	42.9	13.64	260.6
8200	152.0	97.4	0.659	98.1	42.9	13.66	260.2
8300	131.8	83.4	0.759	97.8	42.8	13.85	253.6

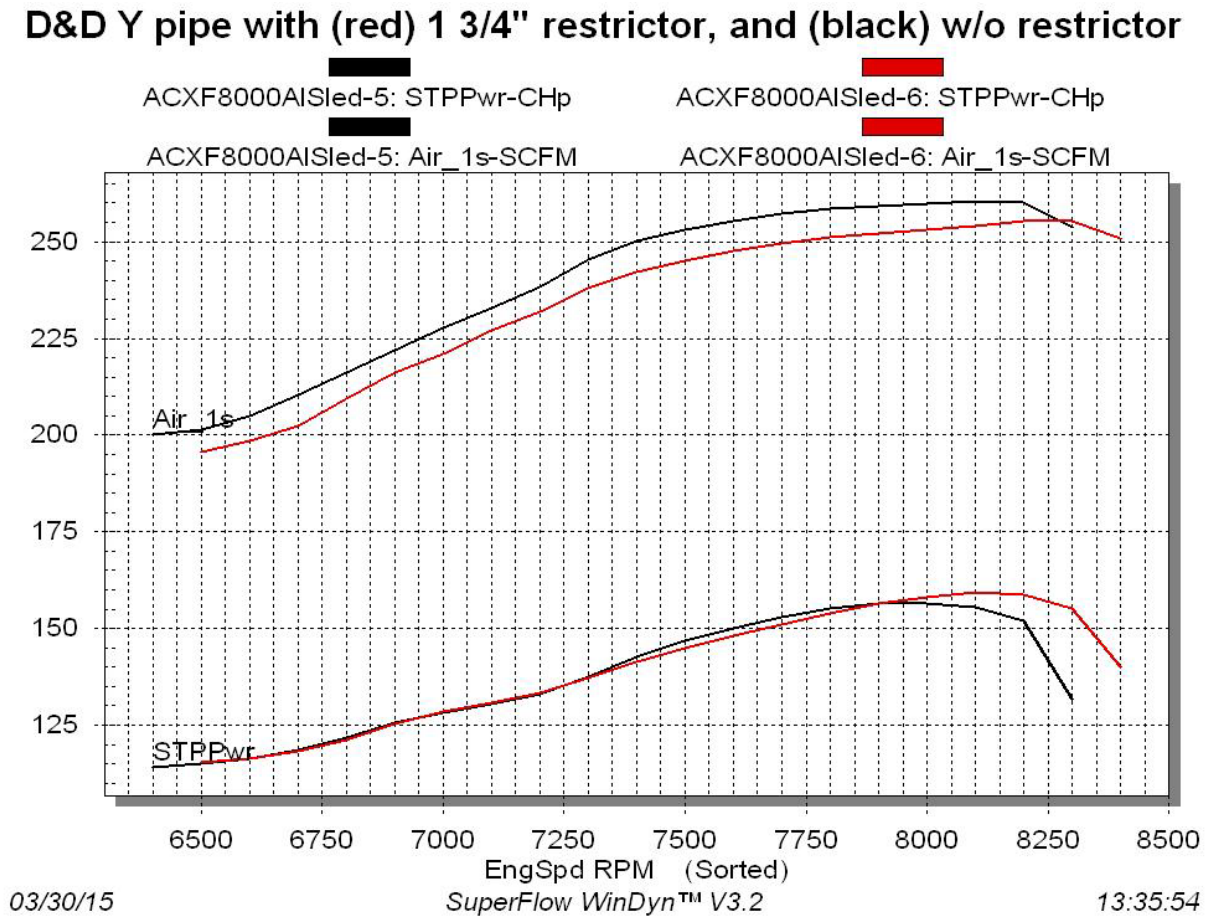
Here's the engine with D&D Ypipe, this time with the 1 ¾" restrictor in place.

D&D Ypipe, 1 ¾" OD restrictor

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6500	115.3	93.1	0.585	66.4	43.6	15.48	195.8
6600	116.2	92.5	0.583	66.8	43.5	15.35	198.5
6700	118.1	92.6	0.584	67.9	43.4	15.29	202.5
6800	121.1	93.6	0.593	70.8	43.1	15.20	209.4
6900	125.4	95.5	0.599	74.0	43.1	15.07	216.1
7000	128.5	96.4	0.600	75.9	43.0	14.97	220.8
7100	130.9	96.8	0.611	78.7	42.8	14.81	227.1
7200	133.4	97.3	0.625	82.1	42.5	14.63	231.9
7300	137.1	98.6	0.644	87.0	42.5	14.32	237.9
7400	141.4	100.3	0.649	90.4	42.8	13.99	242.1
7500	145.0	101.6	0.650	92.9	42.9	13.68	245.2
7600	148.2	102.4	0.650	94.8	42.9	13.42	247.7
7700	151.1	103.1	0.645	96.0	42.8	13.25	249.5
7800	154.0	103.7	0.638	96.7	42.7	13.15	251.1
7900	156.5	104.0	0.628	96.8	42.8	13.11	252.1
8000	158.2	103.8	0.621	96.7	42.9	13.09	253.2
8100	159.2	103.3	0.619	97.1	43.0	13.07	254.2
8200	158.7	101.6	0.623	97.3	43.0	13.05	255.3
8300	155.1	98.2	0.636	97.1	43.1	13.15	255.2
8400	140.0	87.6	0.700	96.5	43.2	13.38	251.0

Note in the graph comparing the D&D Ypipe with and without muffler restrictor, the tighter pipe outler results in the HP being higher, and shifted to a higher RPM. This is due to higher average tuned pipe pressure—more molecules of hot exhaust gas are squeezed together, and spend more time in the pipe, transferring more heat to the thick steel walls of the pipe, which results in ever higher average exhaust temp in the pipe, which increases the speed of the sound waves that supercharge the engine. Whew, long sentence! Then that higher pressure also compresses the

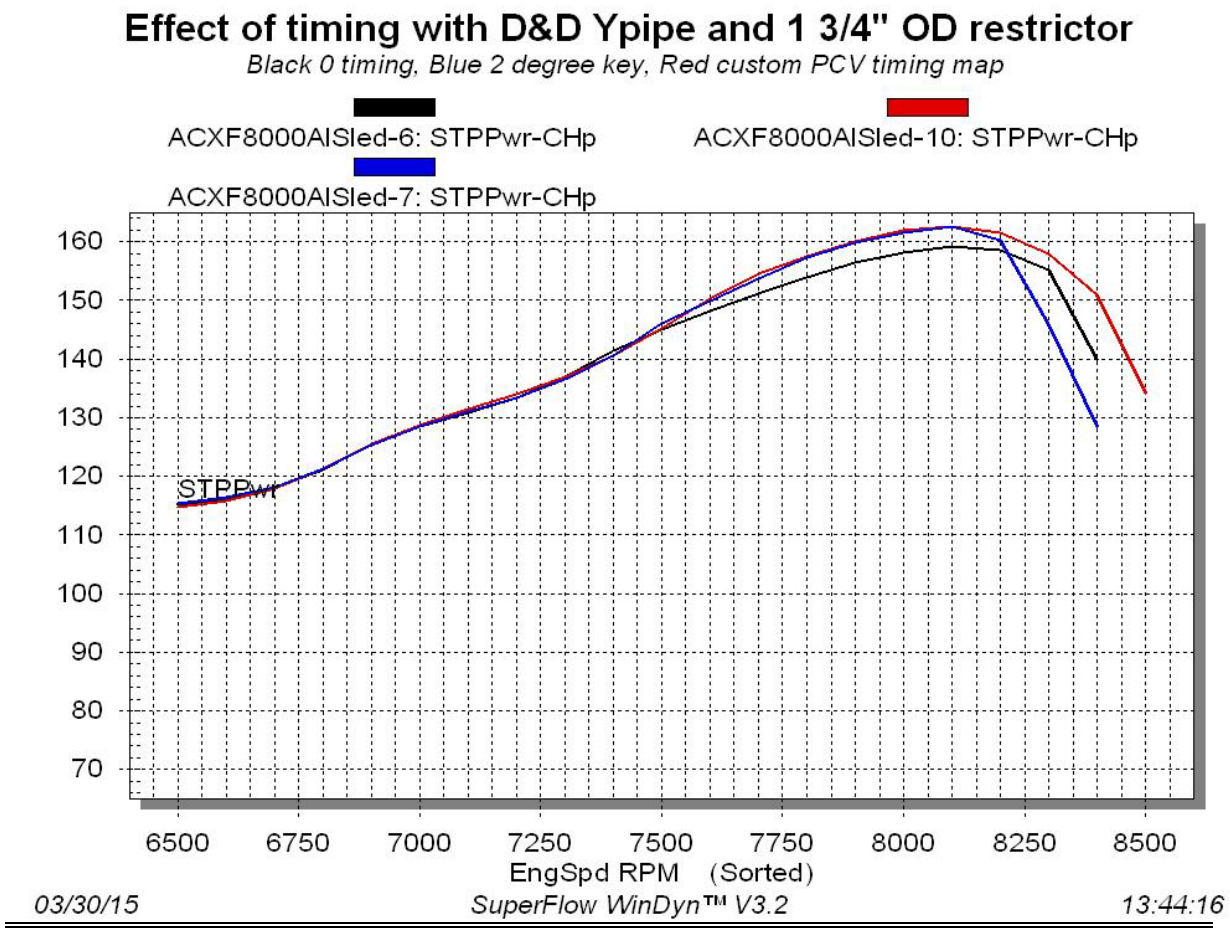
high velocity intake charge coming down the Ypipe, which helps the faster returning sound wave to pack more O2 molecules beack into the cylinder, as the piston closes the exhaust port.
But, there is a limit to pipe pressure—excessive backpressure can result in exhaust gases forced back into the engine with the good stuff—reducing HP. And even worse, those nasty explosive active radical molecules (created during extremely hot combustion) can get packed back into the cylinder instead of being swept out through the muffler, creating snaps of detonation that at best, set off the deto protection reducing HP and at worst, scour away the cooling boundary of air on the piston(s) causing them to grow and seize!



Next we used the 11-013 Power Commander to just add 2 degrees of timing everywhere, just like adding a 2 degree key. As the graph shows, the extra timing didn't help us below 7500, and hurt us on overrev. So we tweaked the timing curve around and only added the 2 degrees from 7500 to 8000, and left it stock everywhere else. As we can see in test 10 (red) the "pile" of HP is much nicer—less HP drop on overrev.

D&D Ypipe, 1 ¾" restrictor, optimal PCV timing curve.

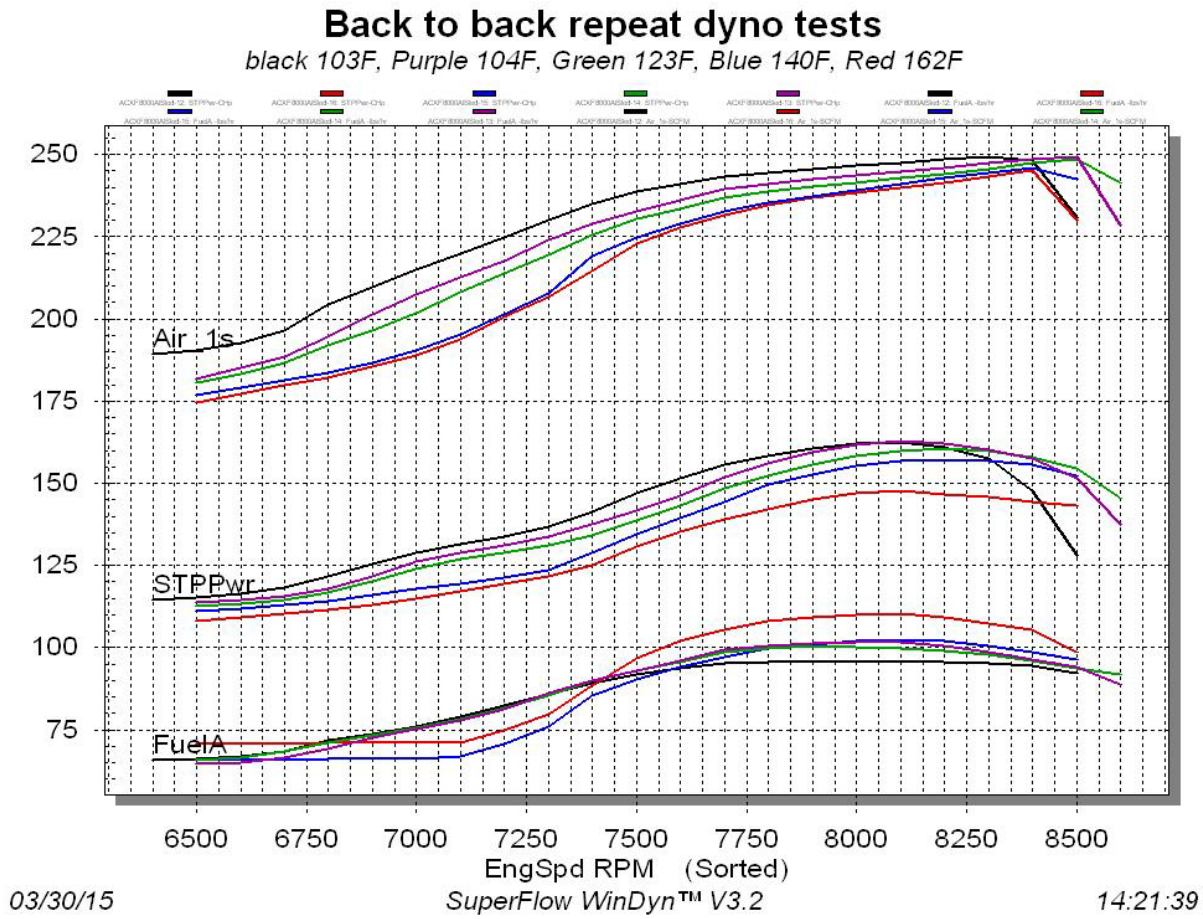
EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA lb/hph	FuelA lbs/hr	FulPrA psig	LamAF1 Ratio	Air_1s SCFM
6500	114.7	92.7	0.565	63.8	40.8	15.98	191.9
6600	115.9	92.2	0.563	64.2	40.7	15.90	194.6
6700	117.9	92.4	0.564	65.4	40.4	15.82	198.4
6800	121.4	93.8	0.567	67.7	39.9	15.65	205.4
6900	125.6	95.6	0.566	69.9	39.6	15.49	211.0
7000	128.7	96.6	0.565	71.5	39.4	15.43	215.0
7100	131.4	97.2	0.576	74.4	39.2	15.37	221.0
7200	133.9	97.7	0.593	78.1	38.9	15.20	226.7
7300	136.9	98.5	0.614	82.6	38.8	14.92	231.9
7400	140.5	99.7	0.630	87.0	39.2	14.60	235.8
7500	145.2	101.7	0.641	91.6	40.2	14.21	239.4
7600	150.3	103.9	0.637	94.1	41.2	13.89	242.1
7700	154.5	105.4	0.627	95.2	41.6	13.65	244.2
7800	157.5	106.1	0.616	95.4	41.7	13.49	245.8
7900	160.1	106.4	0.606	95.3	41.7	13.40	247.1
8000	161.9	106.3	0.598	95.1	41.8	13.35	248.3
8100	162.7	105.5	0.596	95.3	41.8	13.30	249.3
8200	161.6	103.5	0.602	95.6	41.7	13.22	250.4
8300	157.9	99.9	0.616	95.7	41.6	13.21	251.2
8400	151.0	94.4	0.641	95.1	41.9	13.37	251.2
8500	134.2	82.9	0.709	93.5	42.4	13.66	244.5



Finally, Al wanted to see how his engine would perform under extended periods at WOT, in severe conditions with high coolant temp. So we did 5 back to back 300 RPM/ second WOT acceleration tests until the engine went into "protect me from this mad dyno operator" mode. We began with the 80F thermostat just opening, and the first two tests peaked at 103-4 F as the sled's cold coolant began to come up to temp—and HP peaked at 163.4 on the second test, then began to diminish as coolant temp and pipe temp began to climb. We did hear one snap of deto at peak torque (where cylinder filling and effective compression are highest) at about 130F (listening to the long copper tube bolted to the engine and extended into the control room), and that resulted in some timing being pulled by the protective ECU. Finally, as the coolant temp approached 140 F, the ECU went into protect-mode, and it looks like the exhaust valves may have been held lower to reduce airflow and heat (like the Etecs do). Then on test five, note how the fuel flow increased to further cool the engine. By the end of this series of tests, the high temp light was on in the gauge pod.

It would have been good to have a stock head cut by D&D to their LTS spec—a bit less compression and tighter squish clearance—and repeated that series of tests. Al's contemplating that inexpensive mod for "next time", because he's a typically greedy trail rider, always looking for more. But this was a great cheap "tuneup"—10 HP and even more midrange for a few hundred bucks, with no fuel added! But this testing was done at 30-35 F and in sub zero temps, there is greater likelihood of deto because of the extra O2 molecules

filling the cylinders. So Al may have to add fuel or go to a LTS head mod. The Cat 800 engine has excellent cooling—low coolant volume and tight "shrinkwrapped" design create high coolant velocity that is most effective in removing heat from the combustion chambers (see Kevin Cameron's article "Turbulence Needed"). But the increased airflow and cylinder filling may require lowering of compression or more fuel, or less timing as air density increases in winter.



Here's Al's bone stocker, compared to these four other bone stock 2014-15 Cat 800s.