Procedures for Using Standard Almen and Aero Almen Strip Tests Parts III & IV

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Part III - Standard Aero Almen Test Kit

1. INTRODUCTION
   The Air Force Materials Laboratory has worked with equipment manufacturers to develop the standard test kit and to make this test kit as well as standard Aero Almen strips commercially available.

2. AERO ALMEN STRIP TEST KIT
   The standard Aero Almen strip test kit contains the following components:
   A. Almen strip holding fixture
      This fixture consists of a metal base plate with holes drilled for machine screws to attach Aero Almen strips to the base plate. The dimensions of the base plate are 4.5" x 3" x .5". The base plate is made of low carbon steel. The standard holding fixture can accommodate 3 Aero Almen strips. (See the Electronics Inc. holder in the photo on page 4.)
      A larger plate can be utilized that will hold multiple rows of Almen strips. Only one row of strips should be covered during a pass of the blast stream. Adjacent rows of Almen strips can be masked with heavy, soft masking material to protect the adjacent strips from the blast stream.
      The center points of the machined holes on the base plates are 1.562 inches apart for the long side of the strips and .94 inch for the width of the strip. Strips should be firmly attached to the baseplate with a screwdriver.
   B. The Aero Almen Gauge (Figure 1)
      The gauge is similar to the standard Almen gauge used for years to measure deflection/curvature in Almen strips. The Aero Almen gauge has a special weighted block for holding the aluminum Aero Almen strip in place while the deflection/curvature is being measured. With standard Almen strips manufactured from spring steel, a magnet holds the strip in place while the measurement is being taken.

Figure 1. The Aero Almen gauge from Electronics Incorporated

   The Aero Almen gauge is initially “zeroed” by using the zero check block. If the Almen strip is perfectly flat and the instrument is zeroed out correctly, the reading on the gauge will be zero. Once a strip has been blasted, the strip is placed in the gauge strip holder with the non-blasted surface facing the indicator contact point of the gauge. The flat zero check block included in the kit is used to zero out the instrument.
   The gauge measures in tenth thousandths of an inch the additional distance that the indicator contact point must move beyond the zero point to touch the unblasted surface. Care should be taken to “center” the Almen strip in the strip holder by aligning the end of the strip between the end stops and against the back stop pins of the Aero Almen gauge.

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C. The Aero Almen strip test kit also contains a protractor level device that can be used to measure angle of blast in degrees from the horizontal surface of the material being blasted. This will assist in developing data on angle of blast versus Almen arc height. Of course, in a production environment, the angle to the surface must be estimated visually.

D. A 30 power microscope is included to permit (and encourage) visual examination of the surface following blasting. When testing different hardnesses of blast material, differences in actual “peening” effect can be seen with the microscope. Careful examination of the Aero Almen strips following blasting will also provide a good “double check” for the presence of hard particle contamination of the blast media. If visual examination with the 30 power microscope reveals any deep indentations, the blast media should be checked to be sure it is within specification for allowable hard particle contamination.

E. A tape measure is included for measuring distance from the nozzle to the workpiece.

F. A straight blade screwdriver is included for mounting and removal of Aero Almen strips from the Aero Almen block.

G. A supply of 100 Aero Almen strips is also included in the standard test kit.

H. Each kit contains a needle gauge which is used to measure blast pressure just before the blast nozzle.

   Depending on the length of the blast hose from the pressure vessel to the nozzle and the configuration of the blast hose and the blast equipment, there can be a substantial drop in pressure from the gauge at the pressure vessel to the blast nozzle.

   Pressure at the nozzle can be measured by inserting the needle gauge through the blast hose just behind the nozzle. The needle should be inserted perpendicular to the blast hose and the end of the needle should be centered in the hose.

I. Each kit also contains Section 5 of the Design Handbook describing the blasting and testing procedure.

J. Each kit contains a stop watch to measure dwell time, to determine blast strip rates, and to time media mass flow rate tests.

K. A sturdy metal carrying case housing the Aero Almen test kit components is provided to withstand transport of the kit via commercial package shipper, auto, or aircraft baggage handling processes.

Figure 2. The Aero Almen Gauge from Electronics Inc. with test strips and holder

Part IV - Aero Almen Strip Test Procedure

1. INTRODUCTION

The Aero Almen strip test kit is intended for use in all paint stripping facilities. The kit provides a way to check out and verify the dry stripping process.

   For a given set of blasting parameters and media type and size, the kit will permit the measurement of “benchmark” residual stress imparted by the process.

   Once a given set of PMB parameters is used to blast a set of Aero Almen strips, the resulting baseline average Almen arc height is measured and documented. Alternative blast parameters, such as media type, nozzle size, media flow rate, pressure, stand-off distance, and blast angle can be used to develop better production capability by optimizing the stripping rate while maintaining the maximum Aero Almen arc height in accordance with the baseline levels measured.

   The Aero Almen test allows the blast facility to quickly optimize a new blasting process and to develop and document various blast parameter combinations by measuring their relative blast effects. In this way a number of acceptable production blasting conditions could be made to allow a cost benefits analysis study to determine which method is most productive or cost effective since these two are most likely not the same condition.

   The Aero Almen test kit is not intended as a means of approving dry stripping systems and media types. Approvals must come from the appropriate approving authorities in the Air Force and from the appropriate approving authorities in other branches of the service or the FAA for commercial applications.

2. TESTING PROCEDURE

The Aero Almen test consists of a verification of equipment and blast parameters followed by blasting applied using the known (measured) parameters and finally measurement and documentation of all parameters and of the test results.
The blast process parameters that must be measured are media flow rate, nozzle pressure, stand-off distance, and blasting impingement angle.

Equipment calibration consists of “zeroing” the Almen gauge, pre-measuring unblasted Almen strips for flatness, and final measurements of blasted strips after application of each set of PMB parameters.

3. MASS FLOW MEASUREMENT

For a given nozzle size and configuration and a given nozzle blast pressure, mass flow rate, measured in pounds per unit of time, will govern the velocity and impact energy of individual blast particles. A leaner mix (fewer pounds of media an hour) will result in greater individual particle velocity and more impact energy per particle. Conversely, a heavier mix (higher pounds of media per hour) will result in lower velocity and less impact energy per particle.

A leaner mix may result in a faster strip rate. As the strip rate increases, required dwell time decreases and Almen intensity for one strip cycle could be lower for the leaner mix than for the heavy mix. For extended dwell times, however, the leaner mix should result in a higher Almen intensity at saturation for a given set of process parameters.

All of the direct pressure equipment in use for dry stripping has some type of a metering orifice to adjust the flow of media from the pressure pot. Some manufacturers have fixed size “grit stems” at the bottom of the pressure vessel while others have adjustable metering orifices. In conjunction with some of the robotic dry stripping approaches, computer controlled media metering is being used to ensure consistent media flow.

Media pulsing, or inconsistent media flow for a given set of process parameters, results in particle velocity and Almen intensity changes, and should be avoided.

The first important piece of data required to verify the dry stripping process with the Aero Almen test kit is the mass flow rate. There are two suggested approaches to measuring mass flow rate. Either one can be used depending on the specific equipment setup being used.

The first method involves the use of a 30 gallon drum with a top with an opening and a sheet metal deflector and an exhaust tube (see Figure 3). The blast stream is started and the nozzle is then discharged into the drum for a given period of time. The material discharged into the drum can then be weighed and the mass flow in pounds per hour can be calculated. Three separate tests should be made to ensure consistent mass flow rates.

Alternatively, a pre-weighed sample of media can be put into an empty stripping system and the time required to discharge the pre-weighed sample can be determined.

For a large production facility, the 30-gallon drum approach is preferred unless the system has just been cleaned out and is in a start-up mode. If a hand cabinet or a small walk-in booth is being evaluated, the second method may be preferred.

In either case, the Aero Almen test kit has a stop watch that can be used for timing the media flow. Raw data and calculated

![Figure 3: Media Flow Rate Containment System](image)

mass flow rate should be entered on the Aero Almen Test Kit Data Sheet. (See page 7 for a sample data sheet.)

4. NOZZLE PRESSURE

While mass flow rates are being determined, pressure at the nozzle should be determined using the pressure gauge included in the test kit. The needle should be inserted through the blast hose just behind the nozzle. The static pressure in the blast hose is measured by taking care not to allow the “dynamic” or moving air stream forces to be vented into the needle increasing the measured pressure value. The needle should be vented forward toward the nozzle and be perpendicular or canted forward toward the nozzle and should be centered in the blast stream. Nozzle pressure (and pot pressure if available) should be entered on the data sheet.

5. BLAST DISTANCE AND BLAST ANGLE

The Aero Almen strip holder should be placed on the floor of the blast room, booth, or cabinet for conducting tests. Depending upon equipment configuration, an approach should be taken to keep the Almen strip holder from moving during testing. The tape measure and the protractor included in the kit should be used to measure the approximate angle of blast and distance from the surface of the Almen strips.

6. ZERO ALMEN GAUGE

To calibrate or “zero” the Aero Almen gauge, a machined flat steel plate shaped as a rectangular block or as a circular disk is used to locate the dial indicator contact point into the same plane as the four balls mounted in the gauge. The zero block is placed in
the Aero Almen gauge and pushed flat against the four balls with light finger pressure. The “Zero” button is then depressed showing a 0.0000 measurement on the gauge. Make sure the gauge is reading inches, if mm are displayed, depress the in/mm button to convert the reading to inches. The gauge is set to zero at this point.

7. PRE-MEASURE UNBLASTED ALMEN STRIPS
Aero Almen strips are measured just prior to testing. The strip is placed into the holder with the painted surface facing away from the four Almen Gauge locating balls. With the Almen Gauge previously calibrated and zeroed and the Almen strip located between the end stop pins and against the back stop pins, lower the weighted block onto the Aero Almen strip and measure the flatness of the strip and print the reading on the bare unpainted surface.

Print the initial reading with an indelible or permanent marker. Reject the strip if the Almen Strip reading is more than .0015 out of flat. The locating end pins allow the Almen strips to be placed in the same position and orientation for the greatest accuracy in repeated pre and post blast measurements.

8. FIRST CYCLE ALMEN ARC HEIGHT
As stated earlier, in order to verify the process, painted Almen strips should be used for first cycle arc height tests. Use of painted strips will ensure that dwell time is not underestimated. If painted strips are not available, painted panels or scrap parts can be used to determine the proper nozzle traverse speed for one cycle.

Almen strips should be attached to the Almen strip holder firmly using the screwdriver included in the kit. Care should taken to center the strips in the holder. Each Almen strip used in the test should be assigned a number. The number should be written on the nonblasted side of the strip and recorded on the data sheet.

The Almen strip holder, with Almen strips attached, should be placed on the floor of the stripping facility and secured appropriately.

The system should be started up with the nozzle directed off to the side of the Almen strip holder. Using the desired blast distance and blast angle, the blast stream should be directed across the Almen strips at a traverse rate which results in an acceptable paint removal. The stop watch should be started as soon as the blast stream touches the first Almen strip and stopped as soon as all paint has been removed from the strips.

Once the Almen strips are removed from the holder, and the arc height is measured and recorded and the surface is examined. The Almen strips are then allowed to air dry for 24 hours. The Almen strips should be numbered and placed into the holder with the painted surface facing away from the Almen Gauge locating balls. With the Almen Gauge previously calibrated and zeroed and the Almen strip located between the end stop pins and against the back stop pins, lower the weighted block onto the Aero Almen strip and measure the flatness of the strip and print the reading on the bare unpainted surface.

The Almen strip holder, with Almen strips attached, should be placed in the same position and orientation for the greatest accuracy in repeated pre and post blast measurements.

9. FOUR CYCLE AND EXTENDED DWELL TESTS
Next, new painted Almen strips should be numbered and attached to the Almen strip holder, and the Almen strips should be subjected to the equivalent of four blast cycles based on the traverse speed determined from the one cycle test. The blast stream should traverse back and forth twice with the traverse continuing until the entire blast pattern is off of the Almen strips at either end of the Almen strip holder.

Once again, the strips are removed from the holder, Almen arc height measurements are taken and recorded and the surface is evaluated using the 30 power microscope.

Extended dwell tests can then be conducted to determine the “worst case” Almen arc height. One Almen strip should be attached to the Almen holder and the blast stream should be moved back and forth over the strip for the equivalent of ten strip cycles.

Again, the strip is removed from the holder, and the arc height is measured and recorded and the surface can be evaluated.

One cycle, four cycle and extended dwell Almen arc heights can then be compared to the data base in DN 5A5 of this chapter.

Tests should be conducted by the operator on duty at the time to ensure that the test is consistent with the actual paint removal operation. The process is operator-sensitive, and the differences in blasting “technique” may affect arc height.

10. AERO ALMEN TEST KIT STORAGE
All materials used to conduct Aero Almen testing should be kept together in the storage case to prevent damage to equipment or loss.

11. FREQUENCY OF TESTING
Tests should be conducted on a periodic bases every four hours or after any machine setting changes to ensure that blast pressure and media flow rates are being maintained and that residual stress as measured by arc height is within the expected range.

Additionally, tests should be conducted whenever the media supplier is changed or when the type or size of media to be used is changed.

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