2012 Arctic Cat Pro Cross 800 evaluation and tuneup for asphalt…

Billy Howard of Howard's Inc Arctic Cat/ SkiDoo/ Kubota in Coudersport PA (billy007@zitomedia.net) brought this first new 2012 Arctic Cat to DTR for evaluation. Since this was one of Billy's asphalt drag sleds, we would also try to tune it for max power with currently available tuning devices and some created by intuition. Billy and I were assisted and entertained by pals Boyd McGarry, Jamie Hitchcock and Dead One Dave Craiglow.

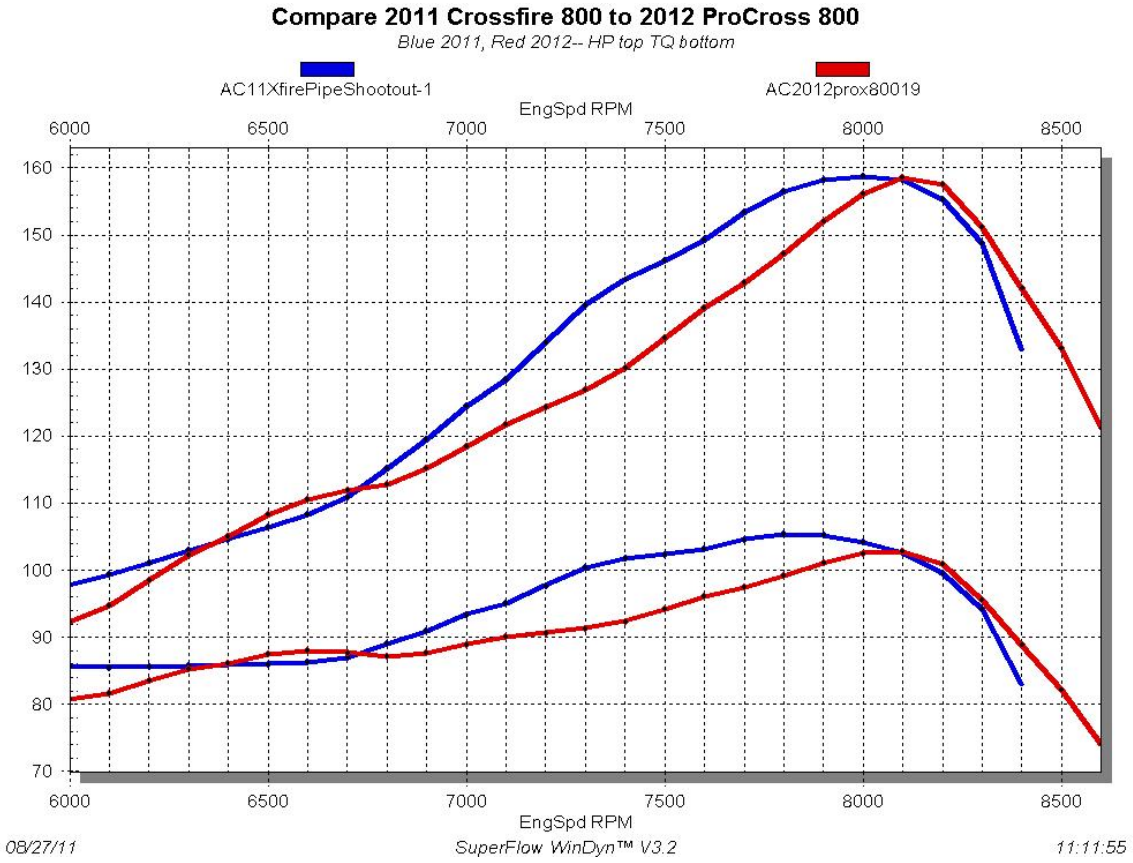
The 2012 800 engine is said to be physically identical to the 2011 version, but subtle chassis changes resulted in different exhaust configuration from Y pipe to muffler. How does the 2012 compare to 2011? Since this is so early in the 2012 model year, there are no aftermarket exhaust parts available for testing just yet. And how does the calibration of the factory ECU compare to last year? Comparing this 2012 ProCross 800 to last year's Crossfire 800, we see a huge difference in air intake configuration. The Crossfire 800 used the tried and true F7 airbox, which with the stock smallish looking plastic intake horn outflows CFM and out HP's every loud sounding but power robbing "big billet" air horn intake that we've tested so far—even on F7s with 900 big bores!

Cold air creates the highest real (not corrected) HP—we lose approximately one percent real HP for each 10 degree F intake temp rise. Sled engines sucking hot underhood air lose lots of HP. Back in the DTR archives that you all should read, in 1988 we saw huge power increases when Tim Bender created an outside air intake for the Yamaha Phazer—dropping measured winter intake air temps a solid 60 degrees on the fan-cooled sled. We discovered back then that cold outside air = low cost extra HP.

Now with the ProCross 800 we have a convoluted, ostensibly much quieter intake that ducts cold intake air from behind the windshield, through a large, complex sound baffled chamber between the hood and engine bay, to a large airbox in front that connects to the EFI throttle bodies. The sled's intake temperature probe is on the inlet of the hood pod, where temps will be coldest. For our dyno tune, this would prove to skew things a bit. By the end of the day, the hot pipe transferred extra, unmeasured heat to the baffled intake chamber in the hood while sitting motionless on the dyno table. This didn't happen with early 300rpm/sec tests with stock tuning, but became an issue as power began to rise and fuel was leaned down for dragracing. Longer 200 rpm/ second tests aggravated the situation. My goof on this day was not inserting a temp probe into the large airbox in the front and monitoring the temperature. But to be sure, the stock testing was done without the intake air being heated. We did several baseline tests with the hood pod in place, but with dyno blower aimed into the underhood area which helped wash the hot air away and keep the pod air intake at room temperature. Next we removed the pod and with the airbox in the front wide open we saw ***no difference in power***, so we can assume that those maze-like baffles inside the pod intake offer little if any restriction to the 800 twin in stock form. So by removing any of the baffles all you would get is louder intake howl and no extra power.

But in the field, if we experience any intake air temp rise from inlet to engine, the A/F ratio will be richer, safer, and HP will drop about 1% per 10 degree F temp rise. We can only guess at the heat transfer from hot engine/ pipe to the plastic ducted air intake shroud in the field. Perhaps it's minimal, or even zero for typical trail riders. But we can expect that those mountain riders who enjoy burrowing through deep powder for long periods of time at WOT will experience actual intake temp increases while the ECUs register cold outside air temps. That sort of abuse will result in safer, richer A/F ratios to protect the engines. But it surely won't take long for front mounted intake to be developed to deal with that. D&D Powersports already has a nice, large front mounted air filter to replace the baffled intake. But before Billy Howard installs a front intake on this sled for asphalt racing, we'll try to monitor the engine air temperature on the stock airbox during some ¼ mile passes.

Beside the revised intake system, the 2012 sled has a slightly different exhaust system—the Ypipe looks straighter and the single pipe has a larger diameter stinger outlet pipe. There is an internal stinger that extends about 5 or 6 inches into the pipe, but the net effect is less backpressure—about 3.0 psi average peak compared to 3.6 psi average peak we measured on last year's sled. Then there is a large insulated stainless steel muffler. While peak horsepower is very similar from 2011 to 2012, midrange torque and horsepower is lower in 2012 due to the exhaust and possibly less midrange timing advance. But that is nothing that the aftermarket pipe people can't rectify!



Here's the stock 2012 800, as shown in the graph. 91 octane 10% ethanol fuel was used. For each test we monitored the ECU for temperature and any sign of knock induced ignition retard, and also listened for clicks of deto with the copper tube bolted to the cylinder head. Coolant temp was in the 120F range, and pipe temperature was always over 1000F at peak revs. Also keep in mind that this tuning was done in summer air, and that when we get time to test with cold air, the tuning may change (we have all of these summer PCV maps available). We had planned to do winter air PCV tuning on this day after we completed Billy's asphalt tuneup, but it was a 12 hour session by test 47, and the cold air data will have to wait until we get pipes/ Ypipes etc to try this fall.

All stock 2012 ProCross 800 tested in summer air.

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF
5600	82.3	77.2	0.621	47.2	0.1	78.1
5700	83.3	76.8	0.646	49.6	1.25	78.1
5800	85.8	77.7	0.623	49.3	1.43	78.1
5900	88.5	78.8	0.639	52.2	1.78	78.1
6000	92.2	80.7	0.615	52.3	2.11	78.1
6100	94.7	81.5	0.619	54.0	2.36	78.1
6200	98.5	83.4	0.606	55.0	2.77	78.1
6300	102.3	85.3	0.600	56.6	3.24	78.1
6400	105.0	86.1	0.589	57.0	3.46	78.1
6500	108.3	87.5	0.576	57.5	3.92	78.1
6600	110.5	88.0	0.563	57.4	4.27	78.1
6700	111.9	87.7	0.563	58.1	4.58	78.1
6800	112.8	87.1	0.598	62.2	4.92	78.1
6900	115.2	87.7	0.612	65.0	5.25	78.1
7000	118.5	88.9	0.627	68.5	5.61	78.1
7100	121.7	90.1	0.630	70.8	5.92	78.1
7200	124.3	90.7	0.640	73.4	6.22	78.1
7300	127.0	91.3	0.672	78.7	6.59	78.1
7400	130.1	92.4	0.681	81.7	6.86	78.1
7500	134.6	94.2	0.678	84.1	7.25	78.1
7600	139.1	96.1	0.678	87.0	7.61	78.1
7700	142.9	97.5	0.664	87.4	7.88	78.1
7800	147.2	99.1	0.658	89.3	8.25	78.2
7900	152.0	101.0	0.651	91.2	8.62	78.2
8000	156.2	102.5	0.638	91.8	8.97	78.2
8100	158.6	102.8	0.634	92.7	9.36	78.2
8200	157.5	100.9	0.676	92.4	9.81	78.2
8300	151.1	95.6	0.673	91.6	10.33	78.2
8400	142.0	88.8	0.697	89.3	10.76	78.2
8500	133.0	82.2	0.726	87.1	11.11	78.2
8600	121.3	74.1	0.785	85.7	11.56	78.2

Next we installed a Power Commander V fuel tuner, and added some midrange fuel and reduced top end fuel. This created higher pipe temperature and as we can see in the graph following, helped overrev HP too.

Install PCV with mild tune

EngSpd	STPPwr	STPTrq	BSFCAB	FulAB	ElpsTm	AirInT
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF
5900	92.7	82.5	0.630	53.8	0.28	77.7
5800	90.7	82.1	0.653	54.6	0.59	77.7
6000	93.8	82.1	0.650	56.2	1.15	77.7
6100	96.2	82.8	0.640	56.8	1.48	77.7
6200	99.2	84.0	0.640	58.6	1.99	77.7
6300	101.7	84.8	0.631	59.2	2.15	77.7
6400	105.8	86.8	0.619	60.4	2.65	77.7
6500	109.0	88.0	0.605	60.8	3.07	77.7
6600	111.6	88.8	0.590	60.7	3.40	77.7
6700	113.4	88.9	0.581	60.8	3.74	77.7
6800	115.0	88.8	0.617	65.4	4.08	77.7
6900	117.0	89.0	0.635	68.5	4.40	77.7
7000	119.5	89.7	0.640	70.5	4.74	77.7
7100	122.3	90.4	0.639	72.0	5.13	77.7
7200	124.5	90.8	0.643	73.9	5.42	77.7
7300	126.7	91.1	0.665	77.7	5.80	77.7
7400	129.5	91.9	0.669	79.9	6.08	77.8
7500	132.8	93.0	0.670	82.0	6.42	77.8
7600	136.3	94.2	0.666	83.6	6.71	77.8
7700	140.6	95.9	0.664	86.1	7.03	77.8
7800	146.0	98.3	0.650	87.5	7.38	77.8
7900	151.8	100.9	0.628	87.9	7.76	77.8
8000	156.5	102.8	0.614	88.6	8.15	77.8
8100	159.6	103.5	0.607	89.3	8.52	77.8
8200	160.7	102.9	0.602	89.0	8.90	77.9
8300	159.4	100.9	0.604	87.2	9.28	77.9
8400	155.2	97.0	0.664	84.3	9.75	77.9
8500	146.3	90.4	0.688	84.8	10.28	77.9

Next we installed a .030” offset timing key, to add timing throughout the power band. This added lots of midrange torque and power and a few more at peak. The increased timing lead also reduced exhaust pipe temp, lowering peak HP RPM and reducing overrev HP.

Install .030” key

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF
5500	84.4	80.6	0.674	52.6	0.11	75.9
5600	85.8	80.4	0.658	52.2	0.71	76.0
5700	86.7	79.9	0.652	52.3	1.16	76.0
5800	88.2	79.8	0.657	53.6	1.36	76.0
5900	91.0	81.0	0.654	55.0	1.87	75.9
6000	93.7	82.0	0.667	57.8	2.35	76.0

6100	96.2	82.9	0.649	57.7	2.49	76.0
6200	100.3	85.0	0.645	59.9	2.97	75.9
6300	103.1	86.0	0.635	60.6	3.13	76.0
6400	107.3	88.0	0.619	61.4	3.61	76.0
6500	110.0	88.8	0.604	61.4	3.83	76.0
6600	113.0	89.9	0.593	61.9	4.25	76.0
6700	115.3	90.4	0.619	66.0	4.62	76.0
6800	117.8	91.0	0.622	67.8	4.88	76.0
6900	120.8	91.9	0.630	70.4	5.27	76.0
7000	123.7	92.8	0.626	71.6	5.57	76.0
7100	126.4	93.5	0.623	72.8	5.94	76.0
7200	128.8	94.0	0.621	73.9	6.19	76.0
7300	131.8	94.9	0.643	78.3	6.61	76.0
7400	135.3	96.0	0.640	80.1	6.86	76.0
7500	140.2	98.1	0.632	81.9	7.21	76.0
7600	145.5	100.6	0.619	83.3	7.59	76.0
7700	150.2	102.5	0.610	84.7	7.89	76.0
7800	154.9	104.3	0.595	85.3	8.25	76.0
7900	159.1	105.8	0.581	85.4	8.62	76.0
8000	162.3	106.5	0.571	85.6	8.95	76.0
8100	163.8	106.2	0.581	87.9	9.37	76.0
8200	159.7	102.3	0.601	88.7	9.94	76.0
8300	149.4	94.5	0.635	87.6	10.4	76.0

Early on we had been monitoring average pipe pressure and found that it peaked at 3.0 psi—quite a bit lower than last year's pipe/ muffler combo. So Billy and his pals dropped a short piece on flared tubing down into the muffler inlet to increase backpressure then reinstalled the stock pipe. This made the backpressure closer to last year's exhaust (not sure of the exact psi since we had removed the pressure sensor by this time) and made the engine much happier. Also pipe temperature rose causing overrev power to increase as well. It appears that at this time we dropped fuel flow another 3% at high revs to make up for the reduced airflow too. Even though BSFC is low, there were zero clicks of deto heard or seen on the Cat computer monitor.

Drop in Billy's exhaust restrictor, reduce fuel flow 3%

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF
5500	82.5	78.8	0.657	50.1	0.58	76.3
5600	83.3	78.2	0.663	51.1	0.99	76.3
5700	84.1	77.5	0.682	53.0	1.47	76.3
5800	85.8	77.7	0.677	53.7	1.67	76.3
5900	89.2	79.4	0.667	54.9	2.21	76.3
6000	91.4	80.0	0.661	55.8	2.35	76.3
6100	95.1	81.9	0.657	57.8	2.84	76.3
6200	97.7	82.7	0.649	58.6	2.99	76.3
6300	101.7	84.8	0.636	59.7	3.44	76.3
6400	105.2	86.3	0.621	60.4	3.80	76.3
6500	108.1	87.4	0.612	61.1	4.08	76.3
6600	110.9	88.2	0.598	61.3	4.49	76.3

6700	113.2	88.7	0.598	62.5	4.72	76.3
6800	115.7	89.4	0.629	67.2	5.11	76.3
6900	118.6	90.3	0.635	69.5	5.42	76.3
7000	121.9	91.5	0.636	71.6	5.78	76.3
7100	125.0	92.5	0.632	73.0	6.14	76.3
7200	127.7	93.2	0.634	74.8	6.40	76.3
7300	131.0	94.3	0.650	78.7	6.79	76.3
7400	135.2	95.9	0.652	81.4	7.12	76.3
7500	139.5	97.7	0.643	82.9	7.42	76.3
7600	144.4	99.8	0.633	84.4	7.77	76.3
7700	149.1	101.7	0.622	85.7	8.08	76.3
7800	154.2	103.8	0.594	84.7	8.45	76.3
7900	158.6	105.4	0.568	83.2	8.76	76.3
8000	162.8	106.9	0.546	82.1	9.15	76.3
8100	166.1	107.7	0.536	82.3	9.49	76.3
8200	168.2	107.7	0.527	81.9	9.82	76.3
8300	168.2	106.5	0.526	81.7	10.24	76.3
8400	164.3	102.7	0.536	81.2	10.79	76.3
8500	157.2	97.2	0.555	80.5	11.21	76.4

Billy and his pals removed the stock reed cages and installed a set of Boyesen Rad Valves. With the higher flowing reeds, the engine made more power from low RPM to beyond the HP peak compared to the stock reeds. For this test we popped out Billy's restrictor, so we should compare this test with the 163.8hp test with no restrictor. With no restrictor, part of the HP gain with the reeds is probably due to the higher pipe backpressure created by the added airflow through the engine. Once again, zero clicks of deto were heard or seen on the computer!

Install Boyesen Rad Valves, remove the exhaust restrictor

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF
6100	107.0	92.1	0.613	60.7	0.46	76.8
6200	108.5	91.9	0.610	61.2	0.84	76.8
6300	110.2	91.9	0.603	61.5	1.63	76.8
6400	112.4	92.2	0.604	62.8	2.17	76.8
6500	114.6	92.6	0.597	63.3	2.46	76.8
6600	116.7	92.8	0.587	63.3	3.02	76.8
6700	118.3	92.8	0.579	63.4	3.61	76.8
6800	120.3	92.9	0.618	68.8	4.14	76.8
6900	123.6	94.1	0.627	71.7	4.56	76.8
7000	127.1	95.4	0.627	73.7	5.09	76.8
7100	129.6	95.9	0.622	74.5	5.61	76.8
7200	131.8	96.2	0.622	75.8	6.04	76.8
7300	134.8	97.0	0.646	80.5	6.54	76.8
7400	139.8	99.2	0.645	83.4	7.03	76.8
7500	145.7	102.1	0.638	86.0	7.57	76.8
7600	150.5	104.0	0.625	87.0	8.05	76.8
7700	155.3	105.9	0.608	87.4	8.59	76.8
7800	159.3	107.3	0.590	87.0	9.07	76.8
7900	163.0	108.3	0.574	86.5	9.61	76.8

8000	166.5	109.3	0.555	85.5	10.15	76.8
8100	168.1	109.0	0.548	85.2	10.69	76.8
8200	167.8	107.5	0.548	85.0	11.20	76.8
8300	163.3	103.3	0.555	83.7	11.86	76.8
8400	150.3	94.0	0.590	81.8	12.67	76.9

It took the guys just a few minutes to pop Billy's exhaust restrictor back in the muffler inlet. And on this test we heard two clicks of deto on the copper tube protruding through the wall of the control room as the engine transitioned through peak torque. But it wasn't enough to cause me to abort the test, and interestingly the knock we heard didn't register on the Cat computer. This was the absolute edge of power on Billy's 91 octane.

Reinstall exhaust restrictor

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF	psig
6000	102.4	89.7	0.619	58.7	0.47	75.8	43.1
6100	104.3	89.8	0.614	59.3	0.61	75.8	43.1
6200	105.0	88.9	0.627	60.9	1.14	75.8	43.1
6300	106.8	89.0	0.621	61.4	1.62	75.8	43.0
6400	109.0	89.4	0.614	61.9	1.80	75.8	43.0
6500	111.6	90.1	0.606	62.6	2.29	75.8	43.0
6600	113.7	90.4	0.610	64.2	2.54	75.8	43.0
6700	116.2	91.1	0.609	65.4	2.92	75.8	43.0
6800	118.5	91.5	0.629	69.0	3.27	75.8	42.9
6900	121.4	92.4	0.632	71.0	3.59	75.8	42.9
7000	124.7	93.6	0.628	72.5	3.93	75.8	42.8
7100	127.9	94.6	0.626	74.1	4.28	75.8	42.9
7200	130.7	95.3	0.640	77.3	4.57	75.8	42.8
7300	134.1	96.5	0.647	80.3	4.89	75.8	42.6
7400	138.9	98.6	0.649	83.4	5.30	75.8	42.6
7500	142.7	99.9	0.641	84.6	5.53	75.8	42.6
7600	147.9	102.2	0.629	86.1	5.91	75.8	42.6
7700	153.0	104.4	0.612	86.6	6.26	75.8	42.6
7800	157.2	105.9	0.592	86.1	6.53	75.8	42.6
7900	162.0	107.7	0.568	85.2	6.93	75.8	42.7
8000	165.9	108.9	0.549	84.2	7.28	75.8	42.7
8100	169.1	109.6	0.535	83.7	7.64	75.8	42.7
8200	171.0	109.5	0.527	83.4	8.02	75.8	42.7
8300	171.1	108.3	0.521	82.5	8.41	75.8	42.7
8400	167.5	104.7	0.518	80.3	8.88	75.8	42.7
8500	159.0	98.3	0.540	79.3	9.35	75.9	42.8

I suggested to Billy that we add 2% to fuel flow in the peak torque area to get rid of the deto. But being the greedy bastard that he is, he was concerned that it might drop his power below 170. He suggested instead adding Klotz octane booster (with some sort of tetraethyl lead "replacement") to the 91 in his tank. I was leery, since octane "booster" hasn't shown me anything in the past, but the word "impossible" has long been deleted

from my own vocabulary. It took two back to back dyno runs to get the "improved" gas through the dyno hoses/ flowmeter but the knock was gone! But also power dropped below 170. We noticed then that the stock air duct below the pod was extremely hot from the back to back dyno passes, probably transferring lots of pipe heat into the intake air. If that air temp had finally heated up to, say, over 100F and the dyno correction factor was based upon 75.8 degrees F, then Billy's engine was being shortchanged. So for one final test we lifted the pod off of the front of the airbox and ducted 75 degree F air directly into the box, and the engine now made 175HP! This is with 91 octane/ Klotz booster, and run for nearly 15 seconds at WOT! So at some point, airbox heat had become an issue—probably after we installed the Boyesen Rad Valves when our air cooling ducts were moved about putting way less cooling air the pod. A real scientist would have done all of these tests again but ensuring that actual intake air temperature matched the ECU and dyno correction temperature (which it surely was for the stock baseline data). And if this were a pipe shootout, we absolutely would have. But this is just a low-buck deal to make Billy's sled run more quickly at the dragstrip. Going from 158HP to 175HP for well under a grand is impressive, and surely trail rideable at well over 170HP on 87 octane. So when we do this again after we get pipes and other stuff to test, we'll be sure to feed properly cool air to the engine. And kudos to the Cat engineers for creating this engine with twin plugs per cylinder (less time for the fire to heat the combustion chamber surfaces), "reverse" cooling (putting the coolant into the heads first—where it's needed—like all modern race engines) and perhaps even higher velocity, turbulent coolant and coolant passages combine to allow us to achieve this incredible power level on pump gas, rewriting the DTR rules of BSFC.

Remove pod that was overheated by repeat runs on the dyno, feed 75F air to intake

EngSpd	STPPwr	STPTrq	BSFCAB	FuelA	ElpsTm	AirInT	FulPrA
RPM	CHp	Clb-ft	lb/hph	lbs/hr	Secnds	degF	psig
6100	105.8	91.1	0.605	59.3	0.64	75.3	43.3
6200	108.1	91.6	0.603	60.5	1.62	75.3	43.2
6300	110.6	92.2	0.596	61.1	2.00	75.3	43.3
6400	113.0	92.7	0.591	61.8	2.54	75.3	43.3
6500	114.9	92.9	0.574	61.1	3.12	75.3	43.3
6600	116.8	92.9	0.569	61.6	3.53	75.3	43.3
6700	118.3	92.8	0.565	61.9	4.01	75.3	43.3
6800	120.7	93.2	0.601	67.3	4.53	75.3	43.1
6900	124.6	94.8	0.615	71.0	5.05	75.3	43.1
7000	128.3	96.2	0.612	72.8	5.55	75.4	43.0
7100	131.6	97.3	0.614	74.9	6.12	75.3	43.0
7200	134.4	98.0	0.608	75.7	6.62	75.3	43.0
7300	137.1	98.6	0.632	80.2	7.16	75.3	42.9
7400	141.4	100.4	0.633	83.0	7.64	75.3	42.9
7500	145.8	102.1	0.624	84.2	8.03	75.3	42.8
7600	150.6	104.1	0.615	85.7	8.55	75.4	42.8
7700	155.4	106.0	0.600	86.3	9.12	75.4	42.8
7800	159.3	107.3	0.584	86.1	9.51	75.4	42.9
7900	163.8	108.9	0.557	84.6	10.05	75.4	43.0
8000	168.0	110.3	0.537	83.6	10.53	75.4	43.1
8100	171.7	111.3	0.537	85.4	11.09	75.4	43.0
8200	174.3	111.6	0.529	85.3	11.65	75.4	42.9

8300	175.5	111.0	0.522	84.9	12.18	75.4	43.0
8400	175.0	109.4	0.511	82.7	12.70	75.4	43.0
8500	173.1	107.0	0.507	81.2	13.27	75.5	43.0
8600	166.0	101.3	0.510	78.2	14.06	75.5	43.1

Graph of all tests below: