The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J2441

ISSUED AUG2000

Issued 2000-08

Submitted for recognition as an American National Standard

Shot Peening

1. Scope

1.1 Form—This SAE Standard covers the engineering requirements for peening surfaces of parts by impingement of metallic shot, glass beads, or ceramic shot.

1.2 Application—To induce residual compressive stress in surface layers of parts, thereby increasing fatigue strength and resistance to stress-corrosion cracking.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply. The applicable issue of other publications shall be the latest revision.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J441—Cut Wire Shot
SAE J442—Test Strip, Holder, and Gage for Shot Peening
SAE J443—Procedures for Using Standard Shot Peening Test Strip
SAE J444—Cast Shot and Grit Size Specifications Peening and Cleaning
SAE J445—Metallic Shot and Grit Mechanical Testing
SAE J827—High-Carbon Cast-Steel Shot
SAE J1173—Size Classification and Characteristics of Glass Beads for Peening
SAE J1830—Ceramic
SAE J2175—Specifications for Low Carbon Cast Steel Shot
SAE J2277—Shot Peening Coverage

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive West Conshohocken, PA 19428-2959.

ASTM E 18—Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 11—Standard Specification for Wire Cloth and Sieves for Testing Purposes

3. Technical Requirements

3.1 Material

3.1.1 MEDIA—As received peening media shall conform to the requirements of SAE J441, J444, J827, J2175, J1173, and J1830.

3.1.1.1 Metallic shot may be used for peening to intensities requiring use of "N," "A," and "C" Almen test strips.

3.1.1.2 Glass beads may be used for peening to intensities requiring use of the "N" test strip.

3.1.1.3 Ceramic shot may be used for peening to both "A" and "N" intensities.

3.1.2 MEDIA MAINTENANCE

3.1.2.1 Media uniformity shall be in accordance with Table 1. Inspection shall be conducted in accordance with 4.3.3.

TABLE 1—SIZE UNIFORMITY REQUIREMENTS OF MEDIA IN MACHINE

Cast Shot Sizes - J444	Cut Wire Sizes - J441	Glass Bead Sizes - SAE J1173	Ceramic Shot Sizes - SAE J1830	0.5% Maximum (by weight) Retained on US Sieve(1) Size mm (in)	Maximum 20% (by Weight) Passing US Sieve(1) Size mm (in)
S930	—	GB 280	—	4.00 (0.157)	2.36 (0.0937)
S780	—	GB 235	—	3.35 (0.132)	2.00 (0.0787)
S660	—	GB 200	—	2.80 (0.110)	1.70 (0.0661)
S550	SCW/CW-62	GB 170	—	2.36 (0.0937)	1.40 (0.0555)
S460	SCW/CW-54	GB 140	—	2.00 (0.0787)	1.18 (0.0469)
S390	SCW/CW-47	GB 120	—	1.70 (0.0661)	1.00 (0.0394)
S330	SCW/CW-41	GB 100	Z 850	1.40 (0.0555)	0.850 (0.0331)
—	SCW/CW-35	—	—	1.18 (0.0469)	0.710 (0.0278)
S280	SCW/CW-32	GB 85	—	1.18 (0.0469)	0.710 (0.0278)
S230	SCW/CW-28	GB 70	Z 600	1.00 (0.0394)	0.600 (0.0234)
—	SCW/CW-23	GB 60	—	0.850 (0.0331)	0.500 (0.0197)
S170	SCW/CW-20	GB 50	Z 425	0.710 (0.0278)	0.425 (0.0165)
—	SCW/CW-17	GB 40	—	0.600 (0.0234)	0.355 (0.0139)
S110	SCW/CW-14	GB 35	Z 300	0.500 (0.0197)	0.300 (0.0117)
—	—	GB 30	—	0.425 (0.0165)	0.250 (0.0098)
—	—	GB 25	Z 210	0.355 (0.0139)	0.212 (0.0083)
—	—	GB 20	—	0.300 (0.0117)	0.180 (0.0070)
S70	AWC-12	—	—	0.425 (0.0165)	0.180 (0.0070)
—	—-	GB 18	Z 150	0.250 (0.0098)	0.150 (0.0059)
—	—	GB 15	—-	0.212 (0.0083)	0.125 (0.0049)
—	—	GB 12	—	0.180 (0.0070)	0.106 (0.0041)
—	—	GB 10	—	0.150 (0.0059)	0.090 (0.0035)
—	—	GB 9	—	0.125 (0.0049)	0.075 (0.0029)
—	—	GB 8	—	0.106 (0.0041)	0.063 (0.0025)
—	—	GB 6	—	0.090 (0.0035)	0.053 (0.0021)

1. Test Sieve specified in ASTM E 11.

3.2 Equipment

3.2.1 PEENING MACHINE

3.2.1.1 Pneumatic and centrifugal machines shall be used to peen parts. Peening streams should have an angle of impingement of 45 to 85 degrees to the areas to be peened. Air pressure or wheel speeds shall be adjusted to yield designated intensities.

3.2.1.2 The peening machine shall provide means of propelling, at a controlled rate, dry metallic shot by air pressure or centrifugal force, or propelling dry or wet glass beads or ceramic shot by air pressure, against the work, and means of uniformly moving the work through the shot or bead stream in either translation, rotation, or both as required. The nozzles and/or the work shall be held and moved mechanically unless purchaser permits manual movement.

3.2.1.3 Unless otherwise specified, equipment for dry peening with either shot or beads should include a separator for size control and contaminant removal. The separator should provide means for removal of fine, broken or defective shot or beads during peening.

3.2.1.4 Each machine shall be qualified for each part number. Either a scrap piece or representative fixture shall be fitted with sufficient test strip holders oriented essentially in the same manner, with the same surrounding features-as the part, to represent the actual designated surface. A saturation curve shall be established for each test strip location. Saturation shall be determined using SAE J443. The test strip fixture employed shall be used to verify specified intensity with every batch of parts during peening as required by 4.1.2.

3.2.2 TEST STRIP, HOLDER AND GAGE—Shall conform to SAE J442 and utilized per SAE J443.

3.2.2.1 In locations where standard test strips cannot be placed to accurately reflect the peening intensity, shaded test strips (as defined in SAE J442) may be used. The response of shaded strips shall be correlated to a standard unshaded strip.

3.3 Preparation

3.3.1 PREPARATION OF PARTS—Parts shall be free of grease, dirt, oil, corrosion, and corrosion-preventive coatings such as anodic coatings, plating, and paint. Areas of the part or workpiece, which are designated to be free from any shot peening marks, shall be suitably masked or otherwise handled to protect such surfaces from the peening stream.

3.3.1.1 Parts shall be suitably mounted and masked as required for peening. Parts shall be free from externally applied loads or forces during shot peening other than normal fixturing in supported areas. Parts to be stress peened shall be loaded in suitable fixturing designed to apply specified pre-peening stresses.

3.4 Procedure

3.4.1 Parts shall be peened on all areas specified on the engineering drawing.

3.4.2 The phrase “peening optional” shall mean that peening on areas so indicated is optional and may have complete, partial, or no coverage.

3.5 Post Peening Treatment

3.5.1 After peening and removal of protective masks, shot or beads and fragments shall be removed from surfaces of parts by a method which will not damage surfaces.

3.5.2 Straightening of peened parts is prohibited, unless otherwise specified.

3.5.3 Subsequent processing for metal removal, such as honing, lapping, or polishing, shall be performed only when specified on the engineering drawing.

3.5.4 Parts shall be protected from corrosion until protective coating or packaging is completed. The method of protection shall be as specified by the responsible authority.

3.6 Properties

3.6.1 COVERAGE—Surfaces, which have been peened, shall show complete coverage as defined in SAE J2277.

3.6.2 INTENSITY—Peening intensity shall be as specified on the engineering drawing, determined in accordance with SAE J443.

3.7 Tolerances—Unless otherwise specified, variation from the specified (minimum) peening intensity shall be –0, +40% to the nearest unit, but in no case less than 0.08 mm (0.003 in). Thus, a specified peening intensity of 0.15 mm (0.006 inches) A, denotes an arc height of 0.15 to 0.23 mm (0.006 to 0.009 in) on the “A” specimen and a specified peening intensity of 0.36 N denotes an arc height of 0.36 to 0.51 mm (0.014 to 0.020 in) on the “N” specimen. Unless otherwise specified, the variation in boundaries of areas to be peened, when limited, shall be –0 to +3.18 mm (–0 to +0.125 in).

4. Quality Assurance Provisions

4.1 Sampling and Testing—A lot shall be all parts in a production run that are peened in one setup of the machine using the same test piece fixture and the same peening parameters and in increments of not more than eight hours of machine operation.

4.1.1 COVERAGE AND APPEARANCE—Each manually peened part and representative parts from each lot of mechanically peened parts shall be inspected for coverage and appearance by one of the following methods defined in SAE J2277.

4.1.2 INTENSITY VERIFICATION

4.1.2.1 At least one Almen strip shall be used to confirm intensity, at each location, at the beginning and end of each lot, and shall be within the tolerance specification on the drawing.

4.1.2.2 For a continuous production operation, the intensity shall be determined:

When the size or type of media in the machine is changed
At least every 8 h for metallic shot
At least every 2 h for nonmetallic shot

4.1.3 MEDIA MAINTENANCE

4.1.3.1 At least one determination for shot size and uniformity shall be made when the size or type of media in the machine is changed, every 8 h of continuous machine operation with metallic shot, and every 2 h for nonmetallic shot.

4.1.3.2 *Shape*—It is permissible for a maximum of 10% of the particles in a representative sample to be broken.

4.1.3.3 *For Wet Bead Peening*—The entire slurry shall be changed often enough that the peening intensity under any given set of parameters remains within established limits for that set of parameters. Fresh beads may be added only once between changes of the entire slurry to maintain the peening intensity.

4.2 Approval

4.2.1 The supplier quality system to insure compliance to this specification shall be approved by the responsible authority before parts for production use are supplied.

4.2.2 The supplier shall establish, for each part number, parameters for the critical items of processing which will produce acceptable peened parts; these shall constitute the approved peening procedures and shall be used for peening production parts (quality plan).

4.2.2.1 Parameters for the critical items of processing include, but are not limited to, the following:

Type of machine (pneumatic or centrifugal)
Number of nozzles or wheels
Size of nozzles or wheels
Nozzle or control cage and wheel position
Air pressure or wheel speed in rpm
Media, hardness size and material
Speed of work movement in translation and rotation
Placement of test strips in relation to the work
Time to peen part
Media metering orifice or flow rate setting
Centrifugal Machine - Flow Rate and/or ammeter reading
Required test strip type
Holding and masking fixture
Intensity
Percent Coverage
Control program reference number (if applicable)

4.2.2.1.1 Any of the previous items of processing for which parameters are considered proprietary by the processing vendor may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.3 Test Methods

4.3.1 COVERAGE—Shall be determined in accordance with SAE J2277.

4.3.2 INTENSITY—Shall be determined in accordance with SAE J443.

4.3.3 MEDIA UNIFORMITY—Shall be determined using the sampling and sieving procedures defined in SAE J444.

4.4 Certification of Conformance—The processing supplier shall furnish with each shipment, if required, a report stating that the parts have been processed and tested in accordance with specified requirements and that they conform to the technical requirements. This report shall include the purchase order number, lot number, part number, serial numbers (if assigned), number of parts, supplier's procedure number.

5. Preparation for Delivery

5.1 Peened parts shall be handled and packaged to ensure that the required physical characteristics and properties of the peened parts are preserved.

5.2 Packages of peened parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery.

6. Acknowledgment—A supplier shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. Rejections—Parts on which peening does not conform to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. Notes

8.1 Information recommended for the Engineering Drawing:

8.1.1 A note specifying shot peening in accordance with SAE J2441.

8.1.2 Defined peening conditions such as areas to be peened, type of media and size, Almen intensity, location of Almen intensity verification, if required, wet peening, areas to be masked, and areas where peening is optional.

8.1.3 When it is impractical to mask or otherwise protect areas designated to be free from shot peening marks, sufficient stock to be provided in these areas for subsequent removal of affected material for compliance with dimensional requirements of the applicable drawing.

8.1.4 All heat treatment to meet requirements for mechanical properties should be completed prior to peening.

8.1.4.1 When such processing is performed, it should be controlled such that surface temperatures should not be so high as to reduce stresses imposed by peening or to adversely affect the mechanical properties of the material. Examples of temperature limits (maximum temperature including tolerance) are shown in Table 2.

TABLE 2—MAXIMUM TEMPERATURE LIMITS FOR PEENED PARTS

Alloy	Maximum Temperature
Low-alloy Steels	246 °C (475 °F)
Corrosion-Resistant Steels	399 °C (750 °F)
Aluminum Alloys	93 °C (200 °F)
Titanium Alloys	246 °C (475 °F)
Magnesium Alloys	93 °C (200 °F)
Nickel and Cobalt Alloys	538 °C (1000 °F)

8.1.5 All machining of areas to be peened should be completed, all fillets should be properly formed, all burrs should be removed, and edges and corners to be peened should be rounded.

8.1.6 When magnetic particle or fluorescent penetrant inspection is required, parts should be subjected to such inspection before being peened.

8.1.7 Areas specified not to be peened may either be masked from the peening stream or they may be peened if subsequent machining operations remove the effects of peening on such areas.

8.1.8 Metal removal after peening will be allowed as approved by the responsible authority.

8.1.9 Aluminum alloy, magnesium alloy, corrosion-resistant alloy, and titanium alloy parts, which have been steel shot peened with carbon steel media, may require cleaning by suitable methods to remove iron contaminants.

8.1.10 If fillet radii on parts are required to be peened, the shot or bead size used should be such that the shot or bead nominal diameter is not greater than one-half the smallest nominal fillet radius to be peened, except that the nominal diameter of the shot need not be smaller than 0.18 mm (0.007 in) and the nominal diameter of beads need not be smaller than 0.05 mm (0.002 in). If the shot or beads must pass through recesses or apertures to peen required surfaces, the nominal diameter of the shot or beads should be not greater than 25% of the width of the opening, except that the limitations as to minimum shot and bead size specified previously for peening fillets should also apply.

8.1.11 When peening with cut wire shot, edges of shot will be prerounded.

8.1.12 The hardness of the peening media should be approximately equal to, or harder than the hardness of the peened part.

8.2 Key Words—Metallic shot, glass shot, ceramic shot, surface stress, shot peening, shot peening intensity, coverage, saturation, fatigue strength, stress corrosion cracking.

PREPARED BY THE SAE FATIGUE, DESIGN, AND EVALUATION COMMITTEE

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—To induce residual compressive stress in surface layers of parts, thereby increasing fatigue strength and resistance to stress-corrosion cracking.

Reference Section

SAE J441—Cut Wire Shot

SAE J442—Test Strip, Holder, and Gage for Shot Peening

SAE J443—Procedures for Using Standard Shot Peening Test Strip

SAE J444—Cast Shot and Grit Size Specifications Peening and Cleaning

SAE J445—Metallic Shot and Grit Mechanical Testing

SAE J827—High-Carbon Cast-Steel Shot

SAE J1173—Size Classification and Characteristics of Glass Beads for Peening

SAE J1830—Ceramic

SAE J2175—Specifications for Low Carbon Cast Steel Shot

SAE J2277—Shot Peening Coverage

ASTM E 18—Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

ASTM E 11—Standard Specification for Wire Cloth and Sieves for Testing Purposes

Developed by the SAE Fatigue, Design, and Evaluation Committee