CrankShop Etec 800 pump gas trail mod

When I created this system for accurate sled engine testing back in 1986, Tim Bender (Bender Racing) was the first professional snowmobile modifier to come here to test and tune, and learn about the significance of fuel flow, air flow and torque and HP that this dyno equipment will measure. As Yamaha's factory supported racer, Tim won lots of big oval ice races with his first dyno project—a lowly Yamaha Exciter twin that Kevin Cameron suggested must have been designed by Yamaha's golf cart division, but was made competitive by Tim's skills, tenacity, and lots (and lots) of dyno time.

One by one, all of the other 1980-1990s Big East sled engine modifiers (D&D, Big Joe DiSpirito, DynoPort Rich, Hooper, HTG, Jaws, who did I forget?) all followed suit and began using this extremely repeatable dyno (within a few tenths of a HP if coolant and pipe center section temps are maintained) to enable them to make more powerful engines, pipes, etc. like Tim did, a few tenths at a time. Larry Audette of the CrankShop specializes in creating powerful SkiDoo engines. He began coming here in 1987 with then-huge (but seeming to grow monthly!) 925cc custom triples he made out of sawed-up and rewelded rotary valve twin cylinder engines (years later CrankShop crankcases and heads would evolve into high quality castings). He had a unique way to use twin rotary valves on his three cylinder engines that overlapped in the center—something that still boggles the mind. Things like port timing, RV timing, ignition timing, compression ratios, pipe design etc were evaluated and optimized resulting in ever-greater horsepower levels. I believe that Larry was the first to make 200HP here. Today, big 1500 CrankShop triples can make 350+ HP (and lots more with turbo boost or N2O). Eventually, like all the Big Easters eventually did, Larry built his own dyno cel to save the cost/ time to travel and test here. But even though they have their own testing facilities, they all like to come here to demonstrate their products and if they are pleased with the results, have me publicize the results Consumer Reports- style.

This is the first time that Larry Audette has been here in about 20 years, and it was great to spend time with him again. He had purchased this Etec 800 new in 2011, and had immediately modified the engine for added pump gas power, only to find out that there was no way to add fuel to support the added horsepower. As years went by Larry had experimented with fooling temp sensors/ baro pressure sensors, adding extra injectors etc. to try to feed fuel to the more powerful modified Etec 800 with the extra fuel it needed. But this year when DynoJet finally came out with the "plug and play" Etec 800 Power Commander V fuel tuner Larry took renewed interest in creating a turn-key 170+ HP pump gas Etec 800 trail engine.

The CrankShop 2011 Etec 800 is "trail ported" with slightly increased compression and fitted with stock reeds. The pump gas used in the test session was provided by me. R+M/ 2 octane was 92.7 and ethanol content was 8.9% measured by our Zeltex optical test system. The ECU had its "breakin mode" eliminated by one of Larry's Bombardier engineer pals. Larry had is own “Buds Light” aftermarket Etec tuner to look at engine conditions and to adjust timing as necessary. And, we would use a new Power Commander V to add enough fuel to make maximum deto-free horsepower. We had a CrankShop Y pipe to test, along with several single pipes that Larry had built. We also had the same Aaen 800R single pipe that made good HP on the stock Etec. Finally, Larry would modify the stock pipe by welding on a larger diameter sealing flange/ inlet pipe that would more closely match the larger donut size of the CrankShop Ypipe.

Here’s the CrankShop trail ported engine with stock reeds, stock exhaust and optimized ignition timing:

BASELINE TEST

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFA_B lb/hph	FulA_B lbs/hr	AFRA_B Ratio	Air_1c CFM	DenAlt Feet	FulPrA psig
5900	82.3	73.3	0.790	62.4	12.96	178.0	439	45.4
6000	81.6	71.5	0.823	64.5	12.98	184.4	439	45.3
6100	89.8	77.3	0.815	70.2	12.80	198.0	439	45.2
6200	91.0	77.1	0.805	70.4	13.14	203.5	438	45.1
6300	92.9	77.5	0.779	69.5	13.75	210.3	438	45.0
6400	98.0	80.5	0.741	69.7	13.99	214.7	438	44.9
6500	102.8	83.1	0.716	70.7	14.02	218.0	439	44.8
6600	106.1	84.5	0.696	71.0	14.14	220.9	441	44.7
6700	112.5	88.2	0.663	71.6	14.13	222.9	443	44.7
6800	115.7	89.4	0.681	75.7	13.61	226.6	444	44.9
6900	123.2	93.7	0.671	79.4	13.24	231.3	443	45.0
7000	127.9	95.9	0.650	79.8	13.42	235.7	444	45.0
7100	131.3	97.1	0.654	82.4	13.28	241.0	444	45.1
7200	138.5	101.1	0.623	83.0	13.48	246.3	445	45.0
7300	143.4	103.2	0.604	83.3	13.70	251.3	444	45.0
7400	147.4	104.6	0.601	85.2	13.66	256.1	444	44.9
7500	152.0	106.5	0.603	88.0	13.51	261.8	444	44.9
7600	156.9	108.4	0.590	88.8	13.63	266.6	443	44.7
7700	160.6	109.5	0.593	91.5	13.50	271.7	446	44.6
7800	163.9	110.4	0.596	93.9	13.35	276.0	447	45.0
7900	164.5	109.4	0.578	91.4	13.92	280.2	445	44.8
8000	164.2	107.8	0.573	90.3	14.26	283.5	446	44.7
8100	158.9	103.0	0.599	91.3	14.17	284.8	448	44.7
8200	149.9	96.0	0.628	90.3	14.44	287.1	448	44.7

==

Here Larry installed a set of Boyesen RAD valve reed cages like the ones tested last winter. The sled that we used for dyno testing still has those same Rad valves on it—now has over 1500 miles so far, and the reeds are still in perfect shape. As we saw in the stock Etec 800, airflow increased 7% and horsepower increased 1.5%. Note that the last two columns show fuel flow A from the in-tank pump to the injectors and fuel flow B shows fuel bypassed from the injectors back to the tank. The net fuel flow is FulA_B (there is no – sign in the channel readouts so _ takes its place). It's interesting to note that other sled bypass systems have fixed fuel flow A from pump to rail, then bypassed fuel A declines as revs climb and more fuel is consumed by the engines. Why does SkiDoo go to the trouble to accurately increase voltage to the in-tank pump as revs climb, keeping bypassed fuel flow constant?

REMOVE STOCK REEDS, ADD BOYESEN RAD VALVES

EngSpd	STPPwr	STPTrq	BSFA_B	FulA_B	AFRA_B	Air_1c	FuelA	FuelB
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Ratio	CFM	lbs/hr	lbs/hr
6000	84.8	74.2	0.845	68.5	12.89	196.0	152.9	84.4
6100	84.7	72.9	0.855	69.2	13.19	202.7	155.0	85.8
6200	92.3	78.2	0.800	70.5	13.51	211.7	156.6	86.1
6300	96.3	80.3	0.776	71.4	13.75	218.0	158.6	87.2
6400	99.2	81.4	0.751	71.2	13.90	219.9	158.9	87.6
6500	100.8	81.5	0.762	73.4	13.67	223.0	160.0	86.5
6600	103.3	82.2	0.760	75.0	13.64	227.3	162.0	86.9
6700	110.0	86.2	0.696	73.2	14.26	231.7	162.4	89.3
6800	114.5	88.4	0.670	73.3	14.56	237.1	162.9	89.6
6900	121.8	92.7	0.661	77.0	14.19	242.6	164.5	87.5
7000	127.1	95.4	0.657	79.8	13.99	247.9	165.0	85.2
7100	133.4	98.7	0.643	82.0	13.93	253.6	165.2	83.2
7200	137.3	100.1	0.633	83.1	14.07	259.6	165.5	82.4
7300	143.0	102.9	0.617	84.3	14.23	266.5	165.0	80.6
7400	149.6	106.2	0.617	88.3	13.92	273.0	167.8	79.5
7500	154.2	108.0	0.592	87.3	14.40	279.2	169.0	81.7
7600	158.2	109.3	0.593	89.8	14.34	285.9	170.7	80.9
7700	162.5	110.9	0.600	93.2	14.10	291.9	174.8	81.5
7800	165.5	111.4	0.594	93.9	14.21	296.5	177.2	83.2
7900	166.5	110.7	0.569	90.6	14.92	300.2	176.5	85.9
8000	164.8	108.2	0.573	90.3	15.17	304.2	175.6	85.4
8100	163.5	106.0	0.573	89.5	15.39	305.9	175.5	86.0
8200	157.7	101.0	0.583	87.7	15.81	308.1	173.2	85.5

==

Next, Larry installed one of his Y pipes, which is a stamping with a larger-than-stock outlet pipe and donut gasket. But this time we got ourselves into trouble with improper use of the aftermarket BUDS system. The instructions warn you to disconnect the power-up jumpers from the sled's battery (those jumpers are used to power up the ECU for monitoring/ adjusting timing with engine off) BEFORE starting the sled. But who reads instructions? Leaving the jumpers in place seems to blast a lot of voltage into the ECU which then feeds extra voltage back through the PCV then through the USB cable and into the computer monitoring/ adjusting the PCV. Unfortunately, in this case it was the split-screen dyno operating computer being used for PCV tuning. With the BUDS jumpers still hooked to the sled's battery, the engine started up strangely, and the PCV screen on the dyno locked up. Thinking that the sled's battery voltage was low, we hooked jumper cables from the huge 13.2 volt dyno starter battery. As soon as we fired the sled up it overheated the USB cable, shorting it out and then it fried the mother board on the dyno computer, leaving us dynoless! A replacement mother board would take days to find and buy, so Larry left his sled on the dyno and he drove home to Vermont. It also burned out a failsafe fuse in the PCV requiring a repair by DynoJet.

Days later we were still computerless, and I discovered that I could borrow the computer from JD Powersports' 902 dyno right next door. It functioned dandily on my 901/902 combo, so I called Larry and he came the next day to finish the test.

We tried the CS Ypipe with three custom stamped single pipes that Larry had brought with him, but none was truly any better than the stock pipe. So Larry "took the high road" and stayed with the stock pipe. And here, we made 170.0 HP at 7950 RPM (not shown in the 100rpm step data). Interestingly, our airflow didn't show much of an increase but HP definitely improved. Was our airflow reading incorrect caused perhaps by less than optimal fitment between the dyno airbox and plastic throttle body adaptor? Or did the CS Ypipe cause airflow to be optimized—less short circuited out the muffler and more packed back into the cylinders? We have a CS Ypipe here to test on Billy Howards' 2013 stocker along with Y pipes from lots of other vendors so we may learn more at that time.

BOYESEN REEDS, CS YPIPE, STOCK PIPE

EngSp RPM	STPPwr CHp	STPTrq Clb-ft	AFRA_B Ratio	BSFA_B lb/hph	FulA_B lbs/hr	CoolOt deg F	Air_1c CFM	CoolFw GPM
6300	96.3	80.3	13.16	0.786	72.2	90	212.8	31.47
6400	98.1	80.5	12.94	0.802	75.0	91	217.2	32.19
6500	99.9	80.7	12.90	0.801	76.3	91	220.4	32.65
6600	102.2	81.4	12.92	0.791	77.2	91	223.1	33.04
6700	106.5	83.5	13.03	0.770	78.2	92	228.1	33.71
6800	114.9	88.8	13.02	0.735	80.6	92	235.0	34.31
6900	121.8	92.7	12.96	0.711	82.6	92	239.9	34.50
7000	127.9	96.0	12.97	0.695	84.9	93	246.5	34.87
7100	132.7	98.1	13.00	0.682	86.3	93	251.2	35.14
7200	138.8	101.2	13.04	0.669	88.6	93	258.6	35.53
7300	144.5	104.0	13.07	0.654	90.3	93	264.3	35.78
7400	151.3	107.4	13.24	0.635	91.7	93	272.0	36.03
7500	156.5	109.6	13.34	0.625	93.4	94	278.8	36.21
7600	161.0	111.3	13.46	0.616	94.6	94	285.2	36.38
7700	165.3	112.8	13.72	0.603	95.1	94	292.1	36.55
7800	168.2	113.3	14.06	0.587	94.2	94	296.6	36.64
7900	169.5	112.7	14.64	0.569	92.0	95	301.7	36.73
8000	169.4	111.2	15.07	0.560	90.6	95	305.6	36.70

8100	167.5	108.6	15.39	0.560	89.5	96	308.5	36.69
8200	162.4	104.0	15.43	0.564	87.4	96	302.1	36.78

==

Here Larry installed the Aaen 800R pipe that we tested on the stocker earlier—this time on the higher flowing CS Ypipe. With the internal stinger seeming to pack more air into the engine, and we had audible clicks of detonation that caused timing to be retarded by the ECU. Too much torque for this engine to deal with using measured 92.7 octane fuel! We added fuel with the PCV to get rid of the detonation, but still managed to make 172 HP. I should note that every time we encountered deto we tried rolling timing back, but that always resulted in less HP than we got with maxed timing and added fuel to cool things off.

BOYESEN REEDS, CS YPIPE, AAEN 800R PIPE

EngSp	STPPwr	STPTrq	AFRA_B	BSFA_B	FulA_B	Air_1c	CoolOt	CoolFw
RPM	CHp	Clb-ft	Ratio	lb/hph	lbs/hr	CFM	deg F	GPM
6200	95.7	81.1	12.60	0.783	71.7	201.4	88	30.97
6300	97.4	81.2	12.48	0.808	75.3	209.5	88	31.43
6400	100.7	82.7	12.59	0.802	77.2	216.9	88	32.15
6500	103.1	83.3	12.71	0.793	78.2	221.6	88	32.66
6600	105.5	84.0	12.66	0.791	79.8	225.4	89	33.12
6700	109.0	85.4	12.59	0.786	81.9	229.8	89	33.62
6800	116.1	89.7	12.44	0.766	85.1	236.2	89	34.22
6900	124.5	94.7	12.50	0.732	87.2	243.1	89	34.58
7000	128.8	96.6	12.53	0.719	88.6	247.5	89	34.85
7100	134.3	99.4	12.55	0.705	90.6	253.7	90	35.28
7200	141.9	103.5	12.75	0.675	91.7	260.6	90	35.61
7300	147.0	105.7	12.97	0.653	91.8	265.6	90	35.85
7400	151.7	107.6	13.07	0.641	93.0	271.0	91	36.10
7500	157.3	110.2	13.07	0.633	95.4	277.9	91	36.38
7600	163.2	112.8	13.05	0.629	98.3	286.1	91	36.52
7700	167.1	114.0	13.13	0.624	99.8	292.1	92	36.59
7800	170.2	114.6	13.43	0.613	99.9	299.1	92	36.68
7900	172.0	114.3	13.93	0.596	98.1	304.7	92	36.71
8000	170.6	112.0	14.29	0.594	96.9	308.8	93	36.75
8100	167.5	108.6	14.49	0.601	96.3	311.3	93	36.77
8200	161.2	103.3	14.77	0.606	93.5	308.0	94	36.78

==

To try to increase the airflow and HP of the stock pipe, Larry used our workshop to portaband saw off the stock pipe's inlet flange and inlet pipe between the spring hooks and the divergent cone. Then he expertly MIG welded a larger inlet flange and inlet pipe. This "Pipe mod" was installed, and this one made over 170.6 HP with no clicks of deto.

BOYESEN REEDS, CS YPIPE, STOCK PIPE w/ CS PIPE MOD

EngSp	STPPwr	STPTrq	AFRA_B	BSFA_B	FulA_B	Air_1c	CoolOt	AirInT
RPM	CHp	Clb-ft	Ratio	lb/hph	lbs/hr	CFM	deg F	degF
6100	88	75.8	12.44	0.844	71.4	196.5	91	44.9
6200	90.8	76.9	12.49	0.846	73.8	204.0	91	44.9
6300	93.8	78.2	12.61	0.831	74.8	209.0	92	44.9
6400	96.4	79.1	12.72	0.820	75.9	213.9	92	44.9
6500	98.5	79.6	12.79	0.813	76.9	217.7	92	44.9
6600	101.2	80.6	12.86	0.800	77.8	221.5	92	44.9
6700	105.5	82.7	12.95	0.777	78.8	225.8	92	44.9
6800	115.3	89.1	13.08	0.728	80.6	233.5	93	44.9
6900	120.5	91.7	13.04	0.711	82.3	237.7	93	44.9
7000	126.1	94.6	12.96	0.700	84.8	243.3	93	44.9
7100	132.7	98.1	12.87	0.688	87.7	249.9	93	44.9
7200	138.6	101.1	12.88	0.674	89.7	255.9	94	44.9
7300	144.1	103.7	13.01	0.658	91.1	262.5	94	44.9
7400	149.7	106.3	13.24	0.637	91.7	268.7	94	44.9
7500	155.4	108.8	13.45	0.621	92.8	276.3	94	45.0
7600	159.7	110.3	13.54	0.612	94.0	281.8	94	45.0
7700	163.6	111.6	13.57	0.609	95.8	287.7	94	45.0
7800	167.3	112.7	13.77	0.598	96.1	293.1	94	45.0
7900	169.9	113.0	14.18	0.581	94.8	297.6	95	45.1
8000	170.6	112.0	14.50	0.573	93.9	301.6	95	45.1
8100	169.6	110.0	14.72	0.573	93.4	304.4	96	45.1
8200	167.1	107.0	15.02	0.575	92.3	306.8	96	45.1
8300	160.1	101.3	15.17	0.582	89.4	300.4	97	45.1

===

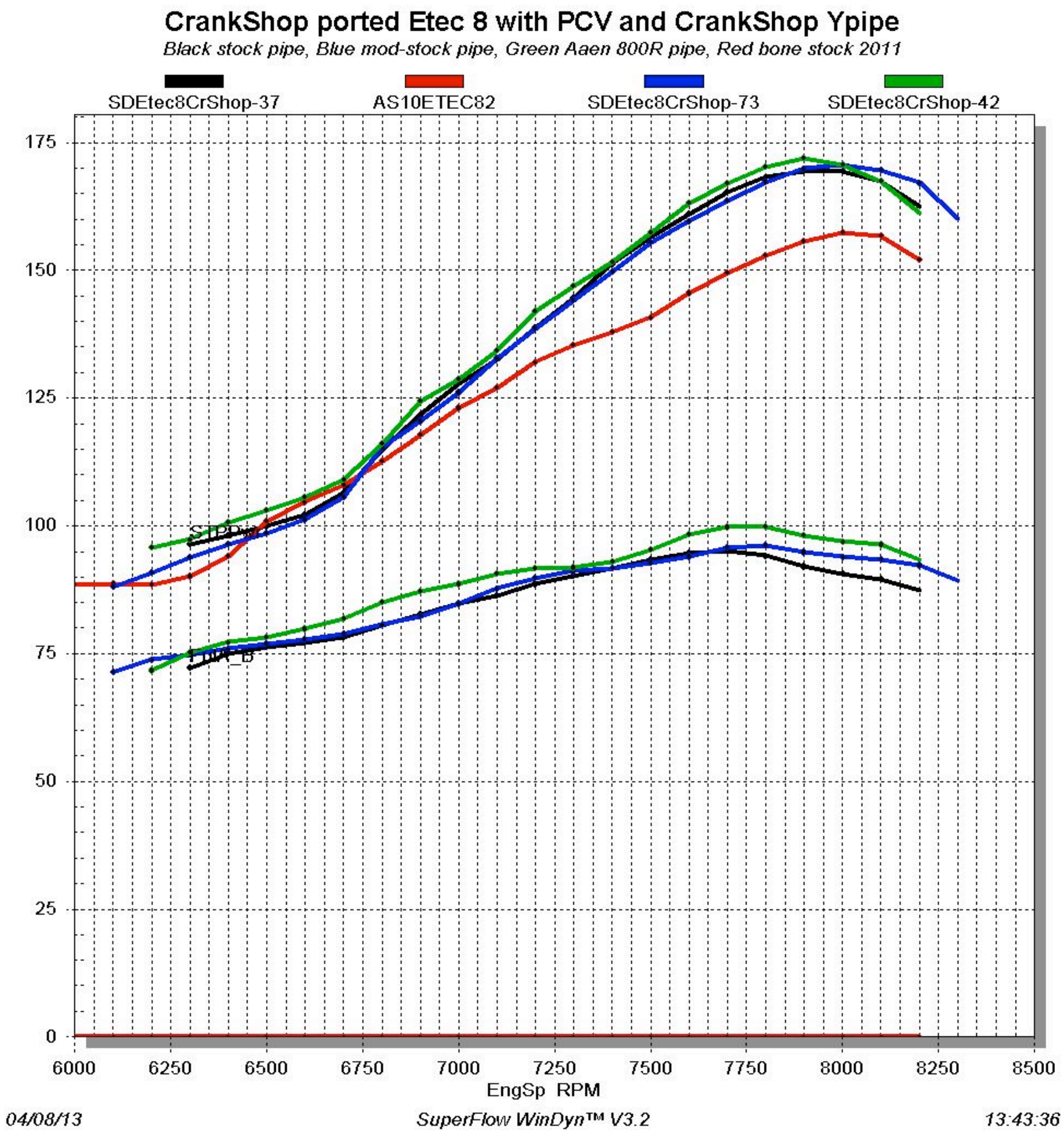
Finally, Larry installed a new set of Vforce 3 reed cages/ reeds. Here we saw a 5% drop in airflow and a 2% drop in HP. Here is the HP with pipe mod the same as the prior test, but with Vforce3 reed cages in place of the Boyesen Rad Valves.

VFORCE 3 REEDS, CS Ypipe, STOCK PIPE w/ CS PIPE MOD

EngSp	STPPwr	STPTrq	AFRA_B	BSFA_B	FulA_B	Air_1c	CoolOt	CoolFw
RPM	CHp	Clb-ft	Ratio	lb/hph	lbs/hr	CFM	deg F	GPM
6100	85.3	73.4	12.04	0.876	72.2	190.7	90	30.69
6200	87.4	74.0	12.34	0.860	72.7	196.8	90	31.09
6300	89.8	74.9	12.56	0.847	73.5	202.7	90	31.68
6400	93.4	76.6	12.69	0.831	75.0	209.0	90	32.33
6500	98.9	79.9	12.80	0.802	76.7	215.5	91	32.97
6600	105.4	83.8	13.03	0.761	77.5	221.9	91	33.41
6700	109.8	86.1	13.21	0.734	77.9	226.0	91	33.78
6800	114.6	88.5	13.24	0.715	79.3	230.5	91	34.25
6900	121.2	92.3	13.13	0.698	81.9	236.0	91	34.82

7000	128.1	96.1	12.99	0.681	84.4	240.8	91	35.14
7100	133.4	98.7	13.08	0.662	85.5	245.4	91	35.41
7200	138.6	101.1	13.19	0.645	86.5	250.4	91	35.71
7300	143.8	103.5	13.22	0.631	87.8	254.8	92	35.99
7400	149.4	106.0	13.30	0.617	89.2	260.4	92	36.23
7500	153.8	107.7	13.45	0.603	89.8	265.1	92	36.42
7600	158.5	109.5	13.51	0.595	91.2	270.6	93	36.66
7700	162.8	111.1	13.51	0.590	92.9	275.6	93	36.82
7800	165.8	111.6	13.70	0.580	93.0	279.9	93	36.87
7900	167.0	111.0	14.17	0.566	91.4	284.4	94	36.84
8000	166.7	109.4	14.59	0.557	89.9	287.9	94	36.86
8100	165.5	107.3	14.86	0.556	89.0	290.5	94	36.97
8200	161.3	103.3	15.03	0.570	88.9	293.2	94	37.05
8300	151.8	96.0	15.01	0.595	87.3	287.8	95	36.94

scroll down---------



The limiting factor in trying to make much over 170hp on pump gas on this particular engine is the 92.7 R+M/2 octane fuel we were using and the ability of the engine to deal with high combustion chamber heat that comes with high torque, high BMEP. Every time we approached 115 lb/ft of torque we had to add fuel or reduce ignition timing to keep detonation in check. Note the fuel flow we needed with the high torque Aaen 800R pipe to keep it from clicking loudly on our copper tube deto sensor. Larry Audette had hoped to pull peak HP RPM up to 8200-8300 with a shorter pipe to make more HP with less deto-producing torque but it seems that the ECU would give us max HP to 8000 then HP would drop regardless of pipe length or pipe center section temperature! Is the ECU dropping ignition timing severely after 8000, or are exhaust valves being commanded to partially close, reducing airflow and HP?

Here’s 33 year old Larry Audette in the late 1980’s with plenty of hair and a welded up “Mach 1 1/2” open mod engine that made, at that time, 187HP--crazy high HP in those days. As I recall it took a few more tweaks and dyno sessions to finally hit 200.

Here's Larry today, 20-some years wiser, having proudly removed his hat to show off his fashionably uncombed-over baldness. Visible over Larry's head is the length of copper tubing that is bolted to the cylinder head, and transmits very audible clicks of detonation into the control room, allowing us plenty of time to abort dyno tests before things go wrong. That $33 length of copper tubing is often more important than the $50,000 instrumentation that tells us everything *but* when deto is occurring!