Additional Notes to the "RMS /Hybrid 54/1280 Assembly and Operation Instruction Manual" for the Revival Hybrid

For User's of Dexter Labs Version of Patrick Carroll's Revival AeroTech RMS Hybrid Rocket Motor

These notes are provided for individuals who use Dexter Labs version of Patrick Carroll's Revival AeroTech RMS Hybrid rocket motor. The topic numbers are keyed to AeroTech's original numbering scheme. I recommend making a check mark in the appropriate place of the original manual and adding a reference to my modified topic.

Topic 2-0. Assembling the forward closure. Since the original motor hardware was shipped mostly pre-assembled, there is no mention of parts used within the forward closure. Specifically, the dash 017 O-ring and the injector plate need to be installed before use. In addition, using the Dexter style fixed-jet injector plates will necessitate frequently changing the plates out to alter the thrust characteristics of the motor. Also, it is wise to replace the O-ring with a fresh one every few months.

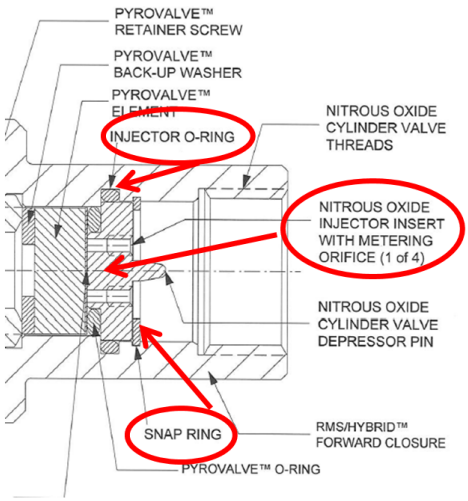

Figure 1. Detail of the top portion of the forward closure showing the injector O-ring, the injector plate and the snap ring.

About ¾" deep in the internal bore of the forward closure there are two grooves and a narrow "shelf" machined in to hold the injector plate, a sealing O-ring (lower and wider groove), and a snap ring (upper and narrower groove)(Figures 1 and 2).

Begin placing the O-ring which is a dash 017 size Buna-N type (McMaster Carr # 9452K71). Lightly coat the O-ring with Krytox or other oxygen-safe lubricant. Push the O-ring down from the top into the bore of the forward closure until it is even with the gland groove just above the plate seating shelf. Using a flashlight along with a wood stick or similar soft material, finish aligning the O-ring with the gland groove and carefully press the ring into place. Once the O-ring is in place, drop the injector plate of choice into the bore from the top opening, pin facing out. Let the plate drop into place on top of the narrow metal shelf just below the O-ring previously installed. Using the same wooden stick used to place the O-ring, press down around the circumference of the injector plate to seat it inside the O-ring and make it evenly flush against the shelf. There should now be just enough space above the injector plate to install the 11/16" stainless steel snap ring (McMaster Carr # 91580A175). thus securing the injector plate and its O-ring (Figure 2).

Figure 2. Photo of the finished installation of the O-ring, injector plate and snap ring.

Topic 1-10 through 1-17. Note that frivolous venting of N_2O is extremely wasteful and environmentally unfriendly! At around $10 per pound for nitrous, it is more economical to use a refrigerator or freezer to chill the flight tank when loading at home. Or, when travelling to a launch, you should buy a couple bags of ice to keep your flight tanks cool until motor assembly anyway; and this ice can be used to cool a flight tank for reloading in the field (Figure 3).

Figure 3. A safe and convenient way to fill a flight tank with nitrous when in the field. The flight tank is chilled with an ice bath contained in an insulated jug while the supply bottle remains at air temperature. Gently open the supply bottle open and let the needed nitrous flow in slowly. Close all valves and carefully disassemble the components in the proper order!

Topic 2-1. This applies if you have an original AeroTech injector plate with the four threaded injector ports adjusted with set screws. For Dexter's approach you will replace the entire injector plate with one containing the appropriate number of drilled jets (2, 3, 4 or 5).

Topic 2-3. The separator disk can be made by using a craft-type 5/8" circular punch to make a disk from 0.010" Teflon sheet (e.g. McMaster Carr # 8569K18).

Topic 2-4. The pyrovalve element was a custom made pressed BP disk but reasonable substitutes can be made from Estes 18mm motors cut into ¼" thick disks with some of the outer paper peeled away to achieve a 5/8" OD.

All Chapter 3 Topics. My personal recommendation is to avoid using petroleum-based lubricants anywhere near where nitrous oxide is present. For these motors that means the entire pin valve assembly and anything near or inside the forward closure and the front combustion chamber O-ring! Anything requiring lubricant in these areas I use Krytox or other oxygen safe lubricant. I use petroleum based lubricants anywhere rear of these locations so the entire liner, rear combustion chamber O-ring and rear closure threads.

Topic 3-6. Stock AeroTech paper reload grains are shown. You will make your own fuel grains from virtually any combustible material. The critical grain dimensions for the 1280 case are 1.86" OD by 10" long with a reasonable sized port inside running the length of the grain.

Topic 3-10. Since the large phenolic washer typically burns out in its center, I have had cases where the pre-heater insulator tube has dropped into the motor core during the burn (as seen in Figure 5). So recently, I have started using an aluminum washer (Figure 4) as a bulkhead inserted at the forward end of the fuel grain to serve as a positive stop for the pre-heater tube. This washer is a modified Mc Master Carr # 93286A156 that I turned down to 2" OD (note that # 93286A155 is 2" stock OD and therefore should work without modification). To use this washer requires shortening the fuel grain liner by about 0.1". This washer is reusable.

Figure 4. Aluminum washer bulkhead placed at the forward end of the fuel grain and just behind the 1.99" phenolic washer to serve as a positive retainer for the pre-heater tube.

Figure 5. A fiberglass pre-heater liner that dropped out of place and fell into the core of the fuel grain during early flight. This caused a noticeable pop in the sound of the burn but no other ill effects were noticed.

Topic 5-2. Making igniters and guides. To make igniters, I use short sections (1.25 to 1.5" long) paper soda straws with a small epoxy plug added to ne end. Drill this plug out just large enough to fit the leads of an e-match. Thread the bare ends of the e-match down and out of the straw. Fill with BP or Pyrodex and tape off the top.

To make the guide tube I use two slightly larger plastic soda straws recovered from restaurants. Slit the top of one straw for about ½" and telescope in the end of the other straw. Tape the two together and finally telescope in the end of the powder charge straw. You will ultimately epoxy this in place.

The finished length of the entire igniter and guide tube is fairly critical for easy and positive placement of the igniter in the motor. You want the finished length to be 13 3/8" long. Once you have achieved this length apply epoxy to secure the powder tube into the guide.

When you are preparing for launch you will appreciate this extra attention to detail because it is a bit difficult to align the powder charge with the hole in the pre-heater grain. It often takes repeated attempts to do this but; if you take the time to cut the igniter to the exact length you will know when you are in properly because the end of the guide tube will be exactly even with the end of the nozzle divergent cone!

Chapter 6. Misfire Procedures. AeroTech provides basic misfire information which should be followed. I have developed some added procedures that I think are useful with this particular type of pre-pressurized hybrid motor.

Topic 6-2. Always pay attention to how much nitrous should be in your flight tank. This means weighing and recording your flight tank/pin valve combo for a tare weight and also weighing the tank often after loading and until you are sure it is empty.

Topic 6-3. Assuming the motor did not fire and you have followed the AeroTech procedures to remove the rocket and motor away from the pad to a safe open area. ALWAYS FOLLOW THE GUIDANCE TO AVOID POINTING THE REAR OF THE ASSEMBLED MOTOR OR THE PIN VALVE END OF THE DISASSEMBLED FLIGHT TANK AT YOURSELF OR OTHERS NEARBY! Wear proper protective gear when working with the motor in these situations. This includes face protection, at least safety glasses, and hand protection in the form of sturdy gloves.

Topic 6-4. Always cool the flight tank first. If the motor is fully assembled put the tank end into a container of ice water for several minutes. If possible I disassemble the motor at the top end of the case first. This leaves the forward closure, pin valve and flight tank assembled. If you must view into the pre heater/pyrovalve chamber, try using a flashlight and mirror.

Topic 6-5. Next try unscrewing the forward closure from the pin valve. Pay attention that the closure is coming loose and not the pin valve. If you get a small burst of nitrous gas when the closure comes off the end of the pin valve, you can be pretty sure the pin valve is okay and whole pyrovalve assembly did not burn and you can proceed to disassemble that component. Prepare for the slight possibility that the pin valve seal will fail during the removal of the forward closure which could send the closure flying!

Topic 6-6. If you get no burst of nitrous gas you may have larger problems to deal with. Use a mirror and flashlight or, less desirable, run your bare fingertip over the end of the pin valve while keeping the motor pointed away. If the pin feels depressed into the valve body and not even with the end of the end of the valve body as it should be; you could have a situation where the pin valve seal has slipped off the pin and is now jammed into the port and blocking flow of the nitrous. Yes, this very event has happened to me. You now must slowly unscrew the pin valve from the flight tank. Again with full protective gear and a heavy duty moving type blanket, use a wrench to break the pin valve loose from the tank then slowly unscrew the valve body until you hear nitrous venting.

Topic 6-7. There are plenty of threads left so do not worry about the valve blowing off the end of tank. Leave the tank covered with the tarp until all sounds of venting have stopped. The tank will now be very cold so use caution as you continue to slowly unscrew the pin valve completely.

APPENDIX

On the third page of the **RMS /Hybrid 54/1280 Assembly and Operation Instruction Manual** appears the following warning:

- **DO NOT USE ORDINARY "PAINTBALL" CYLINDERS AND VALVES IN THE RMS/HYBRID™ MOTOR SYSTEM.** Commonly-available "paintball" cylinders are designed for use with carbon dioxide (CO_2) and are **not** suitable for use with N_2O. Cylinders intended for N_2O service must be "oxygen clean" to prevent ignition of contaminants. "Paintball" cylinder valves use combustible valve sealing components which have been shown to ignite in the presence of flowing liquid N_2O, and are not able to deliver sufficient quantities of N_2O into the combustion chamber to produce designed motor thrust levels.

Since this warning applies to what we are doing using the Interstate Pneumatics WRCO2-PV and certain other components in the revival of the stock motor, we have addressed these concerns as much as possible. Here is what we have done to date:

Cylinders – while the *Catalina Cylinders* product we are recommending here is currently marketed for CO_2 use, it is actually the very same cylinder AeroTech supplied with their Tripoli certified production motor. Just be sure to follow oxygen safe cleaning procedures outlined in the Quick Start Guide.

Paintball Cylinder Valves – the valve seal provided with the Interstate Pneumatics pin valve is made of polyurethane and while it has been shown to be prone to combustion when oxidized with nitrous, it has flown successfully numerous times in these revival hybrids. Another problem with these seals is suitable replacements are not easily available from the distributor. Given these two problems, we are currently investigating the feasibility of using Viton washers for the seals. This should solve both of the above listed problems. Please remain on the lookout for updated procedure documents.

As far as the mentioned low flow of nitrous in the paintball pin valves, during the modification process we have enlarged all ports to match AeroTech specifications and the size of the delivery passages are now identical to the AeroTech original.