SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Procedures for Using Standard Shot Peening Almen Test Strip

RATIONALE

A new procedure for developing correlation charts for both sub-size Almen strips and shaded Almen strips.

1. SCOPE

1.1 Purpose

This SAE Recommended Practice Specification provides the procedures for using test strips per SAE J442 for peening processes.

1.2 Application

1.2.1 Test strips are used to generate saturation curves in order to determine intensity as a means of verifying the repeatability of a peening process.

1.2.2 The process of shot peening or other peening processes cannot, at present, be adequately controlled by nondestructive inspection of the peened parts; therefore, it is necessary to control the process itself to achieve consistent, reliable results. The use of Almen test strips with this recommended practice is a method of measuring and verifying the peening process.

2. REFERENCES

2.1 Applicable Documents

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.

2.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2590 Rotary Flap Peening of Metal Parts

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

SAE J2277 Shot Peening Coverage Determination

SAE J2597 Computer Generated Shot Peening Saturation Curves

SAE HS-84 “SAE Manual on Shot Peening,” (Warrendale, Society of Automotive Engineers, Inc., 2001).

3. TECHNICAL REQUIREMENTS

3.1 Peening Intensity

Intensity is a function of the mass, the hardness, the velocity and the impingement angle of the shot and the distance traveled by the shot stream to the peened surface of an Almen test strip. For each set of peening parameters with a given media, an intensity value can be derived and documented.

3.2 Saturation Curve

A saturation curve, which is a plot of test strip arc heights versus the duration of the exposure to the shot stream, is used to derive the peening intensity for a set of peening parameters. The saturation curve is developed from data points obtained by peening a series of Almen test strips while varying only the exposure. The exposure may be time-based (minutes, seconds, or inverse feed rate) or increment-based (number of passes, rotations or cycles). In general, these points define a typical curve with a shape as exemplified in Figure 1 (Type 1). In some cases, saturation curves can appear as exemplified in Figure 2 (Type 2) and occur only when process variables do not permit the attainment of earlier data points.

The arc height value on the curve that increases by 10% when the exposure time is doubled is declared to be the intensity. The exposure time associated with the intensity value is designated as ‘T’. The exposure time at which the arc height increases by 10% is designated as ‘2T’. The use of computer-generated saturation curves that comply with SAE J2597 is recommended.

In cases where it appears that a data point is erroneous, it is permissible to repeat that test. If the same erroneous value is achieved, then the machine parameters shall be evaluated and adjusted as needed and a new saturation curve shall be generated.

Test strips exposed for extended periods can exhibit arc heights significantly greater than the “intensity” value. This does not imply that extensively long duration peening treatments are in violation of intensity requirements. Intensity is a value derived from a saturation curve and is constant for a given set of machine parameters, regardless of peening time.

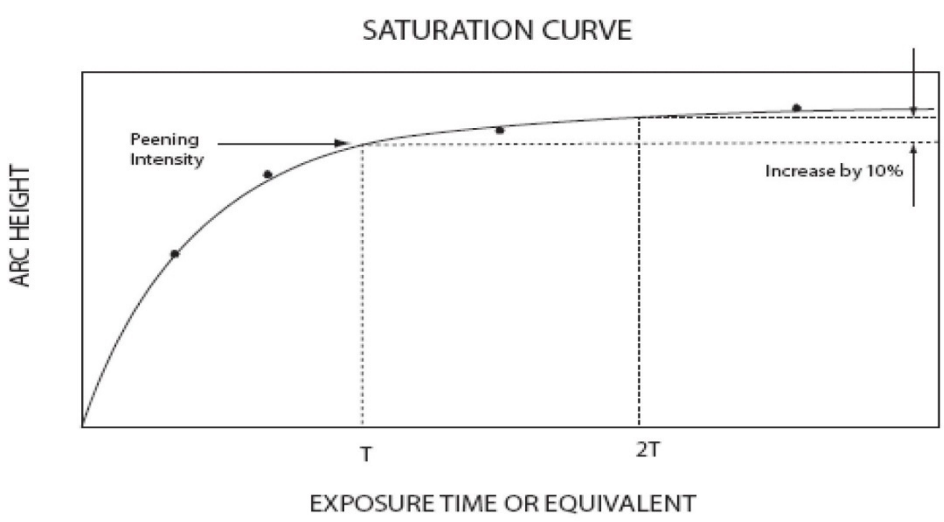

Figure 1 - Time based saturation curve (Type 1)

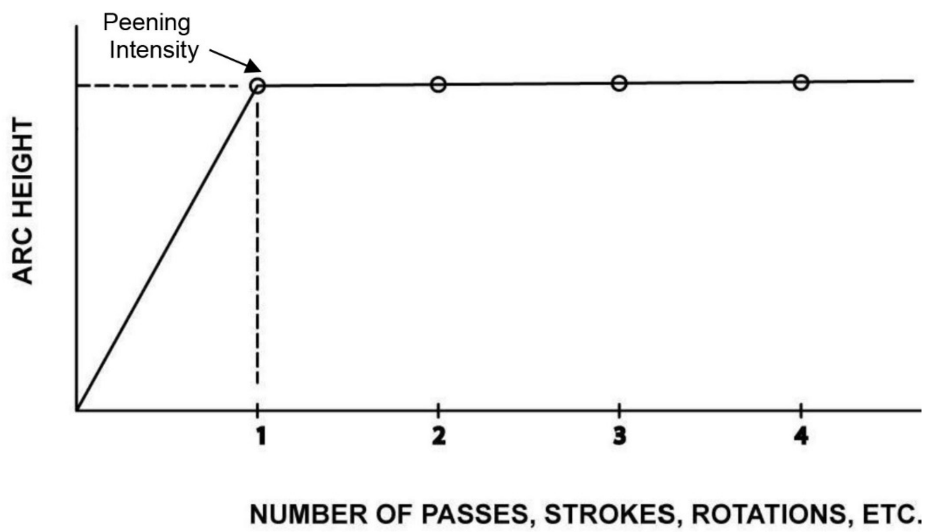

Figure 2 - Incremental based saturation curve (Type 2)

3.3 Intensity Determination Procedure

3.3.1 General

Prior to use, the zero position of the test strip gage shall be checked with the zero block per SAE J442 and adjusted if necessary. The test strips, holder, and gage shall meet the requirements of SAE J442. Pre-bow measurements may be documented prior to peening and then used to provide net arc height measurements after peening.

3.3.2 Verify that the test strip holder meets the flatness requirements of SAE J442. Fasten the test strip tightly and centrally to the test strip holder. Avoid entrapment of any foreign material beneath the test strip.

3.3.3 Expose the outer (top) surface of the test strip (see SAE J442) to the peening stream to be measured. Record the time of exposure or its equivalent.

3.3.4 Remove the test strip from the holder and verify that the peened side of the test strip exhibits uniformly distributed (see 5.4) dents to assure that the test strip surface area within the hold-down screws has not been blocked from the peening stream. The test strip area under the hold-down screws does not require denting.

3.3.5 Measure the test strip arc height with the indicator tip touching the unpeened side of the test strip. Record the arc height measurement and, if using pre-bow compensation for net arc height response, correct the final arc height by subtracting the pre-bow measurement from the measured arc height (see 5.2.2). When sub-size strips are used, pre-bow compensation must be used due to the relatively low final arc height values.

3.3.6 Using different exposure times or equivalents, without changing any other parameters, repeat 3.3.1 to 3.3.5 using a minimum of 4 test strips to construct a saturation curve similar to Figures 1 or 2. The graph shall be constructed by using a minimum of four arc height measurements (data points) other than zero. Plot the data points and then draw a smooth curve representing the best fit of the data points. Alternatively, the use of computer-generated saturation curves which comply with SAE J2597 is recommended.

3.3.7 Peening intensity is determined by interpreting the saturation curve.

3.3.7.1 For Type 1 saturation curves, the intensity is defined as the arc height value on the curve that increases by 10% when the exposure time is doubled. For Type 2 saturation curves, the intensity is defined as the arc height value of the first data point (i.e., at the minimum possible exposure time, T) provided that the arc height increases by no more than 10% when the exposure time is doubled to time 2T.

3.3.7.2 For an intensity correlation using sub-size strips, a minimum of 4 sub-size test strips are required for the upper and lower intensity limits. Using different exposure times or equivalents, without changing any other parameters, repeat 3.3.1 to 3.3.5 using a minimum of 4 test sub-size strips to construct a saturation curve similar to Figures 1 or 2 for the lower intensity limit. Repeat these procedures for the upper intensity limit.

3.4 INTENSITY DETERMINATION PROCEDURE, GENERAL

The procedure to be used in making a production setup in which a machine setting is to be determined for a desired intensity is described as follows:

3.4.1 For oriented part peening, provide a fixture which supports the test strips in the required verification locations per the engineering drawings or work instruction. The setup shall be qualified by placing the test strip fixtures into the machine in the same orientation to the shot stream as the part is subjected. For batch peening, provide a fixture which supports one or more strips in a static location within the blast stream. Do not allow the holders and strips to tumble in the batch of parts because tumbling can distort the strip performance.

3.4.2 The intensity shall be determined by exposing individual test strips at each location in the test strip fixture for increasing exposure times or equivalent and plotting the results from each location on separate saturation curves. RE-USE OF TEST STRIPS IS NOT PERMITTED EXCEPT WHEN MAGNETIC STRIP HOLDERS ARE USED FOR ROTARY PEENING per AMS2590.

3.4.3 If the intensity derivation obtained from the curve is not within the specified tolerance, changes to the machine settings or shot characteristics (type, size, hardness) allowed by the responsible authority are permissible. Sections 3.4.1 and 3.4.2 shall be repeated until the intensity is within the specified tolerance.

3.5 Verification of Intensity

3.5.1 When the machine settings are found that yield an intensity within the specified tolerance, a means of process verification and control shall be implemented. Intensity verification arc height readings shall be taken at a frequency determined to be appropriate for assuring consistent peening intensity. The frequency of intensity verifications shall not be longer than eight hours of operation Two schemes for intensity confirmation, one involving a single holder and strip, the other involving multiple holders and strips, are offered in 3.5.1.1 and 3.5.1.2. Note that the practice of intensity confirmation does not constitute an intensity determination since this would require development of a full saturation curve per SAE J443 using a minimum of four strips.

3.5.2 When using a single holder on a fixture, a single strip may be used to verify intensity. This strip should, ideally, be exposed for the time T derived from the saturation curve and its arc height shall be within the stated tolerance. In practice, this is not always possible (for example, when integral values of strokes or rotations are used). When that condition occurs, the value used shall be rounded to the nearest practical time to T. An arc height is then obtained from the intersection of the saturation curve with that nearest practical time of T, see Figure 3. This intersection shall be called a “Target Arc Height”. A single strip subsequently peened for the selected nearest practical time must repeat the target arc height to within ±0.038 mm (0.0015 inch) or other value acceptable to the responsible authority.

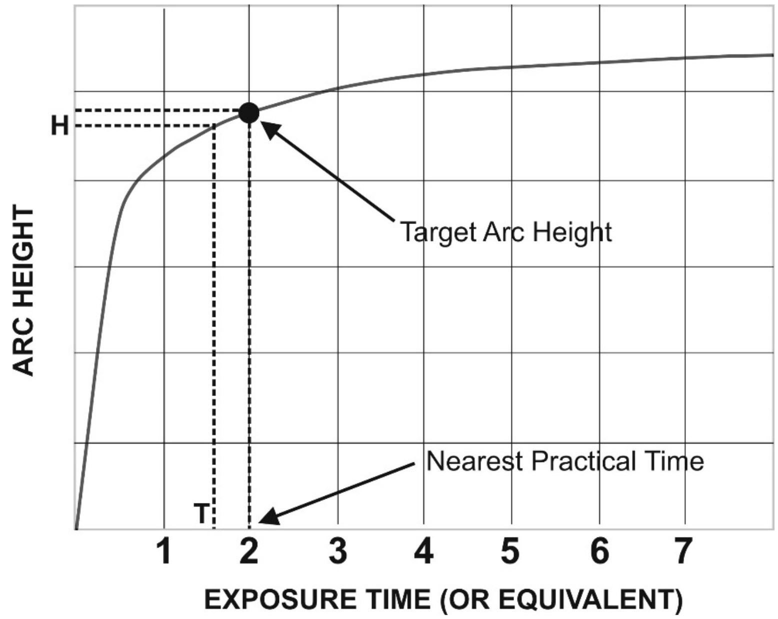

Figure 3 - Target arc height when using nearest practical time

3.5.2.1 Using multiple holders on a fixture will result in various peening intensity times, T. To simplify the verification procedure, a single verification time (or its equivalent) may be selected. This selected verification time may be anywhere between the longest and shortest peening intensity times, T, obtained from the individual saturation curves for the group of holders. New strips shall be placed on each of the holders and exposed for this single selected verification time. The resulting arc height readings of this set of strips shall be recorded as the target arc heights for subsequent verification purposes.

Subsequent verification has to repeat each of the set of target arc height values to within ±0.038 mm (0.0015 inch). The resultant arc height readings do not have to be within the intensity tolerance band for time, T. This is because the single verification time at a given location can be substantially less than or greater than the peening intensity time, T. The purpose of the verification test is to confirm that the arc height at a particular location is consistent. The ability of the test strip to exhibit similar curvature for similar exposure time is sufficient evidence of consistency.

4. DEVELOPING CORRELATION CHARTS

SAE J442 shaded or sub-size test strips require a correlation procedure to the preceding intensity derivation procedure (see SAE HS-84). This procedure shall be used when verifying intensities or arc-heights using sub-size strips or shaded Almen strips, respectively.

4.1 Sub-Size Almen Strip Correlation Development

4.1.1 A correlation chart between standard Almen strip intensities and sub-size Almen strip intensities must be created prior to validation testing using sub-size Almen strips. This correlation chart is created by running a minimum of 4 standard Almen strips and 4 sub-size Almen strips for both the upper and lower intensity limits. The standard and sub-size strips shall be run either simultaneously or separately, without interfering with the peening of other strips, under the same machine parameters. Using different exposure times or equivalents, without changing any other parameters, repeat 3.3.1 to 3.3.5 using a minimum of 4 standard Almen strips and 4 test sub-size strips. Construct a saturation curve using the standard Almen strips similar to Figures 1 or 2 for the lower intensity limit parameters. Construct a similar saturation curve using the sub-size Almen strips under the lower intensity limit parameters. Repeat these procedures for the upper intensity limit. Next, plot this data with the standard Almen strip intensities on one axis and the sub-size test strip intensities on the other axis. This will provide a range of acceptable sub-size intensity values within the allowable tolerance. The calculated sub-size intensity must be correlated back to a standard Almen strip intensity value.

4.1.2 The correlation chart must be recreated after any machine maintenance or critical part replacement on shot peening equipment. The correlation chart is valid only for equivalent shot peening equipment. Adhesive method for sub-size strips must remain constant between the creation of the correlation chart and the sub-size strips used to correlate to the true intensity value.

4.2 Shaded Almen Strip Correlation Development

4.2.1 A correlation chart between standard Almen strip intensities and shaded Almen strip arc-heights must be created prior to validation testing using shaded Almen strips. This correlation chart is created by running a minimum of 4 standard Almen strips for both the upper and lower intensity limits. Using different exposure times or equivalents, without changing any other parameters, repeat 3.3.1 to 3.3.5 using a minimum of 4 standard Almen strips. Construct a saturation curve using the standard Almen strips similar to Figures 1 or 2 for the lower intensity limit parameters. Using the T1 time derived from this curve, run a shaded, or masked, strip under the same parameters used for the creation of the lower intensity limit. This measured arc-height reading will be plotted as a correlated value for the lower intensity limit. Repeat these procedures for the upper intensity limit. The measured shaded strip arc-height will be plotted as a correlated value for the upper intensity limit. The standard Almen strip intensities shall be plotted on one axis and the shaded strip arc-heights on the other axis. This will provide a range of acceptable arc-height values within the allowable tolerance under the same parameters. The measured arc-height value must be correlated back to a standard Almen strip intensity value.

4.2.2 A standard Almen strip shall be shaded, or masked, with an exposed area similar to the peening area of interest. The exposed area on a shaded strip shall be centered along the length of the Almen strip.

4.2.3 The correlation chart must be recreated after any machine maintenance or critical part replacement on shot peening equipment. The correlation chart is valid only for identical exposed shaded strip widths.

5. NOTES

5.1 This report is published by SAE to advance the state of technical and engineering sciences. The use of this Technical Report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising there from, is the sole responsibility of the user.

5.2 Term Clarifications

5.2.1 ARC HEIGHT: A measurement of the curvature of an Almen test strip is the “arc height,” not the “intensity.” Exposing a single test strip does not reveal intensity. Intensity can only be determined from a saturation curve developed by the procedure described in Section 3.

5.2.2 PRE-BOW: The measurement, either positive or negative, of the arc height of an Almen strip prior to peening.

5.2.3 PRE-BOW COMPENSATION: Subtraction of the measured pre-bow from the measured arc height, after peening, to obtain the net change in the arc height from the peening process.

5.3 Almen test strip coverage or time T shall not be associated with part coverage time (see SAE J2277).

5.4 Use of the test strip and inspection for ‘uniformly distributed denting’ in 3.3.4 is to assure that the strip has been peened evenly except in the areas masked by the holding screws by the shot stream. Uniformly distributed denting on the test strip can exhibit partial or full coverage.

5.5 When the test strip type is not specified, it is recommended that the standard Almen test strip A be used for intensities that produce arc heights of 0.10 mm A (0.004 inch A) to 0.60 mm A (0.024 inch A). For intensities below 0.10 mm A (0.004 inch A), the standard N strip is recommended and for intensities above 0.60 mm A (0.024 inch A), the standard C strip is recommended.

5.6 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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