OFFICIAL COPY
JACK C.

→ SPC 95004

NAVAL AVIATION DEPOT
NAVAL AIR STATION
JACKSONVILLE, FLORIDA 32212-0016

CODE 341
WUC: N/A
31 JAN 95

TITLE: PEENING OF METAL PARTS

IDENTIFICATION: LPS 500

CLASSIFICATION: Routine

PUBLICATION: None **SECTION/PAGE**: None **PARAGRAPH**: None

DRAWING: None **CHANGE LETTER**: None

SYSTEM: Any system with parts or assemblies which require either saturation peening or peen forming.

SUBJECT: Shot and bead saturation peening or peen forming of aircraft parts using either manual, automatic, or computer controlled peening equipment.

REF:
(a) MIL-S-13165, Shot Peening of Metal Parts.
(b) RR-S-366, Sieve Tests.
(c) SAE J441, Cut Wire Shot.
(d) SAE J1830, Size Classification and Characteristics of Ceramic Shot.
(e) SAE J442, Test Strip, Holder and Gage for Shot Peening.
(f) PPP-T-60, Tape, Packaging, Waterproof.
(g) AMS 2432, Shot Peening, Computer Monitored.
(h) LPS/JX-501, Shot Peening Using the Rotary Flap Peen Method.
(i) NADEP Jax Instruction 4855.2G, Specials Skills Cert.

ENCL: None

1. **PURPOSE**: This specification establishes the materials, equipment, procedures and requirements applicable to metallic shot, glass bead, and ceramic bead saturation peening and peen forming of aircraft parts and assemblies. This specification has provisions for manual, automated, and computer controlled and monitored equipment.

2. **CANCELLATION**: LPS/JX 341-149

3. <u>BACKGROUND INFORMATION</u>: Peening is a process which cold works the surface of metallic materials and increases resistance to failure by fatigue and/or stress corrosion cracking. The peening process must be highly controlled and monitored. Uncontrolled peening practices are detrimental to a part's serviceability and may cause premature, catastrophic failure. Computer controlled peening presents the optimum means of controlled peening. Automated peening also provides for controlled peening but to a lesser degree than computer controlled. Manual peening provides the least control. Definitions for peening equipment are given in reference (a) and this specification.

4. **<u>APPLICATION</u>**: This specification applies to all aircraft, engine, and ground support components when specified by engineering directives. The specification incorporates the requirements and information necessary to meet or exceed references (a) and (g).

5. **<u>SPECIAL TOOLS AND TEST EQUIPMENT</u>**:

5.1 **PEENING EQUIPMENT:** Peening machines are classified as manual, automatic, or computer controlled as described below.

5.1.1 MANUAL PEENING: Manual peening equipment shall propel the peening media by air pressure or centrifugal force against the part. The machine will include a hopper for recycling the media continuously. The air system will have regulators and oil or moisture traps and/or filters to preclude media and part contamination. The machine shall be capable of consistently reproducing the required intensity.

5.1.2 AUTOMATIC PEENING: The machine used for automatic peening shall meet all of the requirements of the above paragraph as well as provide means for moving the shot stream across the part (or vice versa) in either rotation or translation, or both, as required. The machine shall contain mechanical and electrical devices for the control of media flow rate with adjustable high and low limits and automatic shut-off when the limits are exceeded. The machine shall also contain a separator for continuous removal of broken or defective media during operation.

5.1.3 COMPUTER CONTROLLED PEENING: The machine used for computer controlled peening shall meet the requirements of para. 5.1.1, para. 5.1.2, ref. (g) and be equipped with computer monitoring equipment. This equipment shall continuously monitor critical process parameters through interaction with a sensing system. The media shall be metered to each nozzle with the desired flow rate. The machine shall be capable of interrupting the peening cycle within one second when detected tolerances for shot flow, air pressure, or air flow are exceeded. The peening system shall retain in memory and print out any abort details and be able to resume operations to complete the balance of the peening cycle, from the position of shut down, after the out-of-tolerance condition has been corrected. Computer controlled shot peening machines shall continuously monitor and record process parameters as specified in ref. (g), Table 1.

5.1.4 IN-USE MEDIA MAINTENANCE: The computer-controlled peening machine shall be equipped with shot screening and shot shape control equipment capable of continuously maintaining the quality of the peening media in the machine to no more than 2% of broken or deformed pieces for metallic shot, 5% for ceramic media, and 10% for glass media. For automatic and manual machines, the limits of Table 1 shall be employed.

5.1.5 ROTARY FLAP PEENING: Rotary flap peening shall be accomplished in accordance with ref. (h) when authorized via written engineering directive.

5.2 **ALMEN GAGE:** Almen gages for determining arc height of Almen strips shall conform to the requirements of ref. (a) (type 2). However, type 3 (digital) gages per ref. (g) are preferred and shall be used when available. Almen gages shall be zeroed daily using a calibrated flat gage block. The gage must have current calibration and be free of defects and damage.

5.3 **ALMEN STRIP HOLDER:** Fixture for holding Almen strips during exposure to media stream shall comply with reference (a) and Figure 1.

5.4 **SIEVES:** Sieves for size analysis of media shall be in accordance with reference (b) and Table 2.

5.5 **SIEVE SHAKER:** A standard, motorized sieve shaker for 8 inch diameter sieves with simultaneous rotating and tapping motion shall be used for shot size analysis.

5.6 **BALANCE:** Standard laboratory pan balance capable of weighing up to 3000 grams and resolution of 0.1 gram shall be used during shot size analysis.

6. **<u>SPECIAL MATERIALS</u>:**

6.1 **PEENING MEDIA:** Wrought carbon steel shot and wrought stainless steel shot shall conform to the requirements of reference (c) except as modified in 8.4.1 and 8.4.2. Cast steel shot and glass beads shall conform to reference (a). Ceramic shot shall conform to reference (d).

6.2 **ALMEN STRIPS:** Premium grade Almen "A", "C", and "N" strips per reference (e) shall be used. These strips shall be accompanied by a dated certificate of compliance for hardness, thickness, length, width, and 100% inspected for flatness on both sides. Strips shall be packaged in corrosion inhibitive paper.

6.3 **MASKING MATERIALS:** Cloth-backed adhesive tape, waterproof per reference (f), Type 3, Class 1, electroplating masking tape, Scotch #470 or their equivalents are suitable maskants. Permanent rubber masks or metal shields shall be used whenever possible.

7. **EFFECTIVE DATE:** As indicated on Tech. Data Release Card.

8. **INSTRUCTIONS:**

8.1 **PEENING OPERATORS:** Peening shall be performed only by operators with proper training who demonstrate the requisite skills and ability. Shot peen operators must have special skills certification and be certified per paragraph 8.12.

8.2 **DESIGNATED PEENING AREAS:**

8.2.1 SURFACES TO BE PEENED: Unless otherwise noted, parts shall be peened on all surfaces. Surfaces of holes less than 0.125 inch diameter are not required to meet the designated intensity requirement.

8.2.2 NO-PEEN SURFACES: Areas designated not to be peened shall be masked from the peening stream with appropriate maskant or permanent masks.

8.2.3 SURFACES OF THIN SECTIONS: Thin sections under 0.090 inch in thickness shall not be peened unless specifically required on the appropriate technical document.

8.2.4 OPTIONAL PEEN AREAS: Areas designated as optional peen areas are not required to meet intensity specifications.

8.3 **PREPEENING TREATMENT:**

8.3.1 DIMENSIONS AND SURFACE FINISHES: Dimensions and finishes shall be as specified by the engineering drawing or other document prior to shot peening, unless otherwise noted.

8.3.2 STRAIGHTENING AND FORMING: Straightening and forming shall be completed prior to peening.

8.3.3 HEAT TREATMENT PROCESSES: Heat treatment processes which require temperatures above those specified in paragraph 8.8.4 shall be performed prior to peening.

8.3.4 MACHINING AND DEBURRING: All machining of areas to be peened shall be completed prior to peening. All burrs shall be removed and all sharp edges shall be radiused or chamfered.

8.3.5 NONDESTRUCTIVE INSPECTIONS: All nondestructive inspections, when required, shall be completed prior to peening.

8.3.6 CORRODED OR DAMAGED PEENING SURFACES: Unless otherwise permitted by engineering directive, all surfaces to be peened shall be free of corrosion or mechanical damage.

8.3.7 CLEANING PRIOR TO PEENING: Parts requiring peening shall be free of oil, grease, paint, contamination, etc. See applicable engineering directives for specific cleaning methods to be used.

8.3.8 INCOMPLETE OR QUESTIONABLE DIRECTIVES: Contact the Materials Engineering Laboratory, Code 34100, when peening documentation is incomplete or questionable. If media size and intensity are not specified on applicable documents, they shall be established by the Materials Engineering Laboratory. Tables 3 and 4 are provided for reference.

8.4 **MATERIAL AND EQUIPMENT:**

8.4.1 STEEL SHOT: Extra conditioned cut wire shot (steel or stainless steel) shall be used exclusively for all shot peening at NADEP Jacksonville. The cut wire shot shall conform to the requirements of references (a) and (c). Cast steel shot will be used only in emergencies and with prior approval from the Materials Engineering Laboratory.

8.4.2 CUT WIRE SHOT CONDITIONING: Cut wire shot shall be preconditioned such that the shot shape is predominantly spherical, with no sharp edges. This will require extra conditioning (vice standard conditioning) by the supplier prior to delivery. Standard conditioned cut wire shot may be used only when authorized via engineering directive.

8.4.3 SHOT SIZE ANALYSIS: New conditioned cut wire shot and, when allowed, cast shot, shall be tested via size analysis for conformance with Table 2. Shot size analysis shall be performed as follows:

(a) A 100 gram sample shall be weighed to the nearest tenth of a gram. Using Table 2, select the five seives which correspond to the shot size being tested.

(b) Measure and record the weight of each seive and the bottom pan. Nest the seives from coarsest to finest placing the coarsest on top, then add the bottom pan. Pour the sample onto the top seive and then cover the stack. Place the stack in the seive shaker and run for 10 minutes.

(c) Remove and dissassemble the stack. Measure and record the weight of each seive with retained shot, including the bottom pan. The amount of retained shot on each sieve is equal to the final seive weight minus the initial seive weight.

(d) Compare the percentages of the amounts of retained shot in the seives and pan to the requirements of Table 2. Any new shot which fails to meet sizing requirements shall be rejected from use.

8.4.4 EQUIPMENT CALIBRATION: Measurement equipment such as Almen gages, air pressure gages, etc. which effect the control of the shot peening process shall be calibrated semi-annually against instruments whose calibration is traceable to the National Institute of Standards and Technology (NIST).

8.4.5 ALMEN STRIP TEST FIXTURE: Either a scrap part or a representative fixture shall be fitted with test strip support blocks. These blocks shall conform to the requirements of reference (a) and shall be clamped or welded to the test fixture. Fitting strips directly to the test fixture surface is not allowed. The Almen test fixture shall be oriented to the shot stream and rotated/translated in the same manner as the production part. The design of the Almen test fixture shall be approved by the cognizant airframe engineering branch and the Materials Engineering Laboratory. It shall be serialized or numbered by Code 600 and recorded in the procedure sheet. It shall be used for all subsequent Almen intensity verifications. Modifications to test fixtures must be approved by the Materials Engineering Laboratory and the cognizant engineering branch. The fixture's serial number shall indicate if a modification exists (i.e., 001-94-MOD1).

8.5 **PEENING MACHINE SELECTION:** The selection of the type of peening machine is a critical step in establishing the peening process. The following criteria shall be considered.

8.5.1 COMPUTER CONTROLLED PEENING: A high level of control in the peening process is critical for parts whose fatigue life is affected by the shot peening treatment and parts which are deemed "flight critical". It is preferred that these parts are processed with computer monitored and controlled equipment. Large parts which require fixturing and parts typically peened in batches are also recommended for this equipment.

8.5.2 AUTOMATIC PEENING: Automatic peening is best suited for batch parts which are basically cylindrical.

8.5.3 MANUAL PEENING: Manual peening can used for all applications. NOTE: Upon receipt of computer controlled peening equipment, usage of the manual peening process will diminish. At that time, parts discussed in para. 8.5.1 will be required to be processed with computerized equipment unless written authorization is given for automatic or manual peening.

8.6 **PREPRODUCTION SET-UP VERIFICATION:**

8.6.1 INTENSITY VERIFICATION LOCATIONS: The intensity varification locations shall be as noted on the drawing or other technical directive. When the locations are not identified, they shall be established by the cognizant airframe engineering branch and the Materials Engineering Laboratory.

8.6.2 SATURATION CURVE: The peening intensity shall be determined by the procedures outlined below using test fixtures per para. 8.4.5.

8.6.2.1 Development of Peening Procedure: A peening procedure must be developed for all parts peened at NADEP Jax. A complete saturation curve shall be developed for each intensity verification location and the curves shall form a part of the peening procedure sheet. The critical peening parameters, confirmed by the saturation curves and coverage determination, shall be recorded in the computer program or applicable logbook or document.

8.6.2.2 Generation and Interpretation of Peening Saturation Intensity Curves:

(a) A peening intensity must be specified on the appropriate technical document. The intensity may be given as a decimal or whole number value such as 0.006A or 6A. These values are equivalent. A four point range is typically cited, i.e., 4-8A or 0.004-0.008A. If a single number is given, then two points shall be added and subtracted to establish the range. (i.e., 12A = 10-14A). If a maximum or minimum value is specified, then four points are either added or subtracted as appropriate. (i.e., minimum 10A = 10-14A: maximum 10A = 6-10A).

(b) Select the proper Almen strip (A, C, or N). Place the strip on the Almen gage and test for flatness. The side of the strip measuring zero pre-bow shall remain unpeened and placed against the face of the Almen block. NOTE: Almen strips cannot be re-used.

(c) Inspect the Almen block for excessive wear or contamination. Clean or replace the block as needed. Place the Almen strip onto the block and firmly tighten the four screws. With the Almen strip securely in place, inspect to verify that nothing (especially shot) is trapped under the strip.

(d) Expose the mounted Almen strip to the shot stream for a measured amount of time. The strip shall be peened in a manner which simulates the methods used during production peening of the part. Expose at least three more strips to the shot stream using various exposure times. Time intervals such as 1/2T, T, 2T, and 4T are suggested. For example, if T=10 seconds, then 1/2T=5, 2T=20, and 4T=40 seconds.

(e) Using the Almen gage, measure the amount of strip arc on the unpeened side for each of the strips. Record the arc height and time of exposure onto the strip.

(f) Using a graph of arc height versus exposure time, plot the data points and draw a curve similar to the one shown in Figure 2. Do not connect the data points with straight lines, the curve shall be smooth. A satisfactory saturation curve will exhibit a "knee" and a region which flattens to the right.

(g) Select a point at the knee of the curve (point "a" on Figure 2). Move to the right a distance which doubles the exposure time of point "a". If the intensity at the doubled-time point has less than 10% increase from the intensity at point "a", then point "a" is a suitable saturation point. The arc height at point "a" is the saturation intensity for the machine at the selected settings.

(h) For production peening, the saturation intensity must fall within the four point specified range. If not, new machine parameters must be selected and new strips peened to construct a new saturation curve.

(i) Figure 3 depicts several saturation curves drawn on one graph. With curve 1, saturation is not reached since the curve does not flatten out. After a machine adjustment (i.e., lowered air pressure), curve 2 is drawn but the saturation intensity is below the range. A final machine adjustment is made which produces curve 3 and the desired intensity is obtained.

(j) Upon successful completion of the saturation curve, record all required information on the peening procedure sheet. These parameters will be used to peen production parts.

8.7 **PEENING PROCEDURE:**

8.7.1 COVERAGE OF PRODUCTION PARTS: Unless otherwise specified, the production part shall receive 100% coverage. After exposing all areas of the production part to the media stream for the determined saturation exposure time, inspect for complete coverage per para. 8.10.5. If coverage is incomplete, additional exposure time may be applied. When specified, multiple exposure times are obtained by multiplying the 100% coverage cycle time by the appropriate factor. For instance, a 200% coverage cycle time is obtained by multiplying the 100% coverage cycle time by two.

NOTE:

On the production part, on a unit area basis, the time required to obtain 100% coverage will likely be different from the saturation exposure time determined from the saturation curve. Soft metals such as aluminum will require less exposure time to obtain 100% coverage than harder parts such as steel. Therefore, coverage must be monitored independent of intensity. As a rule-of-thumb, the total surface area to be peened on the production part can be divided by the area of an Almen strip (2.25 square inches). The resulting number can be multiplied by the saturation exposure time. This will give an estimate of the total cycle time which will be required to peen the part.

8.7.2 PRODUCTION PEENING SET-UPS: The production peening set-up shall use the computer pre-program (when applicable) and the procedure sheet (see 8.9.2) to designate the machine and the machine settings, fixtures, and locations of parts and fixtures. Intensity verification using test strips is required by peening a single set of test strips after all monitored parameters, fixtures and locations match the computer preprogram and the procedure sheet. Intensity verification specifics are detailed in paragraph 8.10.3.

8.7.3 NOZZLE HOLDING FIXTURE: For automatic and computer-controlled peening, each nozzle shall be held in a fixture or positioned so that the angle of impingement and stand-off distance conforms to the procedure sheet during peening. The nozzle holding fixture shall be numbered and recorded on the procedure sheet.

8.7.4 PART HOLDING FIXTURE: The part shall be held in a fixture designed to locate the part inside the shot peen cabinet in a repeatable position in relation to the nozzle. For computer controlled equipment, the location tolerance zone is +/- 0.063 inch. For automaic machinery, the tolerance zone is +/- 0.25 inch. The fixture shall be numbered and recorded on the peening procedure sheet.

8.7.5 SHOT SIZE: The shot size cited on the engineering directive shall be used. Deviations will require written authorization from the Materials Engineering Laboratory. For shot selection, the following are guidelines to be used in engineering decisions. Radii shall be peened with shot whose diameter is no larger than one-half the size of the radius being peened. In general, the smallest diameter shot which delivers the required intensity shall be used.

8.7.6 PEENING OF HOLES: Holes larger than 0.125 inch diameter shall be peened to the specified requirements utilizing internal peening setups. No internal set-ups are required if the hole diameter is equal to or larger than half the hole depth, provided that the hole is open to direct impingement from both ends. If such a hole is accessible from one end only, external peening with the specified shot size and intensity for the actual part is then acceptable, provided that the hole receives complete coverage.

8.7.7 FREE EXIT OF SPENT SHOT: For internal peening, the part shall be positioned so as to ensure free exit of spent shot.

8.7.8 SPENT SHOT: Peening with accumulated, non-classified spent shot is not permitted.

8.7.9 PARTS WITH VARIABLE THICKNESSES: When two or more thicknesses are present on the same part and one is over 0.375 inch and the other is less than or equal to 0.375 inch, the part shall be peened as follows:

8.7.9.1 Step 1: The thicker area shall be peened first using the correct shot size and intensity for that thickness and the thinner area shall be masked at any outside corner where the change of cross section occurs. Do not mask an inside radius. If the change in cross section is gradual, the peening intensity and coverage shall fade within two inches into the thinner area.

8.7.9.2 Step 2: The thinner section is then peened to the correct intensity with no masking of thicker sections, except as required by the applicable drawing or other documentation. Complete coverage with the required intensity is required for no less than two inches overlap into the area previously peened.

8.7.10 APPLICATION OF EXTERNAL LOADS DURING PEENING: No external loads shall be applied to the part during peening unless authorized by the cognizant airframe engineering branch.

8.7.11 PEEN FORMING:

8.7.11.1 Coverage During Peen Forming: Peening for 100% coverage (saturation peening) is not required if the sole purpose is to produce a prescribed contour, or peen form.

8.7.11.2 Peen Forming Parameters: Peen forming parameters shall be established so that a minimum of manual procedure is needed to produce the desired contour. This peening schedule shall be recorded for future peen forming of similar parts.

8.7.11.3 Contouring: Using the established parameters from 8.7.7.2, perform the peening operations required to obtain the specified contour. Approved check fixtures shall be used to determine if the contour is acceptable and within allowed tolerance.

8.7.11.4 Peening Precendence: When peen forming and saturation peening are required on a particular part, the peen forming operation shall be completed first, followed by saturation peening.

8.7.11.5 Intensities: Peen forming intensities shall be in accordance with the table shown below.

INTENSITY LIMITS FOR PEEN FORMING

	Maximum Allowable Intensity	
Section Thickness (Inch)	Aluminum and steel	Titanium
0.030-0.059	0.006A	per dwg.
0.060-0.120	0.010A	0.009A
0.121-0.375	0.014A	0.011A
Over 0.375	0.019A	0.014A

8.8 **POST-PEENING TREATMENT:**

8.8.1 INITIAL CLEANING: After peening and removal of masking, all masking adhesive, shot, and shot fragments shall be removed from the surfaces of parts. Only methods which do not scratch or otherwise mar surfaces shall be used.

8.8.2 SURFACE MATERIAL REMOVAL: When surface material is to be removed, one or more of the following methods may be used: polishing, lapping, honing, sanding, or a second peening operation to a lower intensity. Grinding shall not be used unless approved by the Materials Engineering Laboratory. Removal limits are as follows:

(a) For parts with a specified minimum tensile strength of

220,000 psi and over, no more than 5% of the specified minimum "A" intensity or equivalent "N" or "C" intensity shall be removed from the surface.

(b) For other parts, no more than 10% of the specified minimum "A" intensity or equivalent "N" or "C" intensity shall be removed from the surface.

8.8.3 FURTHER CLEANING:

8.8.3.1 Decontamination: Parts made from material other than alloy or carbon steel which have been peened with metallic shot shall be decontaminated as follows:

(a) Corrosion resistant steel and titanium alloy parts shall be decontaminated in a 20 to 50% by volume nitric acid solution at 140F + 5F for 15 to 30 minutes.

(b) Aluminum alloy parts shall be decontaminated in a 50% +/- 5 by volume nitric acid solution at ambient temperature or 20% +/- 2 by volume nitric acid solution at 140F +/- 5.

8.8.3.2 Rinse: After decontamination, parts shall be spray rinsed or rinsed in agitated water.

8.8.3.3 Cleaning Via Glass Beads: As an alternate postpeen cleaning procedure, parts listed in (a) or (b) above may be peened with glass beads using an intensity of 0.002-0.006N. Only trained peeners are authorized to perform the glass bead peening for cleaning purposes.

8.8.4 POST-PEEN HEAT TREAT: To avoid reduction of induced compressive stresses, peened parts shall not be exposed to temperatures higher than those listed below.

(a) Alloy steels........................ 475F
(b) Corrosion resistant steels.......... 750F
(c) Aluminum alloys....................... 200F
(d) Titanium alloys....................... 600F
(e) Magnesium alloys..................... 200F
(f) Nickel and cobalt alloys.............. 1000F

8.9 PROCESS CONTROL:

8.9.1 PEENING SET-UP: The peening set-up shall be established by placing the Almen test strip set-up fixture in the machine in the identical orientation to the shot stream in which the part shall be exposed. Air pressure shall be adjusted to yield the designated intensities. Nozzle positions shall be set so that the shot stream shall have an angle of impingement between 45 and 90 degrees with respect to the Almen strips.

8.9.2 PEENING PROCEDURE SHEET: A peening procedure sheet which shows the peening parameters for production parts shall be established for each part number. The parameters listed on the procedure sheet shall be approved by the Materials Engineering Laboratory prior to initial production peening. The procedure sheet will include a sketch of the machine set-up showing nozzle placement with respect to the part. Locations of Almen test strips will also be identified. The procedure sheet will also include the information listed below. A sample procedure sheet is shown in Figure 4.

* Procedure sheet number and approval date
* Shot peen operator name and certification information
* Computer program name or number (if applicable)
* Part number and nomenclature
* Specific aircraft or engine application
* Peening machine identification
* Fixture identification numbers (Almen strip fixture, part fixture, nozzle fixture, masking fixture)
* Shot flowrate for each nozzle
* Nozzle orifice size
* Nozzle translation speed and direction of travel relative to the part
* Nozzle angles of impingement
* Nozzle-to-part distance
* Air flow of each nozzle
* Air pressure for each nozzle
* Size and material of shot
* Speed, direction, and travel of part in translation or rotation (when applicable)
* Areas to be masked
* Saturation curve for each intensity verification point
* Time of exposure to the shot stream
* Sequence of nozzle shut down (if applicable)
* Designated intensity range
* Target intensity
* coverage requirements
* Prepeening cleaning and other related tasks
* Postpeening cleaning requirements

8.9.3 PEENING PROCESS SHEET: During the peening of production parts, peening process sheets shall be completed and maintained. The peening process sheet shall contain the information listed below. A sample peening process sheet is shown in Figure 5.

* Shot peen operator name and certification information
* Date
* Aircraft or engine type
* Part number and nomenclature

* Part serial number(s)
* Corresponding procedure sheet number for part number
* Required intensity range
* Saturation intensity value from saturation curve on procedure sheet (for each Almen strip location)
* Verification intensity value for peening at saturation exposure time on intensity curve from procedure sheet (for each Almen strip location)

8.10 **QUALITY ASSURANCE:**

8.10.1 SHOT SIZE AND UNIFORMITY: Shot size and uniformity shall be verified by samples taken from the nozzle. Samples shall be taken and analyzed weekly for each shot size to be used. Size and shape analyses shall conform to and meet the requirements of Reference (a). A logbook showing the results will be maintained by each peening shop for a period of five years.

8.10.2 ALMEN STRIPS: Randomly picked Almen strips shall be tested by the Materials Engineering Laboratory for dimensional and physical conformance to the requirements of reference (a).

8.10.3 INTENSITY VERIFICATIONS: Intensity verifications shall be routinely performed to ensure that equipment is operating properly and that the desired, established intensities are being maintained.

8.10.3.1 Verification Frequency: Intensity verifications shall be made with the appropriate Almen strip, A, C, or N. At least one intensity determination for all required locations shall be made before and after each production run and/or at least every eight hours of production when using steel shot (every four hours for ceramic shot and every two hours for glass bead).

8.10.3.2 Verification Tolerance: Intensity verification shall be accomplished at the exposure time which corresponds to the saturation point on the preproduction procedure sheet saturation intensity curve. If the arc height at the saturation point is not within +/- 0.001 inch of the preproduction value, a new saturation curve and procedure sheet shall be generated for the part. The intensity verification value shall be recorded on the peening process sheet.

8.10.3.3 Verification Following Media Replineshment: Intensity verification shall be performed following a major addition or replineshment of media. An addition of 10% or more of full charge is considered a major addition.

8.10.4 RECOVERY FROM SHUT-DOWN FOR OUT-OF-TOLERANCE CONDITION: Upon correcting an out-of-tolerance condition which caused a shut-down of the peening equipment, the part being peened will be completed followed by an intensity verification with the Almen test fixture. If the resulting intensity fails to compare to the original saturation intensity within + 0.001 inch, the Materials Engineering Laboratory must be notified for disposition of the part. Any discrepancies of the machine must be corrected and a new saturation curve and procedure sheet must be generated for the part.

8.10.5 COVERAGE VERIFICATION: **All peened surfaces shall be verified to have complete (100%) coverage.** Peened surfaces which do not exhibit 100% coverage must receive increased exposure time until complete coverage has been obtained. Either of the following methods shall be used for the purpose of verifying complete coverage:

8.10.5.1 10x Magnification and Liquid Tracer System: Peened surfaces shall be visually inspected using 10x magnification or higher in conjuction with a liquid, nonfluorescent tracer system to determine if the entire surface of the required peened area has overlapping dimples.

8.10.5.2 Fluorescent Liquid Tracer System: A fluorescent liquid tracer coating may be employed to indicate when 100% coverage has been obtained. These coatings must be used in accordance with manufacturer's recommendations and shall be approved by cognizant engineering authority.

8.10.6 PREPRODUCTION APPROVAL: Saturation curve generation and machine set-up during preproduction shall be witnessed, verified, and approved by the Materials Engineering Laboratory. Also, first-run production peened parts and corresponding procedure sheets for each part number shall be approved by the Materials Engineering Laboratory.

8.10.7 RECORDS: Procedure sheets (active and obselete), work sheets, computer records, tests, and inspection records shall be maintained by the peening shop for at least five years. The records shall contain all data necessary to verify compliance with this specification. Almen strips used to measure/verify intensity shall also be kept for at least five years. The strips will be annotated with the date, measured arc height, corresponding location on the test fixture, procedure sheet number, and part number.

8.10.8 LOGBOOK: A daily logbook shall be maintained in peening shops to track, as a minimum; workload, machine usage, operator experience, and equipment problems.

8.11 **DEFINITIONS:**

8.11.1 SATURATION INTENSITY: The saturation intensity is determined from a saturation curve. Satuaration exposure time is the minimum duration of peening which, when doubled, increases the Almen strip arc height by no more than 10%. Arc height at saturation should correspond to the arc height required for the part. The re-use of peened test strips is not permitted. The procedures for saturation curve generation are detailed in Reference (e) and this document. A typical curve which exhibits saturation is shown in Figure 3 with the saturation point occurring at time "T".

8.11.2 100% COVERAGE: Complete obliteration of the original surface finish by peening dimples.

8.11.3 PEENING CYCLE TIME: The time required to obtain 100% coverage of the part or peening area.

8.11.4 COGNIZANT: The term applied to the engineering authority responsible for the design and/of the integrity of the parts being processed.

8.11.5 INTENSITY VERIFICATION LOCATION: A critical location on a part at which peening intensity must be verified as correct before the peening process is approved. Locations will be as specified on the control drawing or designated by the cognizant engineering branch and the Materials Engineering Laboratory.

8.11.6 CRITICAL PEENING PARAMETERS: Machine/process parameters which directly or indirectly affect the intensity or coverage obtained in the shot peening of parts.

8.11.7 PEENING CYCLE: A complete peening event in which the part or area(s) of a part are exposed to the shot stream for a sufficient time to obtain the required intensity and 100% coverage.

8.11.8 PROCEDURE SHEET: A data sheet which contains information regarding all selected parameters which are used to establish the peening cycle for a particular part. The peening procedure sheet is described in detail in 8.9.2.

8.11.9 PROCESS SHEET: A daily worksheet used by peening operators to document the peening of production parts. The peening process sheet is described in detail in 8.9.3.

8.11.10 SET-UP: A configuration and/or process in which the shot peen parameters are established and confirmed for a particular part. Critical peening parameters are developed during the set-up process and the Almen test fixture is used to confirm intensity levels and a liquid tracer system is used to confirm that the proper coverage is obtained.

8.12 **SHOT PEEN OPERATOR CERTIFICATION** (per ref. (i) and below):

8.12.1 INITIAL CERTIFICATION: A shot peen operator candidate (not previously certified for shot peening) will receive certification after accomplishing the following.

8.12.1.1 Optical Examination: Optical examination for visual acuity, near vision 20/30 at 16 inches, in either eye.

8.12.1.2 Technical training:

(a) 24 hours of classroom training on shot peen theory, purpose, applications, etc. Lesson plan will be written and administered by Code 34100.

(b) 8 hours of shop orientation and OJT.

(c) 30 days of work experience.

8.12.1.3 Operator evaluation (subsequent to training):

(a) Written exam - minimum passing grade = 80%.

(b) Practical exam - min. passing grade = 80%.

8.12.2 RECERTIFICATION: Recertification will occur every three years and will consist of the following:

(a) Optical Examination: Optical exam per 8.12.1.1 (a) (annual requirement).

(b) 8 hours of classroom refresher training.

(c) Written and practical exam with min. passing score of 80%.

8.12.3 CERTIFICATION CLASSES: Three classes will be employed.

(a) Class 1 (General): Basic certification level which allows the operator to use manual and automated peening booths. Class 1 is achieved after successful completion of the certification or recertification requirements.

(b) Class 2 (Structural): Basic certification (Class 1) plus additional training and certification in on-aircraft critical peening of bulkheads or other areas. Operator must demonstrate an acceptable skill level to be certified for this application.

(c) Class 3 (Computer controlled peening): Basic certification plus additional training/experience to utilize computer controlled and/or robotic shot peen equipment. May require extended off-site training at the equipment manufacturer's facility. Operator must demonstrate an acceptable skill level to be certified for this Class.

8.12.4 NATURE OF WRITTEN EXAM: The written exam will test the operator's knowledge of the technical (classroom) information. In case of failure of the test, the operator may have one retake within five workdays. If the operator fails the second attempt, he shall be disqualified from peening for a minimum of 30 days. A third failure will be cause for removal of the operator from the shot peen process and revocation of his special skill certification.

8.12.5 NATURE OF PRACTICAL EXAM: The practical exam will require the operator to demonstrate the ability to perform daily peening tasks. Testing will cover such tasks as; reading and interpreting shot peen parameters, running Almen tests, generating and interpreting saturation curves, etc. The same failure and retest criteria outlined in para 8.12.4 will apply.

8.12.6 INTERIM TESTING: If given due cause, an operator may be tested at any time between recertification periods. In the event that the operator fails to meet minimum established requirements, a thirty day peening disqualification will result. After the 30 day period, the operator may retest. A second failure will be cause for revocation of certification.

8.13 **RELATED INFORMATION:**

8.13.1 DEPTH OF COMPRESSIVE LAYER: The table below shows typical depths (inch) of compressive stress for common materials:

			DEPTH	
MATERIAL	INTENSITY:	8N	8A	8C
Aluminum alloys		0.003	0.010	0.027
Titanium alloys		0.002	0.007	0.018
Steel (under 200 ksi UTS)		0.003	0.008	0.025
Steel (200 ksi UTS and over)		0.002	0.005	0.015
Nickel alloys		0.002	0.006	0.020

8.13.2 INTENSITY COMPARISONS: Almen test strip "A" is ordinarily used for arc heights up to 0.024 inch; for greater degrees of peening, Almen test strip "C" is used. For intensities below 0.004A, the Almen test strip "N" should be used. For comparison of the nominal intensity designations, the "A" Almen strip deflection may be multiplied by three to obtain the approximate deflection of an "N" Almen strip when peened at the same intensity. The deflection of the "C" Almen test strip may be multiplied by three to obtain the approximate deflection of an "A" Almen strip when peened at the same intensity.

8.13.3 PRECENDENCE OF SPECIFICATIONS: The majority of this Local Process Specification is based on reference (g), which has been invoked by NAVAIR to establish minimum process requirements for computer controlled shot peening. In the event of a problem not addressed within this LPS, reference (g) will apply and take precedence. In the case of conflict, this LPS applies and takes precedence. Any waivers to this specification must be approved by the Materials Engineering Laboratory.

PREPARED BY:

D.W. McKinley
Materials Engineer
Code 34100

APPROVED BY:

F.W. Thomas, Director,
Materials Engineering Div
Code 34000

REVIEWED BY:

J.L. Yadon, Head,
Structural Materials Branch
Code 34100

TABLE 1. Uniformity of shot to be maintained in machine.

Cast shot sizes	Cut wire sizes	Glass bead sizes, max (inches)	Ceramic bead sizes (inches)	Maximum 20% Passing U.S. sieve Number and opening 1/
930	–	.132	–	8(.0937)
780	–	.111	–	10(.0787)
660	–	.094	–	12(.0661)
550	CW-62	.079	–	14(.0555)
460	CW-54	.066	–	16(.0469)
390	CW-47	.056	–	18(.0394)
330	CW-41	.047	0.046	20(.0331)
–	CW-35	–	–	20(.0331)
280	CW-32	.039	–	25(.0278)
230	CW-28	.0331	0.033	30(.0234)
190	CW-23	.0278	–	35(.0197)
170	CW-20	.0234	0.024	40(.0165)
130	–	.0197	–	45(.0139)
110	–	.0165	0.017	50(.0117)
70	–	.0139	–	60(.0098)
–	–	.0117	0.012	70(.0083)
–	–	.0098	–	80(.0070)
–	–	.0083	0.008	100(.0059)
–	–	.0070	–	120(.0049)

1/ Sieve numbers specified in RR-S-366, number in parenthesis represents sieve opening size (inches).

TABLE 2. Numbers and screening tolerances for cast and wrought shot.

Peening Shot		All pass U.S. sieve Number and opening 1/	Max 2% on U.S. sieve Number and opening 1/	Max. 50% on U.S. sieve Number and opening 1/	Cumulative min. 90% on U.S. sieve Number and opening 1/	Cumulative min. 98% on U.S. sieve Number and opening 1/
930	-	5 (.157)	6 (.132)	7 (.11)	8 (.0937)	10 (.0787)
780	-	6 (.132)	7 (.11)	8 (.0937)	10 (.0787)	12 (.0661)
660	-	7 (.11)	8 (.0937)	10 (.0787)	12 (.0661)	14 (.0555)
550	CW-62	8 (.0937)	10 (.0787)	12 (.0661)	14 (.0555)	16 (.0469)
460	CW-54	10 (.0787)	12 (.0661)	14 (.0555)	16 (.0469)	18 (.0394)
390	CW-47	12 (.0661)	14 (.0555)	16 (.0469)	18 (.0394)	20 (.0331)
330	CW-41	14 (.0555)	16 (.0469)	18 (.0394)	20 (.0331)	25 (.0278)
280	CW-35	16 (.0469)	18 (.0394)	20 (.0331)	25 (.0278)	30 (.0234)
230	CW-32	18 (.0394)	20 (.0331)	25 (.0278)	30 (.0234)	35 (.0197)
190	CW-28	20 (.0331)	25 (.0278)	30 (.0234)	35 (.0197)	40 (.0165)
170	CW-23	25 (.0278)	30 (.0234)	35 (.0197)	40 (.0165)	45 (.0139)
130	CW-20	30 (.0234)	35 (.0197)	40 (.0165)	45 (.0139)	50 (.0117)
110	-	35 (.0197)	40 (.0165)	45 (.0139)	50 (.0117)	80 (.0070)
70	-	40 (.0165)	45 (.0139)	50 (.0117)	80 (.0070)	120 (.0049)

1/ Sieve numbers specified in RR-S-366, number in parenthesis represents sieve opening size (inches).

TABLE 3 - Shot Sizes and Intensities for Steel and Titanium Parts.

MATERIAL (1)	Material Thickness 0.090 to 0.375 Inch Inclusive (2.29 to 9.52 mm) Shot Size	Material Thickness 0.090 to 0.375 Inch Inclusive (2.29 to 9.52 mm) Intensity	Material Thickness Over 0.375 (2.29 to 9.52 mm) Shot Size	Material Thickness Over 0.375 (2.29 to 9.52 mm Intensity
Titanium Alloys	110, 170	6 to 10A	110, 170	6 to 10A
Steel, minimum tensile strength 200 ksi (1379 MPa) and Under	230, 330	8 to 12A	230, 330	10 to 14A
Steel, minimum tensile strength over 200 to 260 ksi (1379 to 1793 MPa), incl	170, 230	8 to 12A	230, 330	12 to 16A
All Alloys	Holes Under 0.750 inch (19.05 mm) diameter: 70, 110 Shot at 10 to 15N.			

NOTES: 1. Any shot size and intensity specified on the engineering drawing shall take precedence.

2. Sizes in Table 3 are for ASR (cast steel shot, regular) and ASH (cast steel shot, hard). Equivalent sizes of other media, in accordance with AMS-2431, shall be used when shown on part engineering drawing.

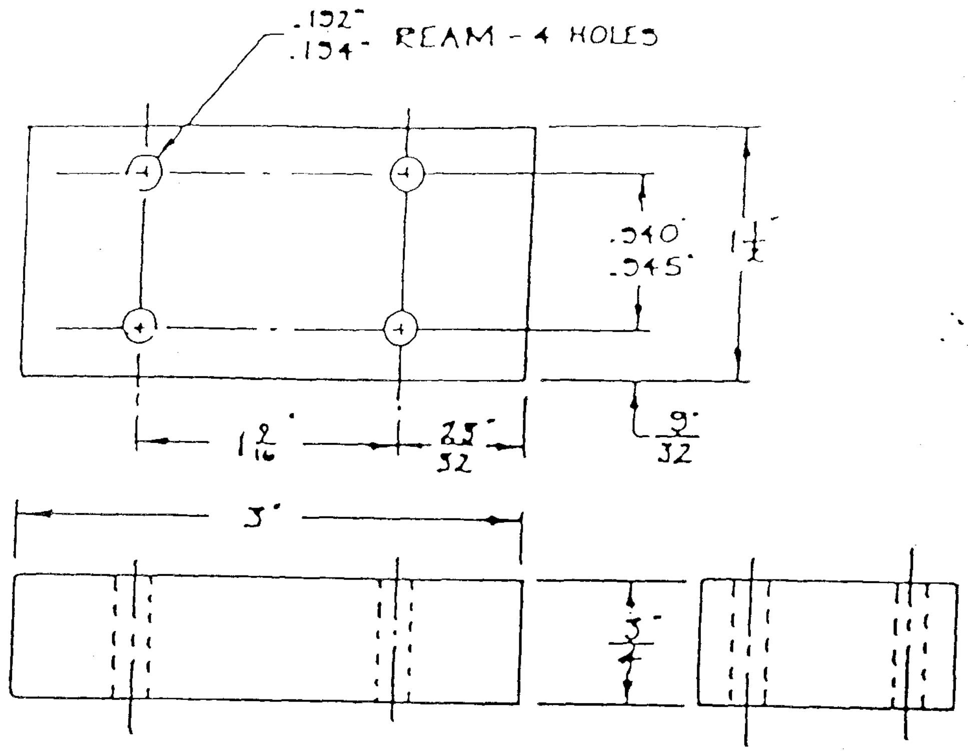
Table 3.

TABLE 4 - Shot Sizes and Intensities for Aluminum Parts,

Areas to be Peened	Intensity (1)	Shot Size (1)
Sections over 0.375 inch (9.52 mm)	10 to 14A	230, 330
Sections 0.090 to 0.375 inch (2.29 to 9.52 mm), incl, in thickness	6 to 10A	170, 230
Holes under 0.735 inch (18.67 mm) in diameter	10 to 15N	70, 130

NOTES: 1. Any shot size and intensity specified on the engineering drawing shall take precedence.

2. Sizes in Table 4 are for ASR (cast steel shot, regular) and ASH (cast steel shot, hard). Equivalent sizes of other media, in accordance with AMS 2431, shall be used when shown on part engineering drawing.



Holding fixture.

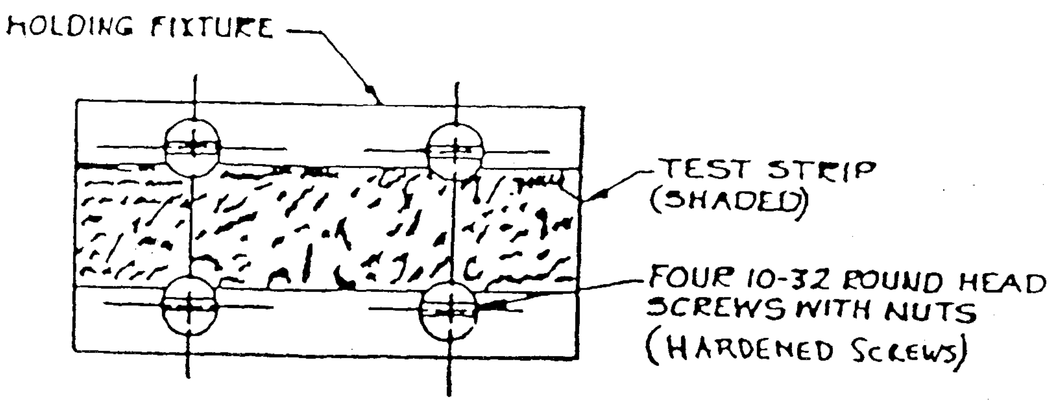


FIGURE 1. Assembled test strip and holding fixture.

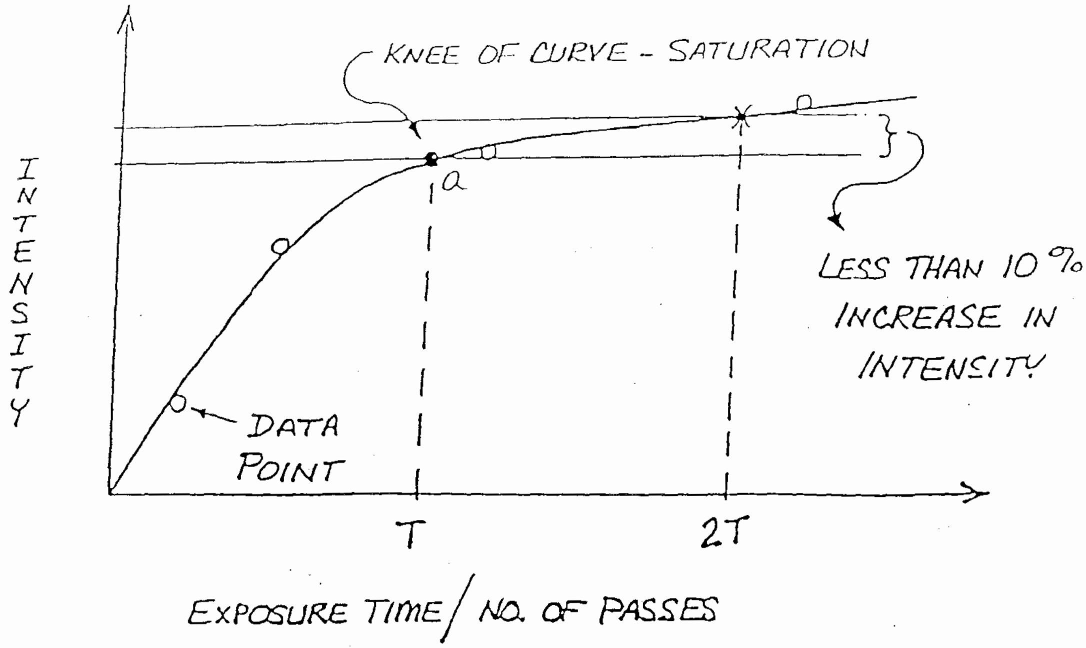


Figure 2. PEENING SATURATION INTENSITY CURVE

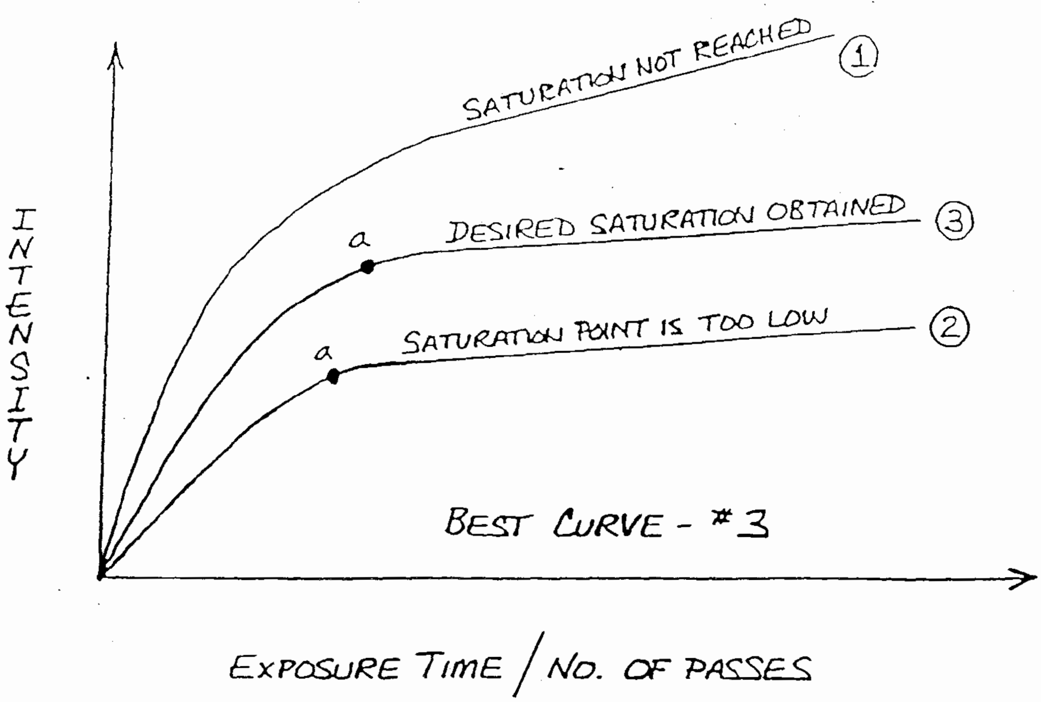


Figure 3. VARIOUS SATURATION CURVES GENERATED TO OBTAIN THE DESIRED RANGE.

SHOT PEEN PROCEDURE SHEET,
For Documentation of Peening Set-up Parameters
Parameter List, Sheet 1 of 3

Procedure Sheet Number ________________ Approval Date ________________

Operator Name ______________________ Certification Number ____________

Computer Program Name/Number (if applicable) ________________________________

Part Number and Nomenclature ____

Part Material and Spec. ____________________ Material Hardness ______________

Aircraft or Engine Type ____________ Peening Machine Identification ______________

Fixture ID Numbers (list all fixtures for: Almen strips, parts, nozzles, masking, etc.):

____

____

____

Number of Almen Test Block Locations on Test Fixture ___________________________

Shot Flow Rate (per nozzle) ____

Nozzle Orifice Size ____________ Nozzle Angle of Impingement _________________

Nozzle-to-part Distance ___________ Shot Type and Size ______________________

Air Flow (per nozzle) _______________ Air Pressure (per nozzle) _________________

Speed and Direction of Part, in Translation and Rotation ___________________________

Cycle Time for Peening of Part _____________ Coverage Requirements ______________

Specified Intensity Range _____________ A C N Target Intensity __________ A C N

Prepeening Cleaning and Other Preparatory Requirements __________________________

____

Postpeening Cleaning Requirements _______________________________________

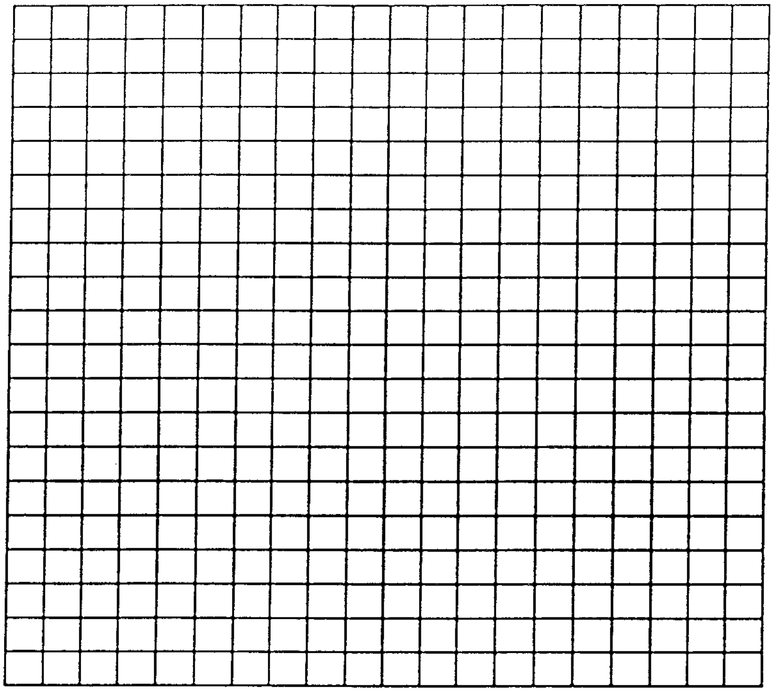
Comments:

Figure 4. Shot Peen Procedure Sheet.

SHOT PEEN PROCEDURE SHEET,

Saturation Curve, Sheet 2 of 3

(NOTE: Use a separate sheet for each Almen strip location)



EXPOSURE TIME (NO. OF PASSES, SECONDS, OR CYCLES)

Almen strip location ____________________________

Saturation curve data:

Time 1: ______________	Arc Height: ____________	A C N
Time 2: ______________	Arc Height: ____________	A C N
Time 3: ______________	Arc Height: ____________	A C N
Time 4: ______________	Arc Height: ____________	A C N
Time 5: ______________	Arc Height: ____________	A C N
Time 6: ______________	Arc Height: ____________	A C N
Time 7: ______________	Arc Height: ____________	A C N
Time 8: ______________	Arc Height: ____________	A C N
Time 9: ______________	Arc Height: ____________	A C N
Time 10: _____________	Arc Height: ____________	A C N
Time 11: _____________	Arc Height: ____________	A C N
Time 12: _____________	Arc Height: ____________	A C N

Saturation intensity of __________ A C N was obtained with exposure time of ______________

Required coverage obtained with exposure time of _______________

Comments:

Figure 4. (Continued).

SHOT PEEN PROCEDURE SHEET,

Sketch of Part, Sheet 3 of 3

(To include nozzle positions, Almen strip locations, and masked areas. Use multiple sheets as required)

Comments:

Figure 4. (Continued).

SHOT PEEN PROCESS SHEET
For Daily Record Keeping of Shot Peen Work

Process Sheet Serial Number ______________ (i.e., 001-95)

Shot Peen Operator Name __________________ Certification Number _____________

Number of Procedure Sheet Corresponding to This Task ___________________________

Part Nomenclature ____

Part Number ____

Part Serial Number(s)

____

____

(Continue on back if necessary).

Aircraft or Engine Type _______________________

Required Intensity Range _____________ A C N

Using the part's Procedure sheet, list the saturation curve intensity value for each Almen strip location:

____

After running verification Almen strips, record the intensity verification values which correspond to the Almen strip locations. These values should be within +/- 0.001 of the above values.

____

Does the verification strip arc height match the saturation curve intensity for each location? If so, proceed with peening of production part. If not, take corrective action or call Engineering.

Comments:

Figure 5. Shot Peen Daily Process Sheet.