Two Examples of Dexter's AeroTech RMS Hybrid Revival Static Tests

6/30/2026 – McDonald Ranch Static Site

A long anticipated static test of two versions of the Revival *AeroTech* RMS Hybrid motor was finally conducted on June 30th 2026. The first motor version was the standard 54/1280 configuration based on Patrick Carroll's work (named Silver for the purposes of this test). The second version was a reduced capacity configuration consisting of a 380 cc *Tuxing* oxidizer flight tank and an AeroTech 54/852 Ns combustion chamber (named Red for the purposes of this test). Fuels used were black HDPE (High Density Polyethylene) pipe for Silver and poplar wood dowel sleeves nested inside of a cardboard tube for Red. Both fuels were a first for me with these larger hybrids although I have successfully used poplar wood fuel in my micro and mini-hybrid motors for many years.

Besides firing new fuels, I was testing the functionality of some pin valve seal materials. Specifically, Silver used a standard polyurethane seal washer as supplied with the stock *Interstate Pneumatics* WRCO2-PV pin valve (right in photo). AeroTech frowns on the use of polyurethane citing combustibility potential in the presence of oxygen. On the other hand, I have had mostly good luck with these factory-provided polyurethane seals; but, started having considerable problems when replacing the factory seals with *Captain O-Ring* brand seals commonly found on the internet. These Captain O-ring seals turned out to be larger diameter compared to the originals (0.27 "compared to 0.23") and were continually being forced off their seat by the oxidizer flow thus blocking the nitrous before it could exit the valve. This required manual venting of several hundred grams of N_2O after each misfire…decidedly, not a fun activity! AeroTech ended up using PTFE washers in their certified motor pin valves. I have not had good luck with these harder washers in the Interstate pin valve due to leakage which seems to result from a small raised rim at the lip of the valve body outlet port causing poor seating. Still trying to reduce the combustibility issue, I have now turned to Viton tm washers (left two items in photo). This material is a fluro-elastomer which is non reactive with nitrous; and, so far, has provided very positive seals for nitrous in the Interstate pin valve.

I also elected to try a graphite throated rebuild of an AeroTech glass-phenolic nozzle in the Silver motor. This was rebuilt by boring a ¾" diameter well into the throat area of a used nozzle. The well was partially "blind" as a step was left at the aft end of the bored hole to support a slug of ¾" graphite rod which was cemented in place with JB Weld epoxy. Following assembly the throat was drilled to 0.450" for this test (any other diameter could be drilled as well); and then the converging and diverging cones were re-shaped with a boring bar.

Description and analysis of the static firings:

Motors:

"Red" (top in the photo below) is a compact version of the revival hybrid configured around the Tuxing 380 cc flight tank. It is paired with an AeroTech 54/852 case hoping for a "broadband" all across the "I" class spectrum motor. For this particular test I filled the tank with 250 grams of nitrous and fitted the forward closure with a 2-jet injector. The fuel grain was made of a wood sleeve that had been drilled from a length of 1 3/8" diameter poplar dowel. This sleve was epoxied into one of my specially made cardboard fuel tubes and then cut down to 6 ¾" length. The pin valve was disassembled and fit with a custom made pin designed to carry 2 Viton stacked washers (*McMaster Carr* #1170N15). The nozzle was a standard undrilled 0.313" throat AeroTech glass/phenolic hybrid nozzle.

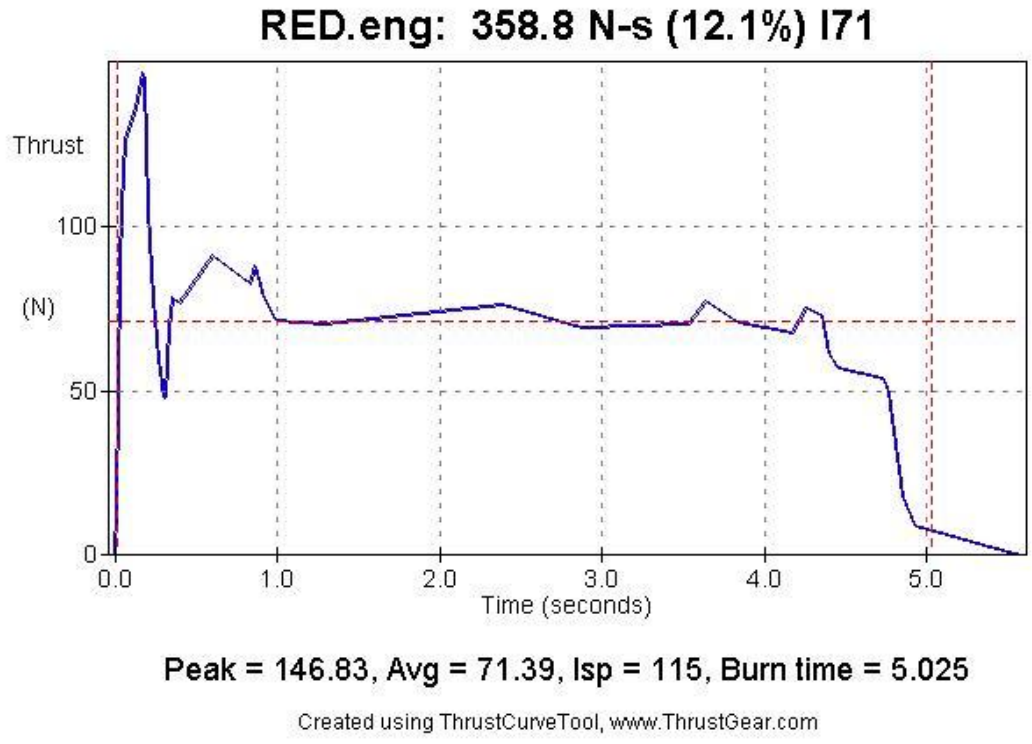
"Silver" (bottom in the photo below) is the standard 54/1280 revival hybrid configured around the *Catalina Cylinders* 440 cc flight tank using an AT 54/1280 combustuion chamber. For this test I filled the tank with 300 grams of nitrous and fitted the forward closure with a 3-jet injector. Fuel is HDPE pipe wrapped with paper to fit the liner. The pin valve is one of my standard modified Interstate Pneumatics WRCO2-PV with polyurethane seal. The rebuilt nozzle was drilled to a very conservative 0.450" throat diameter due to the poorly understood graphite nozzle behavior with these motors.

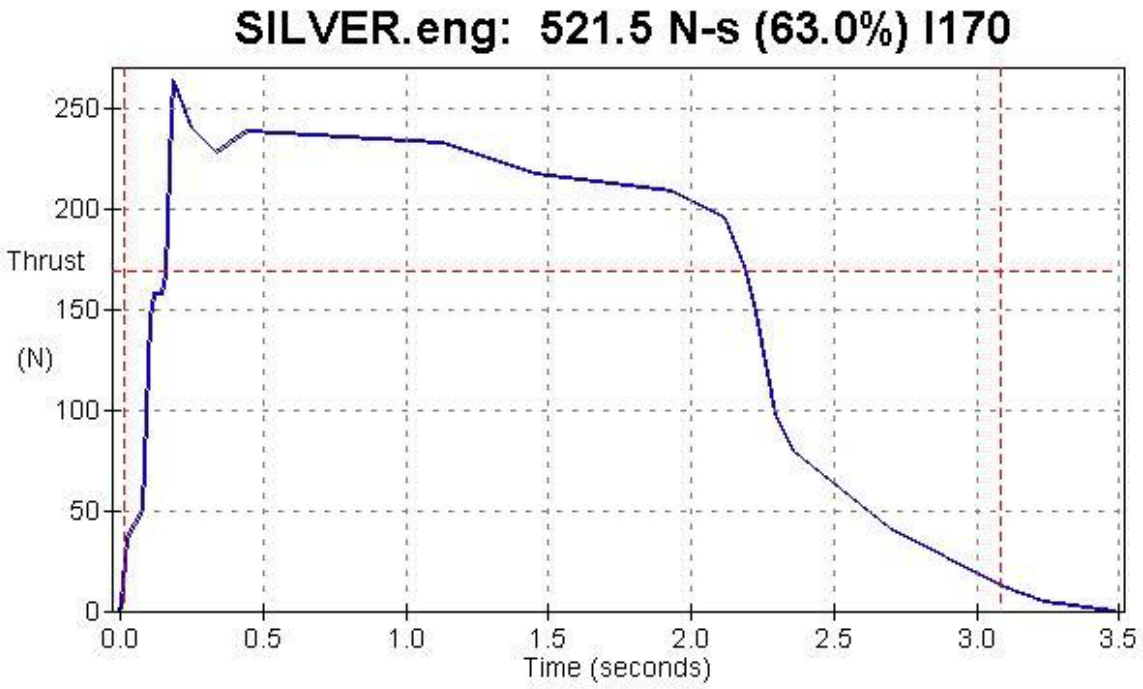
Test Location and operation:

Thanks to the generosity of Ms. Bridgett McDonald, this test was conducted at her family ranch located about 10 miles north east of Brandon Mississippi. The remote location helped insure no neighbors would be alarmed by fire, noise and smoke! After several weather related delays I was able to conduct the test on June 30th and was fortunate to be able to enlist the help of fellow rocketeer Bill Poore to help carry out the set-up, operation and tear-down of the static test stand.

My test stand (described in detail in a separate paper available from micronitrorocketry.com) was lashed in a vertical thrust-up orientation to a sturdy utility pole using ratcheted cargo straps. Upward frame movement was positivly limited by the head of a large lag bolt screwed into the pole. Data and ignition cables were strung to my pickup truck about 50 feet away which served as a "blockhouse" (photos below). Amplified data from the load cell were fed through the cable to a *Dataq* A/D converter and from there to a *Compaq* laptop running the Windaq software. A simple push button ignition system was held in one hand and a data feed start/stop button was held in the other. At about T-3 the data feed button was pressed to start the flow of data to the file and at T-0 the ignition button was pressed to start the motor. Following the test, the data were reduced and plotted using John DeMar's Thrust Curve Tool (graphs below).

Test Results:





Peak = 263.92, Avg = 169.8, Isp = 114, Burn time = 3.071

Created using ThrustCurveTool, www.ThrustGear.com

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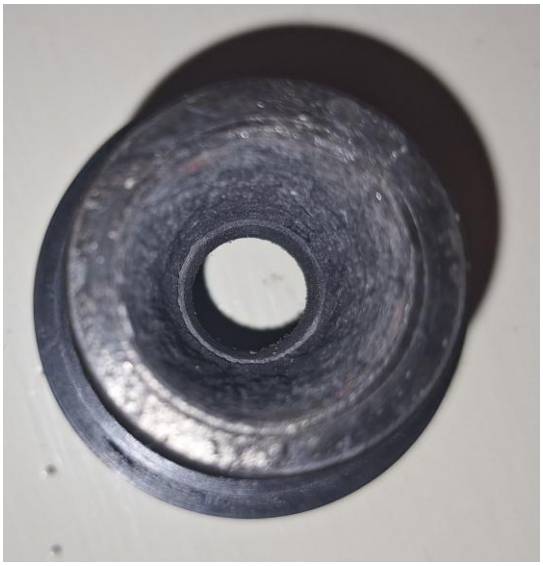
Motor disassembly:

Both motors dissassembled easily and cleanly. It should be noted that I used Krytox lubrication on all forward closure parts and the forward O-ring. Petroleum jelly lubricant was used on the forward case threads, the entire fuel grain outer surface, the entire phenolic motor liner, the rear nozzle O-ring and the rear case threads. Red motor is in the top photo, Silver in the bottom photo.

The Red motor fuel grain (photo below) started out with 46 grams of 1” drilled poplar dowel “tube” nested inside 91 grams of cardboard tube. During the burn all the poplar portion of the grain was evicerated along with an additional 22 grams of paper. The burn was very even (note: injector would be located at the right side of the photo).

The Silver motor fuel grain (photo below) started out with 94 grams of HDPE tube (1.5” ID and 0.175” wall by 8” long) fitted inside 116 grams of cardboard tube wrapped with additional kraft paper and included two short end rings of standard AT phenolic liner. Also, the forward 2” of grain space were filled with cardboard tube the same size as the HDPE. This odd configuration was forced due to slow resupply from AeroTech and cut up remants of an old AT phenolic liner tube had to be used at the forward and rear ends of the grain to maximize effective sealing. This odd grain build appears to have had no noticeable effect on the burn. In total 49 grams of HDPE burned very evenly and the flame front never worked into the cardboard/paper portion of the grain (note: injector would be located at the right side of the photo).

As mentioned above, the nozzle for the Silver motor was a re-built standard 54 mm glass/ phenolic AeroTech hybrid type. After using the original nozzle in a previous burn, I cleaned the burned core and then bored a cavity out of the throat area that was ¾" in diameter by about 0.5" long. A slug of ¾" graphite rod was cut and cemented into the bore with *JB weld* brand epoxy. After curing, the throat was re-drilled to 0.450" diameter for this test and the converging and diverging cones were re-shaped also. Note that 0.450" is a conservatively large diameter when used with a 3 jet injector. AeroTech uses a 0.375" throat with paper fuel in this configuration. This rebuilt nozzle functioned flawlessly with only 0.020" to 0.030" erosion off the throat diameter. Notice that the glass /phenolic body continues to erode away slightly so the life of the rebuilt nozzle will probably be limited to a few re-uses (photos below).



Test and motor burn summary:

Both motors, along with all test infrastructure (test stand lashed to a utility pole, load cell, amplifier, A/D converter, laptop computer running Windaq software and the 12 V ignition system), performed nominally. The Red motor started quickly and burned vigorously with modest flame and smoke. This burn yielded a peak thrust of 147 newtons and an average thrust of 71 newtons over a 5 second burn for a total impulse of 359 Ns. An unusually pronounced thrust peak was observed early in the burn, and the entire poplar portion of the grain (46 grams) was burned away along with an additional 22 grams of cardboard fuel (O/F ratio = 3.7:1 using a 2 jet injector).

The Silver motor burned very vigourously with a bright yellow flame, throaty roar and modest smoke. This yielded a peak thrust of 264 newtons and an average thrust of 170 newtons over a 3 second burn. A lower than expected total impulse of 521 Ns was delivered most likely due to the oversized nozzle throat used in this initial test. A somewhat modest peak thrust spike and an unusually short reduced thrust tail were also noted. Forty nine grams of HDPE fuel was burned away with no burn extending into the cardboard portion of the grain (O/F ratio = 6.1:1 using a 3 jet injector). It should be noted that both fuel grains were made with simple straight-through cylindrical ports; and no "turbulence step" was incorporated along the grain port al la the original AeroTech paper grains.

As far as answers to the specific test questions:

1) Poplar fuel performs well in these larger hybrids.
2) Viton pin seals are extremely effective at providing tight and leak proof seals for N_2O; but due to the softness of Viton they will likely need to be replaced after each firing.
3) HDPE fuel performs well with no problems noted. The slightly weak total impulse performance is most likely due to my using a very conservative 0.450" throat nozzle where AeroTech uses 0.375" throats for 3-jet paper grain burns. I will most likely try a 0.400" throat next time. Far more work needs to be done with this interesting fuel.
4) The stock Interstate Pneumatics polyurethane pin valve seal functioned nominally with no damage observed and no tendancy toward backfire combustion.
5) Graphite rebuilds of AeroTech nozzles worked superbly with no observable chamber pressure problems and very little throat erosion (0.020 to 0.030").

APPENDIX

Motor Specifications:

AT 54/852RMS Hybrid Revival motor (Red)

Nitrous tank and pin valve	597 grams (21.1 ounces)
Nitrous charge	254 grams (9.0 ounces)
Forward closure w/ injector plate	126 grams (4.4 ounces)
AT 54/852 motor case and rear closure	175 grams (6.2 ounces)
Other reusable parts	19 grams (0.7 ounce)

Phenolic nozzle	57 grams (2.0 ounces)
Cardboard fuel grain (outer)	91 grams (3.2 ounce)
Poplar fuel grain (inner)	46 grams (1.6 ounces)
Phenolic motor liner	46 grams (1.6 ounces)
Consumables (washers, pre-heater etc.)	30 grams (1.1 ounces)
Total motor firing weight	1440 grams (50.8 ounces)
Poplar fuel grain burned weight	46 grams (1.6 ounces)
Paper fuel grain burned weight	22 grams (0.8 ounces)
Total fuel burned	68 grams (2.4 ounces)
Oxidizer burned (some leakage which was estimated)	254 grams (9.0 ounces)
Oxidizer to fuel ratio	3.7:1
Phenolic nozzle burned weight 7/16” throat	52 grams (1.8 ounces)
Phenolic nozzle erosion loss (0.313” to 0.450”)	5 grams (0.2 ounce)
Other consumables burned	30 grams (1.1 ounces)
Motor post-burn weight	1083 grams (38.2 ounces)

AT 54/1280 RMS Hybrid Revival motor (Silver)

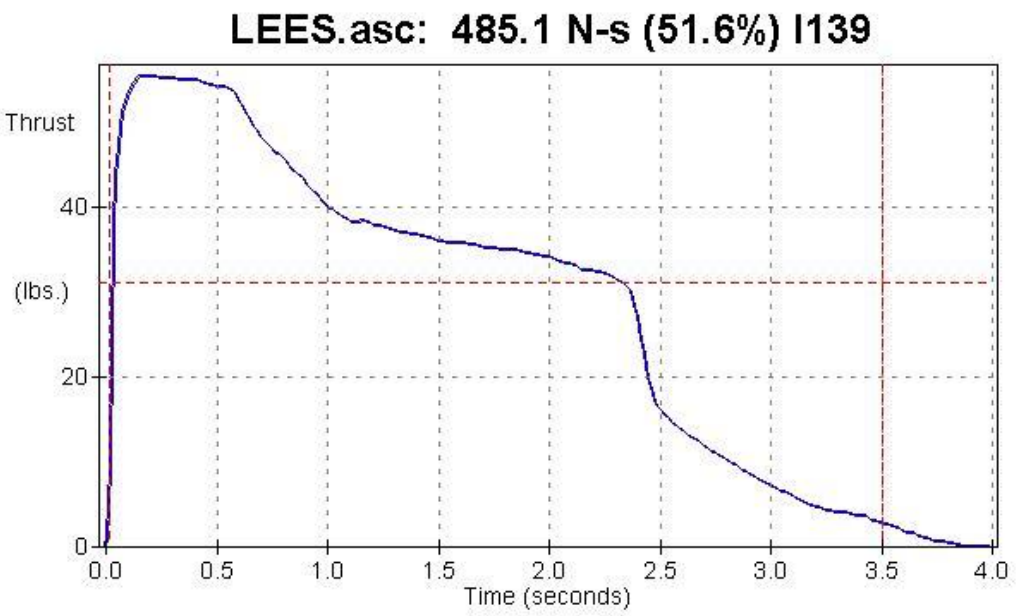
Nitrous tank and pin valve	604 grams (21.3 ounces)
Nitrous charge	308 grams (10.9 ounces)
Forward closure w/ injector plate	126 grams (4.4 ounces)
Standard AT 54/1280 motor case and rear closure	237 grams (8.4 ounces)
Other reusable parts	19 grams (0.7 ounce)
Phenolic rebuilt with graphite throat nozzle (0.450” throat)	48 grams (1.7 ounces)
HDPE fuel grain (front)	94 grams (3.3 ounce)
Combined Cardboard fuel grain, paper fill and phenolic rings	116 grams (4.1 ounces)
Phenolic motor liner (not used)	0 grams (0.0 ounces)
Consumables (washers, pre-heater etc.)	30 grams (1.1 ounces)
Total motor firing weight	1582 grams (55.8 ounces)
HDPE fuel grain burned weight	49 grams (1.7 ounces)
Paper fuel grain burned weight	0 grams (2.3 ounces)
Total fuel burned	49 grams (1.7 ounces)
Oxidizer burned	308 grams (10.9 ounces)
Oxidizer to fuel ratio	6.1:1
Phenolic nozzle burned weight 0.470” throat	48 grams (1.7 ounces)
Phenolic nozzle erosion loss (0.450” to 0.470”)	0 grams (0.0 ounce)
Other consumables burned	30 grams (1.1 ounces)
Motor post-burn weight	1199 grams (42.3 ounces)

8/21/2026 – Bill and Lisa's Gloster Static Site

Description and analysis of the static firings:

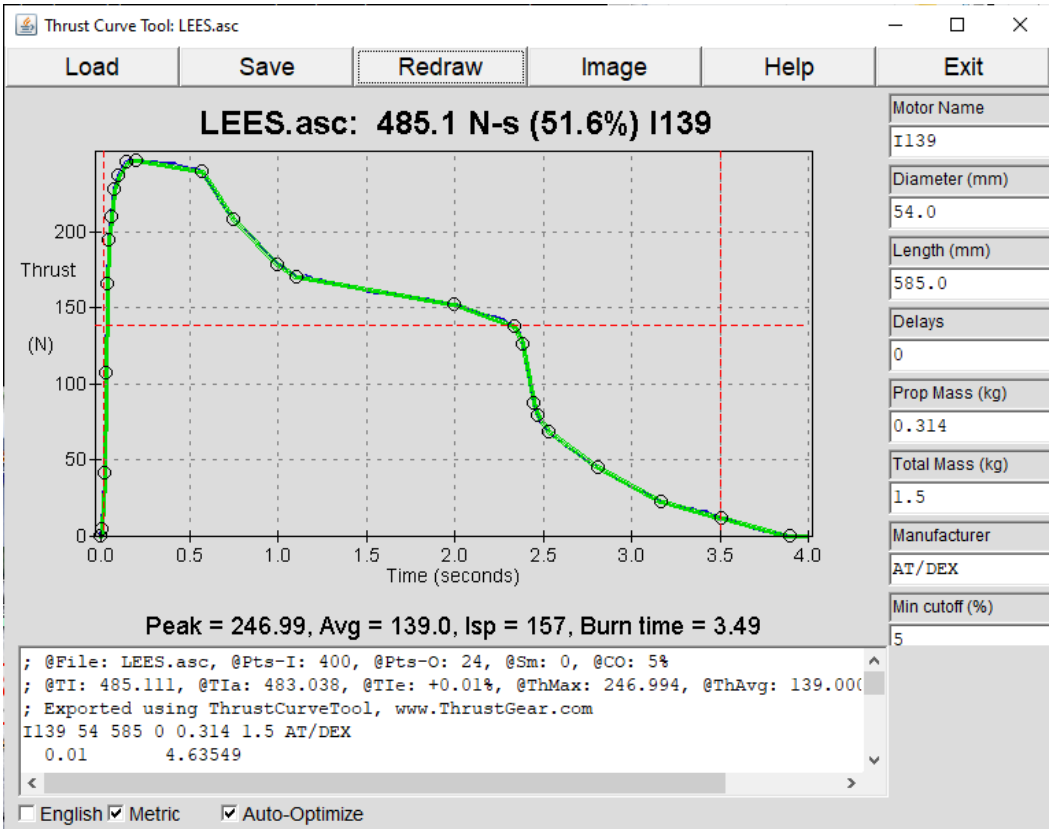
Motors:

"Lee's" is a compact version of the revival hybrid configured around the Tuxing 380 cc flight tank. It is paired with an AeroTech 54/852 case hoping for a "broadband" all across the "I" class spectrum motor. For this particular test I filled the tank with 255 grams of nitrous and fitted the forward closure with a 2-jet injector. The fuel grain was made of a wood sleeve that had been drilled to 5/8" diameter port from two 3.3" length of 1 1/2" by diameter poplar dowel. This sleeve was wrapped with paper to a slip-fit into two 5" long "Alpha" hybrid cardboard fuel tubes and then cut down to 6 ¾" length. The pin valve was a Dexter modified Interstate Pneumatics WRCO2-PV with polyurethane seal washer. The nozzle was a rebuilt AeroTech glass/phenolic hybrid nozzle with a graphite throat drilled to 0.375"



Peak = 55.529, Avg = 31.25, Burn time = 3.49

Created using ThrustCurveTool, www.ThrustGear.com



The polyurethane pin valve seal remained in excellent condition.

The graphite nozzle rebuild worked out very well. The re-drilled 0.375” throat
Eroded to 0.391” for an increase of about only 1/64” in diameter.

Cross section of the full grain following the burn. Note the generally even burn but the slightly expanded burn at the grain segement joints.

Cross section of the poplar fuel grains following the burn. Note the generally even Burn with about 0.15” thick web remaining.

Burn Summary

The motor performed very well. Ignition was crisp and the burn ran without chuff or pop for 4 seconds. Peak thrust was 247 N, average thrust was 139 N; specific impulse was 157 s and total impulse was 485 Ns or about 51% of a full "I" class motor. 255 grams of nitrous burned 59 grams of fuel for an O/F ratio of 4.3:1. The full wood grains contained 88 grams of poplar with a central port of 5/8" diameter. The burn consumed approximately 60 grams of wood. The graphite nozzle eroded from .375" to .391 or only about .016" off the diameter. This compares to the over 0.10" erosion for standard AeroTech phenolic/glass nozzles.

Suggestions: Use this fuel for a full flight! Since 32 grams of wood remained, it should be possible to enlarge the port to ¾" and still not burn into the cardboard liner. It would be interesting to add a 2" long ABS finocyl grain ahead of two 2.5" long poplar grains to hopefully add a bit of smoke. The graphite rebuilt nozzle worked well. I suggest filing the slight erosion groove with JB Weld epoxy and sanding the rear lip even with the divergent cone.

APPENDIX

Motor Specifications:

AT 54/852RMS Hybrid Revival motor (Lee's)

Nitrous tank, pin valve and FC less pre-heater (transport mode)	746 grams (26.3 ounces)
Nitrous tank and pin valve empty	599 grams (21.1 ounces)
Pin valve only ("C" body w/ PTFE + 1 Viton seal)	99 grams (3.5 ounces)
Nitrous charge	255 grams (9.0 ounces)
Forward closure "A" w/ injector plate (loaded – pre-heater)	148 grams (5.2 ounces)
Pre-heater grain only	19 grams (0.7 ounces)
AT 54/852 motor case and rear closure (completely empty)	175 grams (6.2 ounces)
Other reusable parts	35 grams (1.3 ounce)
Phenolic nozzle (rebuild 0.375" graphite throat)	49 grams (1.7 ounces)
Cardboard "Alpha" fuel grain as liner + paper wrap (6 ¾ " long)	62 grams (2.2 ounce)
Poplar fuel grain (1 ½ " OD x 5/8" ID x 6 ¾ " long)	88 grams (3.1 ounces)
Total Fuel Grain weight	150 grams (3.1 ounces)
Phenolic motor liner	46 grams (1.6 ounces)
Combustion Chamber and Forward Closure (fully loaded)	603 grams (21.2 ounces)

Total motor firing weight	1457 grams (51.4 ounces)
Total Motor post-burn weight	1119 grams (39.5 ounces)
Total Flight Tank & Pin Valve post-burn weight	598 grams (21.1 ounces)
Tot Total Combustion Chamber and FC post-burn weight	521 grams (18.4 ounces)
Forward Closure only post-burn weight	146 grams (5.1 ounces)
Combustion Chamber only post-burn weight	375 grams (13.2 ounces)
Liner and Grain combined post-burn weight	138 grams(4.9 ounces)
Total Grain (paper + wood) only post-burn weight	91 grams(3.2 ounces)
Poplar fuel only burned weight	32 grams (1.1 ounces)
Paper fuel grain burned weight	0 grams (0.0 ounces)
Total fuel burned	59 grams (1.1 ounces)
Oxidizer burned (some leakage which was estimated)	255 grams (9.0 ounces)
Oxidizer to fuel ratio	4.3:1
Phenolic nozzle burned weight 25/64” (0.391”) throat	47 grams (1.7 ounces)
Phenolic nozzle erosion loss (0.375” to 0.391”)	2 grams (0.1 ounce)
Other consumables burned	24 grams (0.8 ounces)

Fuel Grain and Various Liners Dimensions:

Pre-burn

AeroTech Phenolic Liner	L=6.9”,OD=1.98”,ID=1.85”
Alpha Cardborad Tube (x 1.32 pieces)	L=5.0”,OD=1.84”,ID=1.60”
Kraft Paper Filler Wrap	L=6.9”,OD=1.59”,ID=1.50”
Poplar Dowel (x 2 pieces)	L=3.3”,OD=1.50”,ID=0.62”
Poplar Dowel Volume Pre-burn (total)	Volume =9.6 cu inches

Post-burn

AeroTech Phenolic Liner	L=6.9”,OD=1.98”,ID=1.85”
Alpha Cardborad Tube (x 1.32 pieces)	L=5.0”,OD=1.84”,ID=1.60”
Kraft Paper Filler Wrap	L=6.9”,OD=1.59”,ID=1.50”
Poplar Dowel (x 2 pieces)	L=3.3”,OD=1.50”,ID=1.20”
Poplar Dowel Burned (x 2 pieces)	L=3.3”,OD=1.20”,ID=0.62”
Poplar Dowel Burned Web Thickness	Radius =0.30”
Poplar Dowel Wall Remaining	Radius =0.15”
Poplar Dowel Volume Burned (total)	Volume=5.5 cu inches
Poplar Dowel Volume Remain (total)	Volume=4.1 cu inches