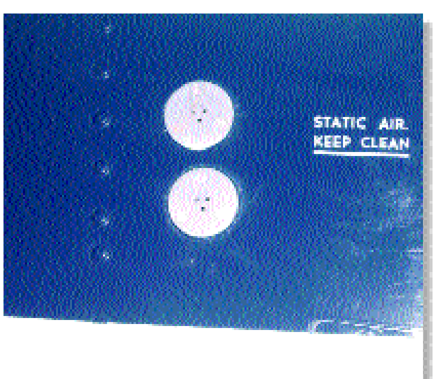
PITOT-STATIC ATTACK

BY BRAD PRIMM

The task of keeping the air-data accurate on-board general aviation aircraft has largely fallen upon the shoulders of the avionics shop. It is a duty that cannot be taken lightly. Every two years, or even more frequently for RVSM equipped airplanes, the aircraft pitot-static systems are assaulted with a variety of test equipment, needles, fixtures, hoses and vacuum/pressure pumps. The following discussion is not going to include detailed instructions for testing the altimeters or air data computers themselves but rather this will be a general overview of SAFE altimeter system testing in the aircraft.

New RVSM tester on left, old reliable on the right.

One of my biggest fears as a practicing avionics technician with altimeter testing responsibility has been the fear of someone tripping over a hose while an altimeter system test was underway. You need to be neat in your setup and not leave hoses in walkways or other areas that might invite someone to step on or trip over them. Routing the hoses under the aircraft belly as much as practicable will help prevent all but the shortest midgets from tripping.

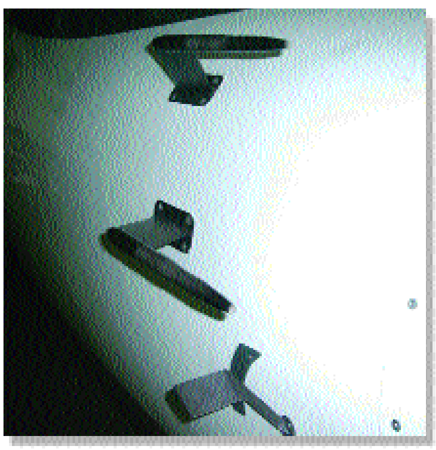


Conventional static ports, affectionately known as Pepper Ports.

Another one of my recurring nightmares has been the fear of not removing all of the tape and tape residue used to seal off alternate or duplicate static ports and drains after the testing is completed. I kept florescent colored tape streamers in the pitot-static hose kit box and hung them from each port that was sealed off. The streamers made sure that I did not forget to remove the tape from any port. Another good practice is to make a separate item on the work order that says, “Remove all tape, tape residue and/or test equipment from the aircraft after Pitot-Static tests are completed.” This item will then get a separate sign-off and prompt the inspector to do that last walk-around to ensure all is back to normal.

The requirement to test altimetry in general aviation aircraft stems from the FAR 91.411 regulations. In that regulation, an owner/operator of an aircraft is required to test the altimeters, static systems, air data computers, and integrated pressure altitude reporting system every two years if the aircraft is to operate under instrument flight rules (IFR). There are no rules in the FARs specifically requiring the periodic check of the pitot systems or airspeed indicators unless of course, the aircraft is equipped with an air-data computer. Any periodic requirements for testing pitot lines and airspeed indicators stem from the maintenance manual inspection requirements of the airframe manufacturer. The requirement for RVSM testing is going to come from FAR 91.180 and Appendix G of that same Part. The shorter testing intervals and tighter tolerances of RVSM aircraft stem from the approved maintenance programs developed for the RVSM approved aircraft.

There are two primary ways to perform altimeter checks. In the past, it was normal to remove the altimeters and send them to an instrument shop. After receipt of the certified altimeters from the instrument shop, the system was leak checked and the inspection was signed off. In recent years, the testing of the altimeters and encoders while still installed in the aircraft has become the norm. This can be tricky since many older aircraft come from the days when this was not the common practice and there may not be instructions in the maintenance manual for the step-by-step performance of these checks. Common sense and experience must prevail to ensure that a cabin pressure gage or hidden airspeed sensor is not damaged or backpressured while performing the checks required.



Both pitot tubes contain two static ports. Another pitot tube with dual static ports is on the pilot's side as well.

Close up of combined pitot-static tube

Advisory Circular 43-203B should be required reading for any technician performing in-aircraft static tests. The following excerpt from paragraph 9.a. hits the nail on the head: "Before any static system is tested, it should be determined that the design limits of instruments attached to it will not be exceeded during test. To determine this, it is necessary to locate and identify all instruments attached to the system. In addition to the altimeter, airspeed, and rate of climb, many airplanes use static pressure for the operation of autopilots, flight recorders, air data computers, altitude reporting digitizers, etc. The use of a static system diagram of the airplane involved may be helpful *(definitely!)* in locating all of the instruments. If a diagram is not available, the instruments can be located by tracing the physical installation." Even though this advisory circular was written in 1979, it is more relevant now than ever before.

Section 9.b. of the Advisory Circular talks about the damage that can be done to instruments that are connected to both the pitot and static systems when only one system is evacuated. This can cause the differential pressure design limits of such instruments to be exceeded. As the Circular says, if you tie both the pitot and static systems together, then you will have zero differential pressure regardless of the amount of static system evacuation. In complex aircraft with dual pitot and static systems, there is always the worry that an aftermarket air data device may be connected to the pilot's pitot and the copilot's static. In this case, you would backpressure or exceed the device limits even if you tie the pilot's pitot and static together since the copilot's side

The static hose kit suitcase provides a convenient way to wheel out the tester for the attack.

will still be at ambient pressure. Normally, I always try to run both sides up together because then it doesn't matter if such a cross connection exists.

Since Advisory Circular 43-203B was written in 1979, it does not contain any guidance for the certification of RVSM equipped aircraft. The best place to find general FAA guidance on RVSM maintenance requirements is www1.faa.gov/ats/ato/rvsm1.htm. The website has the latest FAQ's and FAA orders referencing RVSM including document 91-RVSM, Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations. This document refers to generalities of design and defers all testing details to the approved maintenance program for the RVSM approved aircraft.

More and more of these approved maintenance programs are now requiring that aircraft testing be performed with all pitot tubes and static ports tied

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together during test. In fact, many RVSM test kits come with extra hoses instead of blanking adaptors so all of the pitot-statics can be tested together. Dassault and Airbus are two manufacturers that are now writing their programs with this as a requirement. I suspect the reason for this is to more closely simulate in-flight conditions and to allow a comparison between both altimeter systems. Another trend in the RVSM area is to forbid the use of needles, putty and stretchy hoses over the pitot tubes. I am sure the fear is that residue or contamination from these previously accepted practices could contribute to RVSM altimetry error budgets.

Whenever possible, follow the maintenance instructions listed in the airframe manual. Most newer aircraft maintenance manuals have detailed instructions on the performance of the tests in the aircraft. If you are an independent avionics shop and do not have access to a complete airframe library, ask for the instructions from the aircraft operator or the aircraft manufacturer.

A practice that I have found helpful is to compile a book of pitot-static test information. This book gathers together all of the information that is typically collected as you test various aircraft. Bear in mind that a book such as this must be considered "For Reference Only" and the information contained therein should be supplanted by current maintenance information from an FAA approved source. In my book, we have printed out all of the relevant FARs, Advisory Circulars, ADs, etc. that pertain to pitot-static, transponder and altimetry equipment. In addition, this three ring binder has a tab for each aircraft type that we test and behind these tabs are the piping diagrams and latest airframe test procedures. We also keep the latest information on the various Air Data testing procedures such as Honeywell's Technical newsletter 23-1980-04 and Collins' Service Information Letters such as ADC-86( )/850( ). The book also has all of the related Repair Station forms for recording the results of the testing.

In addition to the book, we keep all of our hoses, AN fittings, putty, fluorescent streamers, tape, etc. in a fiberglass suitcase that is equipped with wheels and a telescoping handle. This makes it easy to wheel out the Barfield test set together with the hose case. Remember, time is money and anything to make the operation more efficient will be appreciated by your customers.

Once out at the aircraft, the setup begins. After reviewing testing information and piping diagrams, the appropriate test adapters are fitted to the aircraft, opposite ports are taped off and the hoses are connected. Fluorescent streamers are attached to wherever tape is applied to block a static port. The Advisory Circular recommends that the connections be made directly to the static ports if possible. It does allow for the connection to a static system drain or tee connection with the static ports sealed off if direct connection to the ports is impractical. Such an alternate connection must be made where the system integrity can easily be checked after the test is completed and the system is returned to normal.

With the test set sitting on a cockpit seat, it is a necessity to proceed cautiously. If you begin introducing vacuum and do not see the immediate results you expect, STOP! Recheck your setup. Once you are sure everything is fine and you see the appropriate EFIS response or altimeter needle movement, it is OK to move ahead.

It is desirable to keep a little bit of airspeed showing on the airspeed indicator while running a pitot-static system "up." This assures me that the airspeed is not back-pressured. This is typically done by closing the crossover valve slowly while the altimeter is climbing until some airspeed is indicated. On fancier test sets such as the DSP-400, you select the desired airspeed and the test box controls the crossover automatically. When descending, always use the pitot vent, never the vacuum vent to bring the system "down." This will automatically keep some airspeed present in the system.

Two different standards are applied to testing static systems. If an aircraft is unpressurized, FAR 23.1325 states that the static system must not leak more than 100 feet in one minute after being evacuated to 1,000 feet above ambient. In pressurized aircraft, the FAR states that the system must not lose more than 2 percent of the equivalent altitude of the maximum cabin differential pressure in one minute. Why the difference? In an unpressurized aircraft, the static lines could leak into the cabin without much influence on the altimeter reading. The cabin pressure may differ from outside ambient pressure by 100 feet or so. In pressurized aircraft, a static leak in the cabin may cause huge errors in the static instruments if the internal cabin pressure is much higher than the outside ambient pressure. In aircraft capable of nine inches or more of differential pressure, the equivalent difference in altitude can exceed 25,000 feet.

Since the aircraft pressurization system maximum differential is expressed in PSI, it is necessary to either connect an accurate vacuum gage referenced to ambient and connected to the static system under test or use the aircraft or test altimeter as an equivalent. Obviously if you use a vacuum gage, when it reads the maximum cabin differential pressure, you have reached the proper altitude to perform the leak test as required by the regulations.

Some of the electronic test standards such as the Setra M370, can be set to display in a variety of units including inches of mercury. When doing a pressurized aircraft leak test with the Setra, change the display to read in inches of mercury, reference the display to zero at the ambient pressure, and evacuate the system until you reach the desired differential pressure. At that point you can perform the leak test.

In order to use the aircraft or test altimeter as a vacuum gage, it is necessary to do the following:

1. Convert the local barometric pressure to PSI using the formula PSI=Inches of Hg/2.036. The barometric pressure can be obtained from the altimeter by setting the altimeter to zero feet and reading the baro scale of the instrument.
2. Subtract the maximum cabin differential pressure in PSI from the value obtained in Step 1.
3. Convert the PSI value obtained in Step 2 to inches of mercury using the formula Inches of Hg = PSI x 2.036;
4. Convert the test pressure expressed in inches of mercury to the test altitude by using a conversion chart based upon the document U.S. Standard Atmosphere, 1976.

There are no specific guidelines in the FARs for pitot systems. When there is also no data in the airframe maintenance manual for testing the pitot system, a good rule of thumb is to test at 200 knots or 230 mph, or redline, whichever is lower. The pitot system should not leak more than 2 knots or 2 mph in one minute.

The job is not complete until the paperwork is done. With the inspections required by FAR 91.411 the sign-off is especially important. The Maintenance Record entry example listed in AC 43-203B is a good start but is too vague for aircraft equipped with dual systems:

I certify that the altimeter and static system tests required by FAR Par t 91.411 have been performed.

The Altimeter has been tested to _________ feet on _________
(date altimeter tested).

Signature_______________________

Date ___________________________
(of Static system test)

Certificate No.___________________

The following sign-off is more specific and complete, lending itself to partial testing (non-RVSM aircraft only) of the onboard altimetry or static systems:

I certify that the altimeter and static system tests required by FAR 91.411 have been performed in accordance with FAR 43, Appendix E (para. Noted)

1. Static System per Para.(a)
write in left,right, or left and right

2. L. Altimeter per Para. (b) to ______,000 Ft. S/N_______(if req'd) on date___________.

3. R. Altimeter per Para.(b) to ______,000 Ft. S/N_______(if req'd) on date___________.

4. Integrated System per Para.(c)
Item No. ______ *list #s above*
Tested by_______________________
Date___________________________

In addition to the sign-off above, an RVSM equipped aircraft would have an entry referencing the specific RVSM test procedure that was performed.

It will probably fall upon the shoulders of the avionics technician with RVSM testing responsibility to verify that the required equipment for RVSM operations is still in the aircraft and operating satisfactorily. This means that an equipment inventory, autopilot testing, alerter testing and detailed inspections of the critical areas around static ports will be a part of the RVSM maintenance program in addition to the altimeter/air data tests themselves.

FAR 43 Appendix E requires that the date of the test and the altitude to which the test was performed be written on each altimeter (air data computer). This is typically done with sticky-back labels. In the case of air data systems, I affix a label to both the remote computer and the altimeter instrument in the panel.

It is also a common practice to fill out altimeter correction cards and affix them to the logbook entry or give them to the aircraft operator. Remember to reverse the sign of the error when transposing the corrections on the card from the altimeter test sheet. This is necessary if the altimeter test sheet asks for the instrument error referenced to the test device. For example, if the master altitude is 1,000 feet and the altimeter under test reads 985 feet, then the instrument error is entered as –15 feet. If the correction card states to add the correction algebraically when the altimeter reads X, then in this example it will be necessary for the pilot to add a +15 feet to an altimeter reading of 1,000 feet in order to arrive at the corrected altitude. Confused? Luckily I have rarely seen a pilot using an altimeter correction card during my long career.

In summary, all I can say to you young, new avionics technicians with altimeter testing responsibility is that it will be a learning experience for all of us as the deadline for domestic U.S. RVSM approaches. Who says you can't teach an old dog new tricks? Ruff, ruff! ❑