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DYNOTECH

THE SNOWMOBILE PERFORMANCE JOURNAL

BATTLE OF OLD FORGE

THE REST OF THE STORY

By now, those of you who are receiving American Snowmobiler magazine (612-738-1953) have read the official report on the first annual American Snowmobiler/DynoTech performance sled field test.

DynoTech subscribers have continually asked for "muscle sled" field tests to go along with our dyno evaluations, to see how true horsepower/weight numbers translate into field performance. Winter dyno tuning and evaluations are a full time job for me; field testing is a whole new ball game. But there is *one* guy in the snowmobile business who has more experience conducting field performance tests than anyone else---Jerry Basset.

I met Jerry Basset, the publisher of American Snowmobiler Magazine, over a year ago when he came to Batavia to write an article about our dyno testing facility. Over dinner one night, Jerry related to me the difficulties he had had obtaining truly stock, unaltered machines for the musclesled "shootouts" that he conducted in the early eighties. I suggested that if he were interested in reviving the performance field tests, DynoTech could assist by dyno testing each manufacturer's sled at our facility, then sealing the engines to ensure that they were stock. Jerry could then conduct the first truly "fair" field performance test. The "Battle of Old Forge" was born.

I discussed this idea with snowmobile performance enthusiast George Taylor, owner of Van Auken's Inn near Old Forge, N.Y. George is in charge of preparations for the annual December "SnoDeo" winter carnival in Old Forge, and after hearing what Jerry and I were proposing, George was happy to offer this year's "SnoDeo" as the "host" of what will hopefully be the first of many annual, American Snowmobiler/DynoTech Battles of Old Forge.

Yamaha factory racer Tim Bender agreed to be the test driver, and with the help of the SnoDeo organizing committee and Jerry Basset, a location and test time was arranged. Local radio broadcasting would be provided, as well as television coverage of the event by Channel 9 TV in Syracuse, N.Y. With the basic scheduling complete, all that remained was dyno certification of the muscle sleds. The sleds were to remain stock, and be shipped to the C&H Dyno for verification and sealing with serial numbered Electric Power Company meter tags. ➡

OLD FORGE, N.Y.

In this part of the country, the Old Forge, N.Y. area is the hotbed of ultra high performance snowmobiling. Every winter weekend, the frozen lakes in this area provide a safe, organized proving ground for what are certainly some of the highest performing "lake racers" in the country. Plowed 750 foot ice dragstrips, complete with starting lights and radar guns are filled each weekend with combatants from all over the East Coast, each spending upwards of $20,000 on engine/ chassis combinations. The rule is: no rules. All you need is a hood, belly pan, snowmobile engine, and good sense of humor.

Slide rail lubers are filled with environmentally safe RV antifreeze instead of ethylene glycol. Quiet pipes are the norm. (continued on page 2)

BATTLE OF OLD FORGE

CONTINUED

The first stock "Battle Sled" on the dyno was a 700 Wildcat provided by Big Moose Yamaha/Arctic Cat of Eagle Bay, N.Y.

Without bothering to remove the seat, fuel tank and dash to install our SuperFlow airflow meter, we connected the 700 Wildcat to the dyno. The crankshaft was connected to our dyno drive shaft and the dyno fuel system was installed to measure fuel flow.

After one "pull", we knew something was amiss. The 700 made too much horsepower! An earlier DynoTech Wildcat 700 (Vol2 #6) had made 112+ horsepower, close to what Arctco suggested it would. With 350 main jets at 63 degrees F CAT, this Cat made 116.1 CBHP. This was two tenths of a horsepower more than our stock project 700 (see Vol 2, #6) made with a gutted airbox. Gutted airbox!?

Removing the PTO carb, we looked inside the airbox with a bend-a-light only to find that the baffling had been hastily removed by an advantage-seeking set-up technician. The sled *was* still stock, but this was stretching it a bit! After the red-faced set-up man replaced the mod airbox with a stock box, the hood was sealed closed.

...OLD FORGE continued

This is big time dragracing; there are no trophies or points awarded, only "crowing rights" at the Saturday night "lying and crying" sessions at the many local watering holes.

Last year's King of the Hill was Gary Udinson's lightweight Indy, powered by a 750cc turbocharged Polaris triple. This year, Gary is a marked man. He is being stalked by perhaps a dozen new Polaris lightweights. Some have 200+ HP Crankshop and other Rotax triples. There are nitrous injected three cylinder Bender Yamahas. There is one four cylinder Polaris, and another Polaris triple complete with a Magnuson supercharger. The owner of the Old Forge bowling alley is purchasing a complete Polaris lakeracer from Jim Dimmermann. Big Bob Gaudreau is reported to have a lightweight, 1050cc triple Cat in the works. It will be an interesting season.

1991 ARCTIC CAT WILDCAT 700
ILLEGAL AIRBOX 350 MJ 44 MM CARBS

ACTUAL DYNOTECH SLED WEIGHT
W/3 GAL GAS: 546 lbs.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .45
Barometer: 30.10

RPM	CBT	CBHP	FUEL	BSFC	CAT
6000	65.3	74.6	60.4	.82	63
6250	69.2	82.3	67.5	.83	64
6500	70.1	86.8	72.7	.85	63
6750	72.8	93.6	77.5	.84	63
7000	72.8	97.0	83.0	.87	63
7250	73.9	102.0	74.8	.74	63
7500	76.2	108.8	79.6	.74	63
7750	77.3	114.1	81.3	.72	63
8000	76.2	116.1	89.4	.78	63
8250	70.3	110.4	78.9	.72	63
8500	57.7	93.4	76.8	.84	64

1991 700 WILDCAT STOCK
350MJ 40MM CARBS (FROM Vol. 2 #6)

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .50
Barometer: 30.10

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	70.3	87.0	55.7	190.4	15.7	.65	60
6750	70.7	90.9	65.1	194.3	13.7	.73	60
7000	71.8	95.7	69.7	195.0	12.8	.74	61
7250	73.0	100.8	77.1	195.8	11.7	.78	61
7500	75.7	108.1	80.7	200.5	11.4	.76	62
7750	76.3	112.6	93.2	206.7	10.2	.84	61
8000	73.9	112.6	92.9	209.7	10.4	.84	62
8250	64.9	101.9	84.2	208.8	11.4	.84	63
8500	33.2	53.7	77.2	194.6	11.6	1.46	62

Next on the dyno was George Taylor's Mach 1X.

The Mach 1X engine differs from the standard Mach 1 in that it has stamped twin pipes, 520-580 rotary valve timing, twin 44mm Mikuni carbs, a freer breathing airbox, and earlier ignition system (which limits high RPM retarding of the timing curve). The chassis is an amazing 39 lbs. lighter than the standard Mach 1, but still is similar in weight to the Wildcat 700 and RXL.

➡

Even with drastically corrected jetting, the Mach 1X only made 110 CBHP on the C&H Dyno, quite a bit lower than the Mach 1X prototype we tested earlier. Bombardier dealer Tom Smith, of Smith Marine in Old Forge, discovered that both the ignition and rotary valve timing were retarded, and he made the necessary adjustments to bring the engine into proper tune. The following test data resulted, with jetting that is pump gas safe at 65 degrees F.

1991 STOCK MACH IX 420-460 MJ

ACTUAL DYNOTECH SLED WEIGHT W/3 GALS OF GAS: 554 lbs.

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .45
Barometer: 30.09

RPM	CBT	CBHP	FUEL	BSFC	CAT
6250	57.1	68.0	47.3	.71	65
6500	58.6	72.5	50.5	.71	65
6750	62.7	80.6	57.7	.73	66
7000	65.0	86.6	61.4	.72	65
7250	67.4	93.0	61.8	.68	65
7500	68.8	98.2	64.0	.66	65
7750	69.1	102.0	68.0	.68	66
8000	69.6	106.0	72.8	.70	65
8250	71.4	112.2	73.2	.66	65
8500	70.8	114.6	76.1	.68	66
8750	67.0	111.6	76.6	.70	66

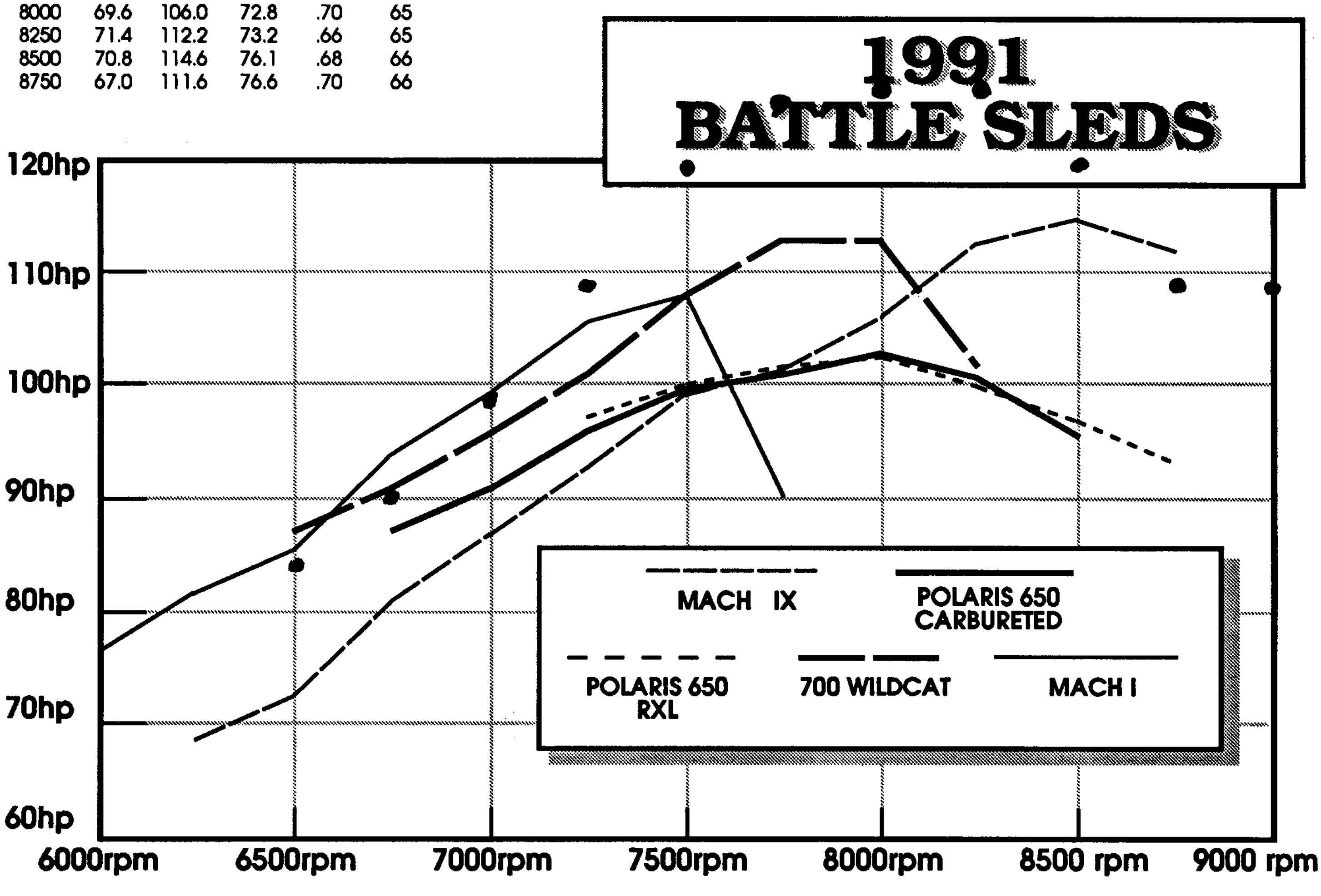
Long Island auto dealer Buzz Chew donated the use of his new stock Mach 1 for the Battle of Old Forge. While it made slightly more torque and horsepower than our original prototype or production project sled (Vol 2, #5 & #6), the engine was stock and typical. The Mach 1 was the heaviest sled we tested.

1991 STOCK SKI DOO MACH I 370-390 MJ

ACTUAL DYNOTECH SLED WEIGHT W/3 GALS. OF GAS: 593 lbs.

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .45
Barometer: 30.08

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	67.3	76.9	59.0	141.5	11.0	.78	67
6250	68.6	81.6	63.7	150.0	10.8	.79	67
6500	69.1	85.5	64.7	154.6	11.0	.77	68
6750	72.8	93.6	67.8	163.2	11.1	.74	67
7000	74.2	98.9	70.3	168.7	11.0	.72	67
7250	76.6	105.7	73.8	177.7	11.1	.71	67
7500	75.7	108.1	75.1	185.2	11.3	71	67
7750	61.0	90.0	75.2	187.0	11.4	.85	67
8000	40.8	62.1	72.5	176.3	11.2	1.19	67



BATTLE OF OLD FORGE

CONTINUED

Pete Webb of Webb Polaris and Webb Perfomance let us use his new Polaris RXL for the shootout, and this one was typical of all of the Electronic Fuel Injected Polaris engines we have tested this year. The 1991 chip has eliminated the previous low RPM, Wide Open Throttle overrich fuel flow that we reported in Vol 2, #3. The W.O.T. fuel flow now correctly follows the horsepower curve, peaking around 8000 RPM, then declining at higher engine speed.

Now, there is an aftermarket pipe manufacturer that is recommending bolting their high RPM pipes on the RXL with no chip change! With no mass airflow sensing capabilities, the RXL's ECU doesn't know what pipes are being used, and the fuel flow will decline even as high RPM airflow and horsepower (caused by the addition of aftermarket triple pipes) is increasing! This will probably result in too low fuel flow for the horsepower generated at 8750-9000 RPM, and the BSFC will at best be in the high .50's. Beware.

1991 STOCK RXL POLARIS 650

ACTUAL DYNOTECH SLED WEIGHT
W/3 GALS. OF GAS 563 lbs.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .45
Barometer: 30.37

RPM	CBT	CBHP	FUEL	BSFC	CAT
7250	69.9	96.5	70.5	.71	45
7500	69.8	99.7	73.2	.72	45
7750	68.5	101.1	75.1	.72	45
8000	67.1	102.2	72.9	.70	46
8250	63.5	99.7	70.9	.69	45
8500	60.1	97.3	69.2	.69	45
8750	56.2	93.6	66.7	.69	45

The last of our Battlesleds was Rob Schooping's brand new stock carbureted 1991 Indy 650. As we expected, with the corrected 240 main jets (for 42 degree F Carb Air Temp) installed, the engine made virtually the same CBHP as the RXL.

The following data was generated at 42 degrees.

1991 STOCK POLARIS 650 CARBURETED 240 MJ

ACTUAL DYNOTECH SLED WEIGHT
W/3 GALS. OF GAS: 530 lbs.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .25
Barometer: 30.39

RPM	CBT	CBHP	FUEL	BSFC	CAT
6750	66.9	86.0	60.5	.68	42
7000	68.2	90.9	66.1	.71	41
7250	69.5	95.9	70.5	.71	41
7500	69.6	99.4	74.0	.72	42
7750	68.3	100.8	74.8	.72	41
8000	67.3	102.5	71.6	.68	41
8250	63.7	100.1	69.0	.67	40
8500	59.1	95.6	69.5	.70	41

THE FIELD TEST SESSION

Two weeks later, on the day of the test, the sleds were unsealed and prepared for the "Battle". This is where I goofed a bit.

The temperature was cold and blowing, around 20 degrees F, and the altitude was 500 ft higher than the dyno. Jerry Basset was in charge of recording the radar speeds and elapsed times in the eighth and quarter miles, and I was to make sure that jetting was correct for the day, and that clutches were left alone.

While a large crowd of onlookers gathered, Tim Bender was busy checking out the testing and shutdown area with the Mach 1X (equipped with the 63 degree dyno jets in the carbs). A crew from Syracuse Channel Nine TV was interviewing the articulate Jerry Basset, and they wanted to talk to me next. Instead of determining what carburetion would be fair for each of the battle sleds, I was frantically trying to figure out something halfway intelligent to say to the TV reporter.

After the TV interview, the sleds were all lined up and ready to be run. "Time to jet up, guys", said the dyno man. The whole group protested, offering safe-looking spark plugs as evidence that the 60+ degree F dyno jets would be adequate for 20 degree F, 1/8 and 1/4 mile runs on 92 octane pump gas. ➡

Everyone was allowed to run the warmer weather dyno jets, which immediately put the Polaris RXL at somewhat of a fuel flow disadvantage. The RXL, of course, would automatically enrichen the fuel flow for the colder, 20 degree temperature of the day. The RXL's BSFC would remain around .70, but the carbureted sleds would benefit from the colder air's increasing the engine's horsepower more than 1% per ten degrees, effectively lowering the BSFC. Fuel flow remains constant regardless of air temperature, horsepower increases dramatically, and the engine's BSFC plummets.

Tim Bender blasted the Mach 1X through the 1/8 mile first, recording an 81 mph speed. The 700 Wildcat was next, and Tim was clocked at 77 mph, which was a much lower speed than the corrected horsepower difference would suggest. I then realized that the now stock airbox effectively richened the 700 Wildcat to an unfair disadvantage, and told the technicians from Big Moose Yamaha/Arctic Cat to lean down the 700 from its original 350 dyno main jets to 320 main jets. Understandable protests from the other groups accompanied this unscheduled jet change, but in fairness to the Cat people, I had to do it. Tim hopped on the leaned-down Wildcat and blasted off two 81 mph 1/8 mile passes, tieing the "X".

Even with its leaner jetting, the standard Mach 1's acceleration was about the same as the RXL's. Since the Mach 1 is some 40 lbs. heavier, this equal acceleration is understandable. (The 1/4 mile E.T. of the RXL was actually one second slower than that misprinted in the American Snowmobiler article).

Rob Schooping was late for the "Battle", so we used a bone stock, stock jetted (260 mains) 650 carbureted Polaris that Rick Baxter had in his trailer. It bogged horribly (worse than the stock RXL's bog) and the 1/8 mile speed was unimpressive.

After the middleweight sleds were run in the eighth, the musclesleds were run in the quarter mile. The people who were aware of the sleds' leaner jetting were taking bets on who would make it to the end of the quarter mile on all cylinders!

First came the Mach 1X. Tim blasted off a 91 mph quarter mile run, and we were all relieved to see the 1X live for the full quarter. What you have to remember is that it's a quarter mile down, *and* a quarter mile back. Of course, with Tim it's W.O.T. both ways. Halfway back on the return run, the Mach 1X engine locked up; the explanation from the Ski Doo guys was that it was either out of gas, or had an electrical problem.

Bender then blasted the Wildcat 700 to two 87 mph, 1/4 mile runs, W.O.T. up and back, no problem. Both the RXL and the Mach 1 ran the 1/4 mile at around 85 mph.

Rob showed up with his carbureted Indy 650 as our quarter mile tests were underway. We unsealed Rob's hood, and he went back to his trailer for fuel. *And to make some minor clutch changes.*

Due to a communication breakdown on my part, Rob was unaware that the clutches on the Battle sleds were to remain completely stock. Tim Bender jumped on the dyno jetted (240's) 650 Indy, which rocketed out of the hole and eclipsed the quarter mile E.T. and speed of the Wildcat at 88mph! Because of the possible clutching controversy, the American Snowmobiler article included the carbed Indy 650 for a side comparison only.

The Mach 1X was then refired for a second pass. This time, Tim didn't make it the full length of the quarter mile. At about 1200 ft., the engine quit. Again, the blame was placed upon an electrical problem, and we never saw the inside of the engine. At any rate, the Mach 1X should probably not be run, more than 1/8 mile with 420-460 main jets at 20 degrees F on 92 octane gas.

NEXT YEAR

We *are* planning to do it again. Next time, there will be no confusion about clutching and jetting. We'll run them out of the crate, dyno tested and tuned only to the factorys' recommended jetting for temperature and altitude. No more compassionate fudging of jet specs. Both the X and the Wildcat have ultra-safe factory jetting, and that's the way they should be run.

After the out of the crate runs, we could run a second session, allowing the dealers/ owners to rejet and reclutch as desired.

It was an enjoyable, educational experience for all of us. Basically, the sleds performed as the dyno horsepower and actual weight would suggest. Proper dealer prep, including jetting and clutching are a big key to sled performance; next year's "Battle" may make that even more evident.

650 WILDCAT

SLED OWNER: KEITH FORD
PISECO, N.Y.

SLP TRAIL SPEC & REED TEST

Jim Tanner, of Tanner's Outdoor Sports in Speculator, N.Y., had installed a set of Starting Line Products ported cylinders on Keith Ford's 1990 Wildcat 650 long track trail sled, which Keith brought to us for dyno evaluation and tuning.

SLP's Jim Fairchild had told me that their custom reed cages for the 650 Wildcat work well with their trail mod porting, and Keith's Wildcat provided a perfect oppurtunity to evaluate this combination. We tested these reed cages on the stock 650 engine in Vol2 #3, and found that they provide a nice improvement in airflow and horsepower. Earlier, Greg Hennel had tried the SLP reed cages in his full mod 140+ H.P. Wildcat 650, and saw no change in airflow or horsepower. We (and many of our subscribers) were interested in seeing how the high flow reed cages would work on a trail mod engine.

We also had Boyeson replacement fiber reeds to compare with the stock reeds for airflow and horsepower capability. In Vol1 #4, we tested the Boyeson reeds vs. the stock reeds in our 1988 FIII spec Wildcat test, and saw a very slight airflow and horsepower improvement. For our reed analysis, we used the SLP trail ported cylinders with 44mm carbs and the new SLP twin pipes with individual silencers. Our Carb Air Temperature during the test was around 50 degrees F, and 480 main jets and CC0 needle jets gave us a Brake Specific Fuel Consumption of .60 or more. As usual, for safety's sake we used C10 100 octane unleaded gasoline.

With the stock steel reeds in place, and the reed stops set at 10mm, the following test data resulted:

WILDCAT 650 SLP TRAIL SPEC/REED TEST
480MJ-CC0nj-STOCK REEDS-SLP PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .22 Barometer: 30.12

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	65.2	74. 5	61.1	179.2	13.5	.81	47
6250	67.9	80. 8	65.4	188.4	13.2	.80	47
6500	69.3	85. 8	72.0	191.4	12.2	.83	48
6750	71.5	91. 9	69.8	195.4	12.9	.75	46
7000	78.0	104.0	69.5	204.7	13.5	.66	47
7250	81.6	112.6	77.6	214.6	12.7	.68	47
7500	84.8	121.1	78.7	224.2	13.1	.64	47
7750	84.6	124.8	84.5	226.8	12.3	.67	48
8000	79.3	120.8	80.1	226.4	13.0	.65	47
8250	56.9	89.4	80.5	216.3	12.3	.89	48

Installing the Boyeson reeds in the stock cages, with the stops set at 10mm, the peak airflow and horsepower were very slightly diminished. For some reason, there was an even more dramatic reduction in airflow and horsepower in the midrange. This is different than the result we obtained by installing the Boyeson reeds in our FIII ported Wildcat in Vol1 #4, and emphasizes the importance of using a fully instrumented dynamometer to extract the maximum horsepower from any engine.

WILDCAT 650 SLP TRAIL SPEC/REED TEST
480MJ-CC0nj-BOYESON REEDS-SLP PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .22 Barometer: 30.11

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	65.2	74.5	68.3	183.6	12.3	.91	48
6250	66.2	78.8	72.2	186.9	11.9	.90	46
6500	68.0	84.2	70.3	190.2	12.4	.82	47
6750	71.2	91.5	71.0	191.9	12.4	.77	49
7000	75.5	100.6	74.7	199.6	12.3	.73	49
7250	79.1	109.2	74.1	207.2	12.8	.67	49
7500	83.5	119.2	78.3	219.1	12.8	.65	48
7750	84.1	124.1	78.0	224.1	13.2	.62	48
8000	80.5	122.6	86.2	223.6	11.9	.70	49
8250	72.4	113.7	83.2	221.5	12.2	.72	48

The SLP reed cages and fiber reeds were installed with the stops set at 9mm, following SLP's directions. This resulted in an unusual *decrease in airflow* accompanying *a definite increase in horsepower.* We see this occasionally, but the reverse situation is the norm. It is somewhat more common to see engine modifications increase airflow and decrease horsepower (eg: extrudehoned Wildcat cylinders in Vol1 #4). The SLP reeds caused the power peak to increase to a slightly higher RPM (interpolating the data, the power peak would be at 7900 RPM), but the midrange power suffered slightly. This is an unusual occurance, but nonetheless here are the results. (Note that both fiber reeds increased power at 8000 and 8250 RPM.)

WILDCAT 650 SLP TRAIL SPEC/REED TEST
480MJ-CC0nj-SLP REEDS-SLP PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .22 Barometer: 30.14

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	65.5	74.8	64.0	184.4	13.2	.84	48
6250	67.1	79.9	66.5	186.4	12.9	.82	48
6500	69.1	85.5	75.4	191.0	11.6	.87	48
6750	72.0	92.5	71.4	194.5	12.5	.76	47
7000	75.0	100.0	68.2	200.2	13.5	.67	47
7250	79.2	109.3	78.4	209.4	12.3	.71	47
7500	84.3	120.4	78.1	220.8	13.6	.64	46
7750	85.1	125.6	75.4	223.9	13.6	.59	47
8000	82.6	125.8	79.5	223.0	12.9	.62	48
8250	77.5	121.7	85.1	221.3	11.9	.69	48

1986 FIII V-MAX

THE MAXIMUM V-MAX

STOCK EVALUATION AND PIPE TEST

Sled owner: Bob Blizniak
Orchard Park, N.Y.

This is the last of our two cylinder V-Max articles.

The "Formula III" specs for the V-Max were developed by the Yamaha factory to try to make the 540cc piston port twin competitive in oval racing in 1983. Tim Bender's Factory FIII V-Max utilized shortened stock pipes with stingers in place of the stock cannister muffler.

Bender Racing modified this sled to Formula III specs, and while they declined to give us the exact port dimensions, they did tell me that this is their most difficult and time consuming porting procedure. Typically, it takes Lee, Bender's portmeister, ten hours to complete each set of FIII V-Max cylinders.

The exhaust ports are raised and widened, the intakes are lowered and widened, and the transfer ports are raised, reshaped and widened. The rear transfers are widened so much that they nearly meet in the back of the cylinders. On this particular engine, cranking pressure was a relatively high 160 p.s.i., and squish clearance is .050".

With this type of compression on the V-Max, 100+ octane should be used for extended high speed operation. On pump gas, it may be possible to provide enough fuel at all throttle positions to keep the BSFC safely above .70 lb/hphr. But if the fuel flow is slightly lean *anywhere*, the engine will surely detonate when it encounters the lean spot.

Unlike either the stock or update ported versions, the FIII ported V-Max does benefit somewhat from the use of 44mm carbs. In this case, the air temperature was in the mid 80's F, and the carbs were fitted with BB0 needle jets and 380 main jets.

1986 YAMAHA V-MAX FIII SPEC 44MM-380MJ-BB0 nj-STOCK PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .705
Vapor Pressure: .97
Barometer: 30.32

RPM	CBT	CBHP	FUEL	BSFC	CAT
6750	51.3	65.9	39.4	.63	84
7000	50.7	67.6	41.5	.64	84
7250	56.1	77.4	53.0	.72	84
7500	58.5	83.5	53.7	.68	84
7750	63.5	93.7	67.8	.76	84
8000	67.0	102.1	62.1	.64	85
8250	67.4	105.9	57.1	.57	86
8500	64.7	104.7	55.7	.56	84

1986 YAMAHA V-MAX FIII SPEC 44MM-380MJ -BB0 nj-CUT STOCK PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .705
Vapor Pressure: .97
Barometer: 30.33

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	47.3	63.0	44.8	.74	82
7250	51.3	70.8	44.4	.66	82
7500	53.5	76.4	45.0	.62	83
7750	54.5	80.4	43.2	.56	80
8000	58.3	88.8	54.7	.64	81
8250	61.8	97.1	50.9	.55	82
8500	64.4	104.2	51.8	.53	83
8750	64.5	107.5	53.1	.52	83
9000	61.7	105.7	56.3	.56	84

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FIII V-MAX *continued*

1986 YAMAHA V-MAX FIII SPEC
44MM-380MJ-BB0 nj-AAEN PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .705
Vapor Pressure: .97
Barometer: 30.32

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	44.9	59.8	49.6	.87	86
7250	51.1	70.5	55.1	.82	86
7500	51.4	73.4	51.1	.73	86
7750	54.9	81.0	52.5	.68	86
8000	58.7	89.4	55.1	.65	86
8250	58.5	91.9	54.1	.61	86
8500	61.7	99.9	52.6	.55	87
8750	61.7	102.8	53.0	.54	86
9000	55.6	95.3	49.5	.55	86
9250	47.8	84.2	44.5	.56	86

1986 YAMAHA V-MAX FIII SPEC
44MM-380MJ-BB0 nj-PSI PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .705
Vapor Pressure: .97
Barometer: 30.31

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	45.3	60.4	42.3	.74	87
7250	52.0	71.8	45.4	.67	87
7500	52.4	74.8	56.4	.79	87
7750	54.8	80.9	49.8	.65	86
8000	59.3	90.3	47.2	.55	87
8250	62.9	98.8	57.5	.61	88
8500	62.9	101.8	50.9	.53	87
8750	62.4	104.0	50.9	.52	87
9000	60.4	103.5	46.3	.47	87

FEEDBACK JIM CZEKALA

DG PIPE UPDATE

We finally had an opportunity to dyno test the DG Exciter single pipe. We tested it on a Bender trail ported 91 Exciter, and as its appearance might suggest, it performed exactly like the PSI single, within several tenths of a horsepower at each RPM level.

INDY 500 TURBO PROJECT SLED

I just returned from spending a long weekend in Minnesota with Kip and Pat Campbell and Ted and Grace Haines of Forest Lake (see Kip's letter in Vol2 #6). Kip and Forest Lake Motor Sport technician Danny Blachfelner had just completed the installation of the Middlesex Turbo on our new Indy 500 Classic, complete with their own electric boost-sensing fuel system. Danny also installed a variable turbo boost control, and four rectangular, colored dash lights which are activated sequentially at 5, 10, 15, and 20 lbs. of boost. For durability, they installed forged pistons and solid copper headgasket.

The sled is being shipped to N.Y., its first stop being the dyno for final jetting and clutching data. We'll be doing a full test on this engine/turbo combination in an upcoming issue.

COMMONLY ASKED QUESTIONS ON EFI

Q- What's happening with our FIII EFI Polaris?

A- Polaris factory sponsored racer Jim Appolson's IRS EFI deal didn't materialize as we had hoped. Political difficulties arose as the result of IRS' pending litigation against Polaris Industries over patent infringement. So, Jim's out there changing jets with the rest of the Polaris racers.

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FEEDBACK

Q-How's the DynoTech EFI Avalanche working?

A-IRS recently sent us a new system to replace the one we currently have on the three cylinder Exciter. Since ours was a prototype, they wanted us to have the production version. It should be installed and tested by mid January.

Q-What aftermarket components have we tested for the Polaris RXL?

A-First, bear in mind the fact that the RXL engine should generate maximum horsepower at a BSFC of around .60 lb/hphr. The .70 BSFC we saw on the 91 RXL tested in this issue gives us a .10 lb/hphr "safety cushion".

We tested Decker's replacement stock chip, and it lowered the WOT fuel flow around 5%, and dropped the BSFC into the high .60's. This should be O.K. for guaranteed 92 octane, but "bar gas" buyers should be cautious.

Webb Performance used our dyno recently to test an RXL lean-out device they sell which includes a dash mounted switch. With the switch off, the stock fuel flow is retained. Turning the switch on lowers the fuel flow 5% by fooling the ECU into thinking the air inlet temperature is higher than it is. Like the Decker chip, Webb's switch drops the BSFC into the mid .60's.

Raymond Burkholder of Hy-Per-Star performance installed the IRS programmable ECU and harness on his stock RXL (a three hour job) With the supplied stock RXL map, the WOT horsepower was increased with a similar reduction in fuel flow.

Then, Raymond installed PSI Trailblaster pipes on the stock RXL along with PSI's battery relocation kit (a two hour job). Then, using our laptop computer we reprogrammed the ECU with PSI's Trailblaster map (a thirty second job). The problem was, the PSI Trailblasters worked too well on the stock RXL.

With an intake air temperature of 40 degrees F, and a barometric pressure of 30.5 the engine made 122 observed horsepower (118 corrected horsepower) at 9500 RPM with 76 lbs. of fuel. The resulting .63 lb/hphr BSFC didn't seem bad, but we were actually lean to the point of diminished horsepower.

Using our laptop computer, we enrichened the entire map by adjusting the ECU's "ADcomp" from the standard 1.45 to 1.85 (a fifteen second job). This resulted in the engine making 129 observed horsepower at 9250 RPM (125 CBHP) on 78 lbs of fuel (78/129=.60 BSFC). According to the laptop computer monitoring the ECU, the injectors were running wide open at 78 lb/hr. This means that as the air temperature drops, and horsepower increases, there is no additional fuel available. RXL engines with aftermarket pipes really need larger injectors to be safe in cold, dense sea level air.

While I was in Minnesota I attended a dragrace/radar run at Spicer Lake hosted by Nelson Marine. There, I met a DynoTech subscriber from Alberta, Canada, who was testing his stock RXL with SLP's new pipes and IRS ECU kit, and larger IRS injectors. He had observed Kip Campbell and I leaning out the ADcomp on Kip's new EFI RZ700, and asked us to do the same to his.

I quickly connected the laptop to his ECU, leaned out his fuel flow (he was running 105 octane gas, so we had room to play), and his performance was worse. Again connecting our laptop to his ECU, we noticed that the computer showed that the engine water temperature was 22 deg F, and the air intake temperature was 115 deg F. The two sensors had been mistakenly been reversed! Most likely, the low speed cold engine enrichment was staying on, then the engine was leaning out the top end due to the "high" intake air temperature. Correcting this, the ADcomp was returned to standard, and the RXL then ran fine.

I-500 ENGINE CERTIFICATION

The certification process has been completed with all of the 65 horsepower engines passing the test. Our next issue will deal with the testing of the four engines.

STROKER UPDATE

The owner of the engine that was detuned as a result of having its stroke increased has had a reversal of fortune. He revised the port timing by raising the cylinders with a spacer, and machined a new set of combustion chambers to compensate. The result was that on his next dyno session, the engine was better than it was originally. Data and details will be included in our next issue.

PIPE SHOOTOUT #15

1991 CARBURETED INDY 650

SLED OWNER: Kelly Sweet
Alexandria Bay, N.Y.

We installed the new Polaris "02" engine on the dyno and did our usual easy break-in cycle. For engine safety, we used 100 octane unleaded gasoline. Both the foam and tray were removed from the airbox.

With the outside air temperature in the mid 40's F, the maximum horsepower was made with 230 main jets. The "02" engine made 101.3 CBHP @8250 RPM. BSFC at maximum power was .60 lb/hphr. Installing 220 mains caused the horsepower to decrease. We allowed the engine a .10 lb/hphr safety cushion for pump gas, which required 250 main jets. The air/ fuel ratio with the stock pipe was around 12-1.

Installing triple pipes on the engine allowed the engine to make maximum horsepower with BSFC in the low .50 lb/hphr range. Again, we allowed a .10 lb/hpr cushion, with .60 being the safe number. It took a mid to high 12-1 air/fuel ratio to accomplish this with the aftermarket pipes.

From these test results, it's obvious that all Polaris has to do to get back into the fray of the "horsepower wars" is to stamp out a nice set of their own quiet triple pipes. How about an RXL-X?

Unfortunately, at test time the we didn't have our new Starting Line Products 650 pipes. Like the new DG pipes, they have a three into one collector, using individual glass pack silencers which connect into one single pipe outlet. Both the DG and SLP pipes apparently clear the battery box when installed on the RXL.

We'll be doing the modified "02" pipe shootout shortly, and will include the SLP pipes in that test. We'll also test the welded section, silenced HTG pipes that we tried on the full mod "02" engine in V2 #6. When we have the opportunity, we'll try the new SLP pipes on another stock "02" engine.

STOCK POLARIS INDY 650
250MJ-Q2nj-STOCK PIPE

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.17

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7250	62.6	86.4	70.3	180.1	11.8	.80	44
7500	64.2	91.7	70.3	186.7	12.2	.75	45
7750	64.7	95.5	70.9	185.0	12.0	.73	45
8000	63.9	97.3	70.4	186.6	12.2	.71	45
8250	61.6	96.8	68.9	185.4	12.4	.70	45
8500	58.5	94.7	70.0	186.8	12.3	.73	46
8750	53.9	89.8	69.8	185.1	12.2	.76	45

STOCK POLARIS INDY 650
250MJ-Q2 nj-DRE PIPES-92dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.16

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	62.0	79.7	53.0	182.3	15.8	.65	48
7000	65.0	86.6	60.2	195.8	14.9	.68	47
7250	67.1	92.6	66.3	199.4	13.8	.70	48
7500	67.3	96.1	68.3	202.0	13.6	.70	47
7750	68.3	100.8	70.1	200.4	13.1	.68	46
8000	69.4	105.7	70.8	199.1	12.9	.66	46
8250	69.8	109.6	70.7	197.4	12.8	.63	47
8500	69.1	111.8	71.3	198.6	12.8	.62	45
8750	69.1	115.1	71.7	198.6	12.7	.61	47
9000	69.5	119.1	72.5	200.4	12.7	.60	47
9250	68.3	120.3	73.3	201.9	12.6	.60	47
9500	64.5	116.7	74.6	202.6	12.5	.63	47

PIPE SHOOTOUT continued

STOCK POLARIS INDY 650
250MJ-Q2 nj-AAEN PIPES-92dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.16

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7500	65.4	93.4	66.0	197.1	13.7	.70	49
7750	66.8	98.6	69.3	197.2	13.1	.69	49
8000	67.2	102.4	69.4	197.3	13.1	.67	48
8250	67.1	105.4	70.3	195.9	12.8	.66	48
8500	66.7	107.9	71.7	196.5	12.6	.65	48
8750	66.9	111.5	72.3	198.8	12.6	.64	48
9000	67.2	115.2	72.0	199.4	12.7	.62	49
9250	66.3	116.8	72.9	199.3	12.6	.61	48
9500	64.1	115.9	73.9	201.0	12.5	.63	47
9750	61.2	113.6	72.6	202.4	12.8	.63	47
10000	56.8	108.1	70.3	199.6	13.0	.64	47

STOCK POLARIS INDY 650
250MJ-Q2 nj-PSI TRAIL BLASTERS-92dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.16

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	61.3	78.8	64.0	192.2	13.8	.80	45
7000	63.5	84.6	66.9	195.7	13.4	.77	45
7250	64.0	88.3	69.7	200.8	13.2	.77	45
7500	64.2	91.7	70.4	203.2	13.3	.75	44
7750	65.3	96.4	70.4	201.6	13.1	.71	42
8000	66.9	101.9	72.0	201.4	12.8	.69	43
8250	66.9	105.1	72.5	201.7	12.8	.67	42
8500	67.1	108.6	72.9	203.8	12.8	.66	43
8750	67.4	112.3	74.4	206.1	12.7	.65	42
9000	67.6	115.8	74.2	209.6	13.0	.63	43
9250	63.5	111.8	74.5	208.9	12.9	.65	44
9500	55.5	100.4	77.1	208.0	12.4	.75	44

STOCK POLARIS INDY 650
250MJ-Q2 nj-PSI LAKE BLASTER PIPES-96dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.16

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	66.5	88.6	60.9	195.0	14.7	.68	47
7250	68.3	94.3	65.8	199.5	13.9	.69	47
7500	69.0	98.5	68.7	202.9	13.6	.68	46
7750	70.2	103.6	70.0	201.6	13.2	.66	46
8000	70.3	107.1	71.3	202.0	13.0	.65	46
8250	70.2	110.3	73.4	204.3	12.8	.65	44
8500	69.5	112.5	74.4	206.8	12.8	.65	45
8750	69.0	115.0	74.8	209.9	12.9	.64	44
9000	67.0	114.8	75.1	209.9	12.8	.64	46
9250	61.1	107.6	75.0	207.6	12.7	.68	45
9500	41.7	75.4	73.4	201.2	12.6	.95	44

STOCK POLARIS INDY 650
250MJ-Q2 nj-DG PIPES-100dB

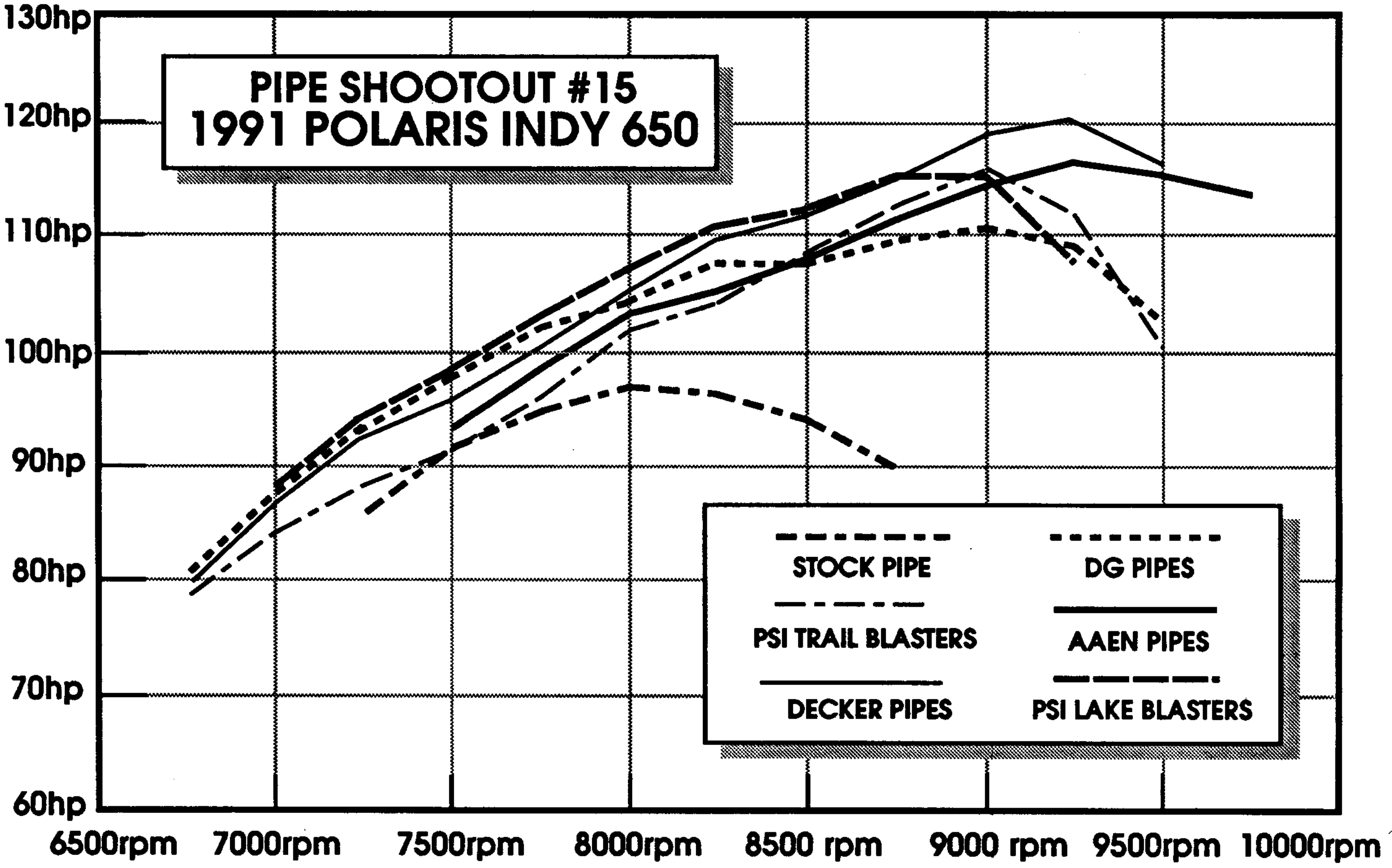
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .18
Barometer: 30.15

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	62.8	80.7	57.6	186.1	14.8	.70	47
7000	66.0	88.0	63.5	193.7	14.0	.71	47
7250	67.8	93.6	67.8	197.6	13.4	.71	48
7500	68.7	98.1	68.5	202.0	13.5	.69	49
7750	69.4	102.4	71.0	201.2	13.0	.68	48
8000	68.9	105.0	72.6	201.9	12.8	.68	47
8250	68.3	107.3	73.3	201.8	12.6	.67	48
8500	66.8	108.1	73.6	203.9	12.7	.67	46
8750	65.4	109.0	73.0	205.8	12.9	.66	46
9000	64.4	110.4	73.0	205.0	12.9	.65	48
9250	61.6	108.5	73.6	204.7	12.8	.67	48
9500	56.9	102.9	73.5	206.3	12.9	.70	46

It's interesting to compare the results of this test with our first Polaris 650 pipe shootouts.

In Vol 1 #3, we did pipe shootouts on both a stock and modified "01" (1989) engine. With the triple pipes, these new stock "02" cylinders flow more air than the "modified" "01" engine in that issue! If we had the same amount of compression as the mod "01" engine and used similar "drag" jetting, our 1991 stocker would surely have made as much horsepower as our earlier mod engine!

This test demonstrates how crucial careful and accurate monitoring of engine airflow and fuel flow is in obtaining an accurate assessment of an engine's performance.



Why does the new "02" Polaris carbureted 650 engine have such a high BSFC with the stock single pipe? This engine loses power when jetted below .60 lb/hphr, while last year's "01" carbureted engine was easily tuned for maximum horsepower with a BSFC of close to .50 lb/hphr. The carbs, combustion chambers, ignition timing, crankcase volume, and single pipe on both versions are the same; the new "02" cylinders must be the cause.

The inordinately high BSFC on the "02" engine with the stock single pipe is probably due to the relatively large size of the intake and transfer ports. The stock intake ports are large enough to accomodate the "03" engine's 46mm EFI throttle bodies. When the 38mm carbs are installed on these cylinders, there is a 4mm step behind the rubber carb flanges. The transfer volume is also very large.

These factors probably combine to lower intake air velocity enough to reduce vaporization of the fuel. More of the fuel travels through the engine in the form of large droplets, crawling along the interior engine surfaces. These droplets sneak through the engine unburned, though counted by the watchful flowmeter on the dyno. The lower flowing, but higher velocity ports in the "01" cylinders, enable more of the fuel to become, and more importantly, to stay vaporized.

All of this happens with the stock single pipe, which makes peak horsepower at 8000 RPM, with 185 SCFM of air. As soon as we install good triple aftermarket pipes, the engine seems to come alive. Air velocity increases about 10%, fuel vaporization is more complete, and BSFC is lowered.

VOLATILE SPIRITS

KEVIN CAMERON

THE CELLAR DWELLER

Gasoline is not a pure substance as are water or methanol, but is a mixture of hundreds of hydrocarbon molecules. Indeed, it would be hard to define gasoline in any precise way, except to say that it consists of petrolem hydrocarbons whose boiling points lie within a certain range-- something like 85 deg. F to 400 deg. F. Specific gravities of gasoline vary considerably also, with aviation fuels sometimes being as light as .680 and other gasolines being as heavy as .750.

REFINERY METHODS

So-called straight run gasolines are those simply distilled out of crude oil. To increase yields of gasoline, methods were found to break down, or "crack" heavier molecules into the lighter ones that are gasoline. At first, high temperatures were used--thermal cracking. Later, catalytic methods allowed reaction temperatures to be reduced--"cat-cracking". Cat cracking produces stable gasolines containing many knock-resistant branched chain hydrocarbons. In catalytic reforming, first used around 1940, molecular structures are altered to more knock-resistant types. Polymer gasolines are made by joining lighter molecules.

HYDROCARBON FAMILIES

There are several families of fuel hydrocarbons. The paraffinics take the form either of straight chains of single-bonded carbons with their attendant hydrogens attached, or can exist as branched chains. Within a given chemical formula, the same number of carbons and hydrogens may be assembled in many different ways. The aromatics are ring compounds, in which six carbon atoms form a ring. Benzene, toluene, and xylene are important aromatics. High percentages of benzene can cause rough running. Its high combustion speed leads to a rapid rate of combustion chamber pressure rise. Benzene is associated with an unpleasant exhaust odor. Olefins resemble the paraffins except that they include one or more unstable double carbon bonds. The instability of olefins is responsible for the deterioration of some gasolines in storage--the phenomenon of "stale" gas. Napthenes are in effect paraffins assembled in ring structures.

DETONATION AND FUEL RESEARCH

The need to understand the phenomenon of detonation, or engine knock, led early on to intensive fuel research. The efficiency and power of piston engines rise with compression ratio, but at some point abnormal combustion, in the form of knock, appears. Compression ratio cannot be raised further without the risk of engine damage. Better fuels do not give more energy per pound; they simply resist knock better, allowing a higher compression ratio to be used. The extra power potentially available from high-octane fuels results from their ability to run at a high compression ratio (or at high supercharge pressure).

ANTI-KNOCK RATINGS

The anti-knock quality of fuels is rated on the octane scale. An excellent engine fuel is iso-octane, and its anti-knock level is arbitrarily set to 100. Normal heptane, a very pro-knock fuel, is given the value of zero. To rate a fuel sample, it is run on a special test engine whose compression ratio can be varied as it runs. Operating under specified conditions of load, RPM, inlet temperature etc., the test engine's compression ratio is raised until detonation just begins. The ratio is noted. Next, various mixtures of iso-octane and n-heptane are run in the engine, until a mix that just detonates at that ratio is found. If, for example, that mixture is 72% iso-octane, 28% n-heptane, the fuel is rated 72 octane. Running in a fuel test engine is the only way to determine octane rating--there is no chemical analysis.

For motor vehicle gasolines, two rating schemes are used--the Research and Motor methods. The research method is the less severe, using 125 deg F. intake temperature, 600 RPM, and 13 degree spark lead. The Motor method uses a 300 deg. F intake temperature, 900 RPM, and 19-26 degree ignition lead. What you see on the gas pump is the average of the two, (R+M)/2. The octane ratings of some fuel types are temperature sensitive; the sensitivity is defined as M-R. Paraffinic fuels have near-zero sensitivity, while cracked fuels have positive numbers.

In general, the aromatics have the best overall anti-

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THECELLAR DWELLER

KEVIN CAMERON

knock properties, napthenes and olefins are middling, and straight-chain olefins have the worst. Of course, certain branched-chain paraffins–notably iso-octane and triptane–have outstanding antiknock ratings. Chemically, knock is thought to result from thermal breakdown of some fuel molecules in the unburned fuel after normal combustion has started. This thermal breakdown results from a rise in temperature and pressure as more and more of the charge is consumed. When enough unstable fragments have accumulated, the last part of the fuel/air charge ignites before the flame front reaches it, and at supersonic speed, delivering a violent impact against the interior of the combustion chamber. You hear this impact as engine knock. In this model, it is easy to see that straight chain molecules would be most easily broken by thermal vibration, while branched-chain and ring structures would be more durable.

FUEL VOLATILITY

Another important quality in fuel is its volatility. A pure substance like water has a definite boiling point, but the constituents of the mixtures we call gasoline boil across a wide range. As the temperature of a liquid sample is raised, the most volatile part burns off first, and so on.

The simplest measure of fuel volatility is the Reid Vapor Pressure, which is the measure of potential evaporation loss at 100 deg. F.

Using special distillation apparatus, a complete distillation curve can be obtained for any fuel sample. Such a curve relates temperature to the percentage of fuel boiled away at that temperature.

To make engines start in cold weather, the so-called "front-end" of a gasoline's distillation curve, or first 10% to evaporate, is made extremely volatile–often by dissolving fuel gases like butane or iso-pentane in it. The presence of such fuel gases is why stored fuels must be stored in sealed containers. Otherwise, the volatile front-end of the fuel may evaporate, making what remains in the drum mysteriously unable to start cold engines.

LATENT HEAT OF VAPORIZATION

Another fuel property is latent heat of vaporization–the amount of heat energy it takes to vaporize one gram of fuel. In general, pump gasolines have low latent heats, aromatics have latent heats about 20% higher, and alcohols have very high latent heats, 2-3 times higher than pump gasolines. A high latent heat can keep a fuel from evaporating completely during the intake process, especially in engines that turn very fast or have especially cool intake systems. High latent heat fuel can be useful in an engine with a heat problem.

COLD STARTING

When you flip the choke on, the carburetors deliver a 1:1 fuel/air mixture instead of the normal 12-14:1. Only a small fraction of the fuel delivered during cold-starting actually evaporates; this is the front-end of the fuel. The part that does evaporate forms a combustible mixture, and the engine fires and runs. As the cylinders and intake system warm up, they begin to evaporate the heavier reactions of the fuel, and the actual evaporated mixture enriches. Now the choke must be gradually turned off, until the engine is warm enough to evaporate all the fuel, all the time. All the sputtering and refusing to accept throttle is just the mixture, falling back to being too lean to burn because not all of it is evaporating yet.

ANTI-KNOCK RATINGS AND THE REAL WORLD

Octane ratings are determined with the test engine running at constant speed, using a steam-heated intake system that evaporates 100% of the fuel delivered. Real life isn't like that; the throttle is constantly moving, the engine is accelerating and decelerating, and the load is changing. In the auto industry, another rating system, called road octane, is sometimes used to take account of this. It uses a specified cycle of road driving.

Why should throttle position, load, and engine acceleration affect matters? During idle and low throttle running, fuel has to pass between the throttle and carb bore, and in squeezing through this tiny space it gets well atomized, and the intake system evaporates almost all of the fuel before it reaches the cylinders. Once the throttle opens, however, a heavy stream of fuel pours from the jets. Part of this evaporates immediately (the front-end and low boiling fractions), but much of it remains in liquid form–either as air-entrained droplets of various sizes, or as a wet coating, slowly washing along the walls of the intake system, crankcase, and transfer ports.

What does this mean? It means that, during a sudden throttle opening, it will be the low boiling parts of the fuel that win the race to the combustion chambers, while the "heavy ends", the less volatile parts of the fuel, will be delayed as they creep along the walls, or as heavy fuel droplets fail to make the many

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THE CELLAR DWELLER

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turns on the way, and smash onto the walls as well. And what if the front-end of the fuel doesn't have as good an octane rating as the rest of the fuel? During the instant that the cylinders are receiving mainly the volatile fractions, and the heavy stuff hasn't caught up, your engine may very well detonate briefly. Any detonation, even intermittent, can raise engine temperature and, in time, cause parts damage.

If you are using a leaded racing gasoline, the situation can be worse yet, for tetraethyl lead does not evaporate easily. This puts it with the heavy ends, not with the volatile front-end. A sudden throttle opening, therefore, tends to leave the lead behind for an instant. And so it is. During dyno testing, an engine is shown to make power at such-and-such a main jet. Now the owner tries to run that jet out in the real world; his engine is snappy and responsive--until it sticks solid. Shucks. Call it "octane lag".

A more volatile anti-knock additive which exists--tetramethyl lead--originated in 1960. Sometimes used in no-lead gasolines in small quantities is MMT--methyl cyclopentadienyl manganese tricarbonyl. Each has its uses.

CALMING DYNO FEAR

Because of the imperfect correspondence between dyno and field test results, some tuners and engine builders distrust dynanometer testing. If some of the fuel based reasons for the differences are understood, such distrust has no reason to exist at all.

DEVELOPMENT OF FUELS

Most of today's knowledge of fuel chemistry dates back to the intensive research that accompanied the development of aircraft engines for and during World War II. Individual pure fuel hydrocarbons were prepared and anti-knock tested in a search or easily synthesized materials that could be blended with ordinary refinery gasolines, plus lead, to yield maximum quantities of 100 octane aviation fuels. At that time, triptane was identified as a nearly ideal aircraft fuel. Using triptane plus lead, aircraft engines could be supercharged to a level that delivered 300% of the horsepower possible on pure iso-octane. The problem was, triptane is not cheap to make, while there are several processes for producing iso-octane. Octane was produced by a synthesis process called alkylation, so mixtures of octanes (there are four structures with high anti-knock ratings) are called alkylates.

Aviation fuels therefore consisted of high-grade refinery gasolines, plus alkylate, plus lead, plus certain amounts of aromatic hydrocarbons that were (a) available because they were by-products of explosives manufacture and (b) of high anti-knock rating.

THE NO LEAD WORLD

All this changed when lead was found to poison catalytic converters, and to cause intelligence loss to young children frequently exposed to exhaust fumes. At first, the move to low-lead or no-lead fuels caused a terrible drop in octane numbers of pump fuels. Since then, fuel chemistry has found ways to creep back up somewhat in anti-knock ratings--but at a price. Now more aromatics must be used--chiefly heavy loads of toluene (benzene and xylene are more strongly carcinogenic). Toluene was, in former times, used as an octane booster when used in serious amounts such as 10-20%. Now this is routine in pump gasolines. Alkylates are used as well. Further, alcohols, which have high anti-knock ratings, are added. These are supposed to be used at levels of 5% or less, but sometimes the blender "slips" a little. Alcohols are valuable in hot-running engines because the heat they absorb in evaporating pulls the intake temperature down, thereby reducing combustion temperature and suppressing detonation.

RACING GASOLINES

Racing gasolines are supposed to be more consistent than what you get at the pump, but that doesn't mean they are all the same. Race gas blenders have agreed to add no more than 4.3 grams of tetraethyl lead to each gallon of product, but in the war, up to six grams were found useful. Some blenders start with av-gas as a base, and add aromatics to it. Such a fuel may not evaporate as easily as fuels based on cat-cracked stock and dosed with alkylates. Some use large doses of alcohol for its refrigerant effect. In line with pump gas blending, some racing use is being made of MTBE (a powerful smelling ether, but not the one used as an anesthetic). This stuff acts like alcohol in that it has oxygen in it and has a good anti-knock rating, but does not have the affinity for water that the alcohols do. Gases with alcohol, if they absorb enough water from the atmosphere or from contaminated tanks, will separate.

What does all this mean to the gasoline user? Because there are significant differences in the way gasolines perform, it's wise to be prepared for these differences.

Engines need to receive a fully evaporated fuel-air

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THECELLAR DWELLER

KEVIN CAMERON

mixture. Any fuel present in the combustion chamber as large droplets, or on the chamber walls, will not properly participate in combustion. To compensate for this, you have to enrich the carburetor's mixture so that what does evaporate forms a correct mixture. The extra fuel that doesn't burn simply absorbs heat from combustion, reducing power output somewhat. It may also result in a smokier-than-usual exhaust.

Because breakup of the carburetor's fuel stream depends on intake velocity and turbulence, you can in general expect better mixing from smaller carburetors. As a carburetor is made bigger, the percentage of fuel passing through the engine unburned as large droplets tends to increase. Because fuel evaporation also depends on intake temperature, extra-big carburetors are also extra-touchy about weather changes. The mixture was OK at -5 degrees, but then it warms up to 25 degrees. This will cause some of the previously unevaporated fuel to evaporate, making your engine very rich--more so than you'd expect just based on air density.

SPECIFIC GRAVITY

If you always use pump gasoline, or use only one brand and type of racing gasoline, specific gravity isn't important to you, but if you plan to test several fuels, it's desirable to know their specific gravities. Any lab supply company can supply you with a specific gravity float and a graduated cylinder in which to make the measurement of fuel S.G. Even though all hydrocarbon fuels contain close to the same energy per pound, there are light and heavy gasolines. Switching from one to another will require jetting changes. A light gasoline at .680 S.G. will require bigger jets than a heavy gas at .750 S.G.--in rough proportion to the specific gravity difference.

VOLATILITY PROBLEMS

Any fuel containing hard to evaporate fractions may not evaporate completely in your engine. This may occur because your engine has a very cold air intake system, turns very high RPM, or has very poor fuel droplet breakup owing to oversized carburetors, etc. It may also occur at very low temperatures. In particular, fuels containing alcohols require a lot of energy to evaporate. If high RPM is the factor, your engine may lose some power at peak revs, which it would not lose running on an easier-to-evaporate fuel. Some fuel blenders recommend alcohol-containing racing gasolines automatically for any two-stroke--probably because the outboards they are familiar with turn what snowmobilers would consider low RPM. Outboards have large pistons that may need the extra cooling afforded by fuels containing alcohols. Therefore, don't automatically accept such a recommendation; test for yourself.

Some users have had trouble using aviation fuels. Be sure in advance that the oil you plan to mix will dissolve completely. Occasionally, a particular oil won't dissolve in av-gas, but leaves a few oily blobs in the bottom of the can which wait to jump straight onto your sparkplugs and foul them.

A sluggishly evaporating fuel may appear to run well in your engine when the air temperature is high. As the weather cools, you naturally expect to have to richen up (see the temperature chart supplied by your sled's maker), but if at the same time, some of your sled's fuel is not evaporating, it will make this effect stronger than it should be. If you find you have to enrich more than the temperature chart calls for, the fuel may be a problem. Don't be surprised if a more volatile, or lower latent heat fuel improves this situation.

It can also happen that a high-octane but hard to evaporate fuel may produce more detonation in a given engine than a lower octane but easier to evaporate fuel does. In such a case what is happening is this: on the first fuel, the engine leans out as it revs up, and there is less time available for full evaporation. Therefore the engine detonates because its true, evaporated mixture strength is too lean. On the second fuel, the necessary true mixture strength is maintained across the rev range, so the engine doesn't detonate.

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