SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Shot Peening Coverage Determination

RATIONALE

The document is being revised to: (1) establish guidelines for visual (magnified) examination to determine coverage. Alternative indirect methods can assist but not necessarily replace visual examination. Revision (2) clarifies that full/coverage allows random unpeened islands smaller than the peening dimples.

1. SCOPE

This SAE recommended practice provides some procedure for determining shot peening coverage and relating coverage to part exposure to the media stream. Effectiveness of shot peening is directly dependent on coverage. Either incomplete or excessive coverage can be detrimental to fatigue strength and life.

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.

2.1.1 SAE Publications

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

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

SAE J443 Procedures for Using Standard Shot Peening Almen Strip

3. COVERAGE

Coverage is related to the duration of part exposure to the media stream, hardness of the part, hardness of the media, and intensity.

Coverage, up to 100%, is defined as the percentage of a surface that has been dented at least once by the peening media. Customarily, coverage estimates are obtained by optically aided visual inspection of the peened part. Estimates of coverage by visual observation are necessarily subjective especially when full coverage is being approached.

Coverage is considered full when approximately 98% of the surface is dented, notwithstanding that both accuracy and repeatability of a 98% estimate are problematic. The important pragmatic criterion for such estimation is that individual unimpacted islands can exist and are permitted provided that they are randomly distributed, and the largest dimension of any single island is less than the typical indentation diameter. Coverage greater than full coverage, when required, is obtained by peening for multiples of the time required for "full coverage". The minimum peening time required to achieve full coverage can be determined by incrementing the peening time until full coverage is deemed to have been obtained. Methods of assessing and predicting coverage are described herein.

4. COVERAGE INSPECTION/DETERMINATION

Coverage determination shall be performed on representative areas of the peened surfaces. These areas can include recesses and shaded regions that are difficult to access. Sampling of peened parts shall be as required by the shot peen process specification or as agreed upon between provider and customer. Coverage customarily is determined by visual inspection; however other methods may be employed.

Coverage inspection methods depend upon many factors primarily the size of the dents. Large dents can be inspected with no optical magnification while small dents can require 10 -30X or higher magnification. For purposes of this recommended practice, coverage inspection methods are classified as direct and indirect.

4.1 Direct Inspection Methods

4.1.1 Optically aided visual

As mentioned previously this method commonly implemented at 10-30X magnification by microscope or hand magnifier is the customary method employed for coverage inspection and estimation. Lower magnification even down to 1X can be possible when dents are large. When dents cannot be otherwise resolved, magnifications greater than 30X can be necessary.

4.1.2 Optical analyzers

Optical analyzing vision recognition instruments may be used for coverage estimation. Such systems must be “trained” in specific situations to provide true coverage estimation because of the effects of differences in surface roughness, reflectivity and geometry which can affect instrument output.

4.2 Indirect Methods

The following methods may be used when agreed between customer and user.

4.2.1 Fluorescent Tracers

These tracers are coatings that are applied to parts before shot peening. After peening the amount of coating removal is a visual indication of the actual part coverage.

4.2.1.1 Prior to peening, coat a representative area of a part or sample piece according to manufacturer's recommended practice. After peening, inspect the peened surfaces with 10x minimum magnification to verify the required level of coverage. Then view the same surfaces under ultraviolet light in a darkened area to determine the amount of tracer removal.

4.2.1.2 The amount of coating removal on subsequently peened parts shall be compared with the amount of coating removal from the sample prepared in 4.1.1. Parts exhibiting more residual fluorescence than the sample piece are inadequately covered, and shall be visually examined with 10x to 30x magnification.

4.2.1.3 Complete tracer removal does not necessarily coincide with full visual coverage

4.2.2 Dye Marker Inks

Dye marker inks may be used in the same manner described for fluorescent tracers with white light inspection.

4.2.3 Replicas

After a part has been shot peened, a replica of the surface can be made and used for clarification of coverage

4.2.4 Coverage Coupon

A coverage coupon is a metal sample heat treated to a hardness similar to the part to be peened which may be used to exhibit coverage. In situations where peening impressions on the coverage coupon are small and therefore not readily observable, such as on high hardness parts or with low intensity peening, striations may be introduced by grinding or sanding the coupon surface prior to peening to facilitate subsequent observation for coverage. Care should be exercised to verify that the coverage rate of the coupon is comparable to the coverage rate of the part to be peened. It should noted that the rate of work-hardening affects rate of coverage. Rate of work-hardening depends on metallurgical characteristics: crystal structure, number of phases, etc. For example austenitic steels generally work-harden more rapidly than ferritic steels. Coupon testing should be restricted to the establishment of the minimum peening time required to achieve a nominal 100% coverage. It is not a substitute for component coverage inspection.

4.3 Part Peening Time Determination

Peening time to reach full coverage of parts is not related to the intensity/saturation times referenced in SAE J443 for Almen strips. That is because parts generally have different shapes, hardness and strain hardening characteristics from those of Almen strips. Soft part surfaces require less peening time than hard part surfaces to achieve full coverage – other factors being unchanged. That is because the size of each indent is larger for soft surfaces.

4.4 Relationship of Coverage to Exposure Time

Equation 1 expresses a relationship between coverage and time of exposure that can be useful for relating coverage to exposure time.

$$C_n = 1 - (1 - C_1)^n \quad \text{(Eq. 1)}$$

where:

C_1 = % coverage (decimal) after 1 cycle
C_n = % coverage (decimal) after n cycles
n = number of cycles (number of passes, number of rotations or uniformly chosen increments of time)

As this expression indicates, coverage approaches 1.0 (100%) as a limit. It is difficult to accurately assess the amount of coverage as coverage approaches 100%. Since coverage approaches 100% as a limit, and since estimates can be made up to and including 98%, 98% is arbitrarily chosen to represent full coverage. Beyond this value, the coverage is expressed as a multiple of the exposure time required to produce 98% coverage. For example 150% or 1.5 coverage represents a condition in which the specimen has been exposed to the blast 1.5 times the exposure required to obtain 98% coverage. A chart plotted to a convenient exposure time scale is shown in Figure 1.

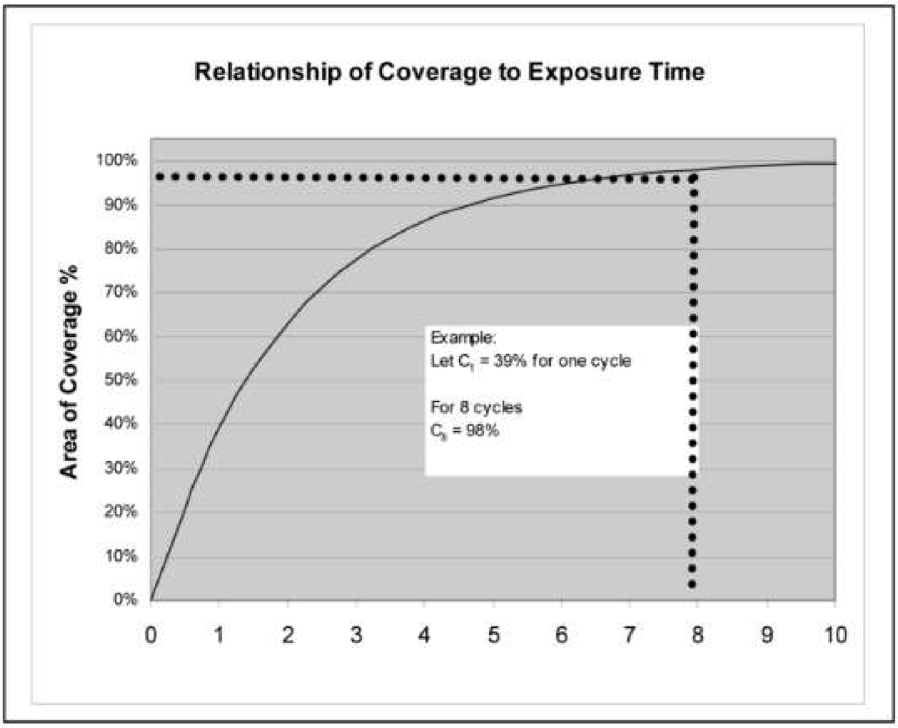

FIGURE 1 - FACTOR OF EXPOSURE TIME, T

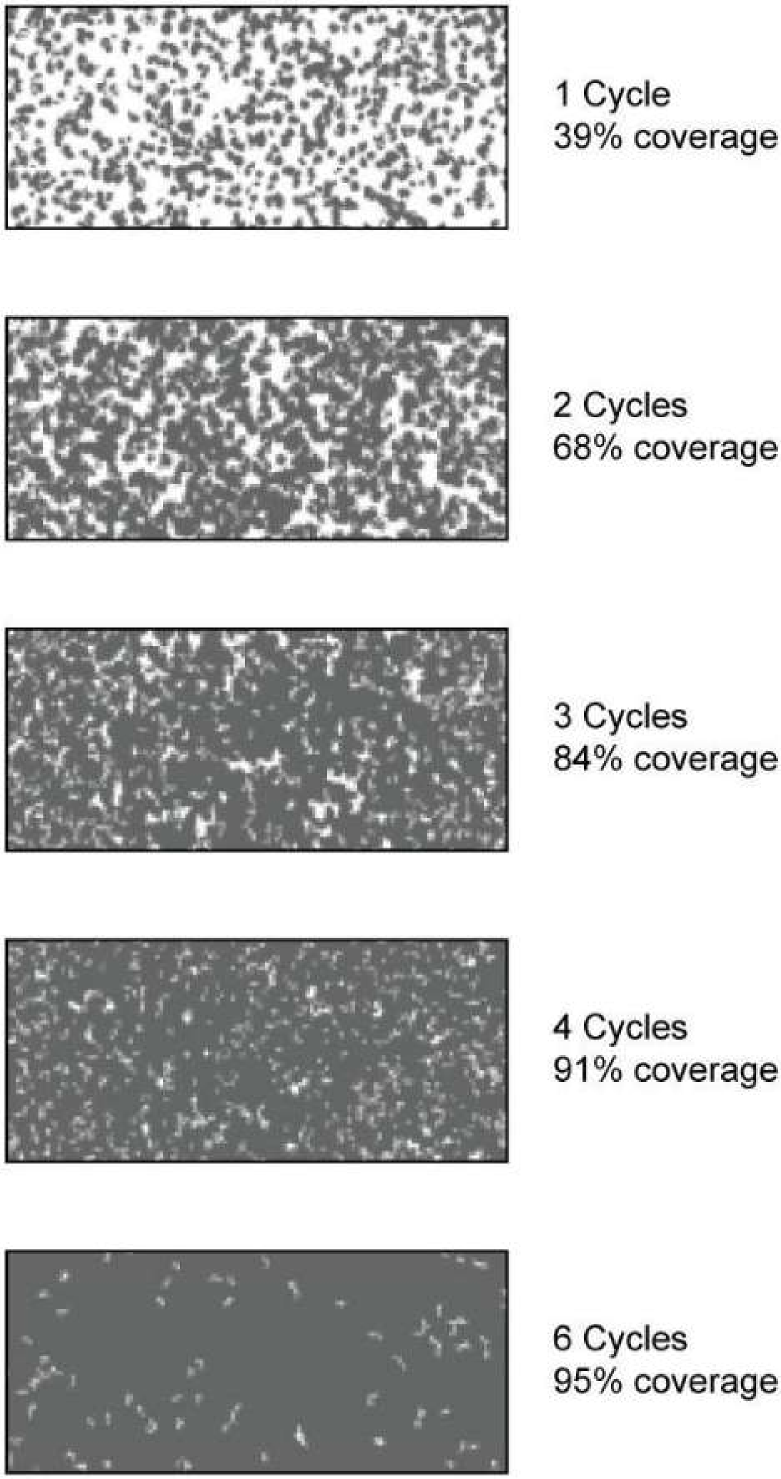

FIGURE 2 - EXAMPLE OF COVERAGE

4.5 Prediction of Passes Required to Achieve 98% Coverage (Full Coverage)

The coverage measured after one pass can be used to predict the number of passes required to achieve 'full coverage' (98%). This is based on the relationship given in 3·2. A graphical representation is given in Figure 3. For example: if one pass gives 80% coverage then three passes should give at least full coverage, if one pass gives 60% coverage then full coverage requires five passes, and if one pass gives 39% coverage then full coverage needs eight passes.

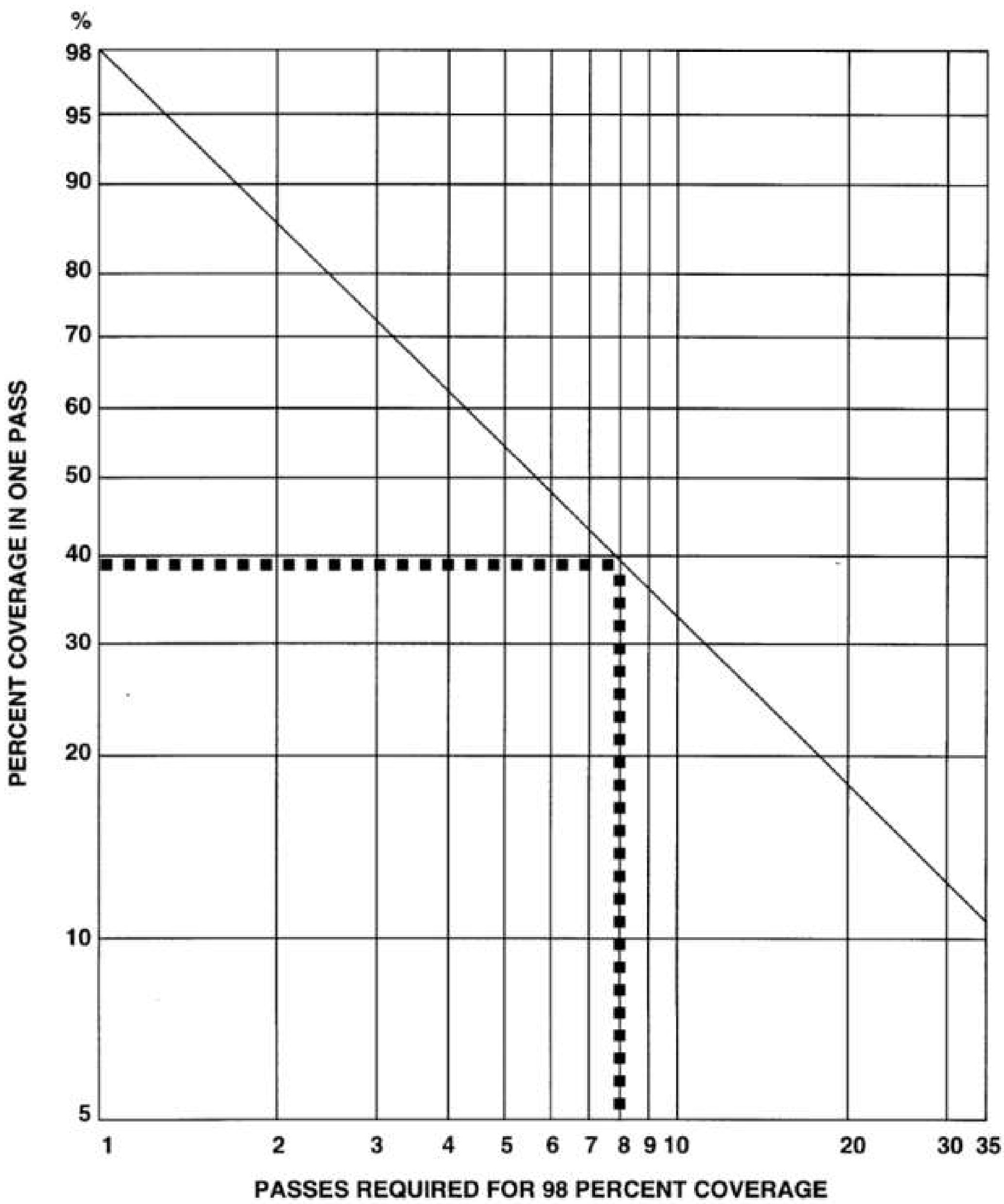

FIGURE 3 - NOMOGRAPH TO PREDICT COVERAGE AFTER EXPOSURE TO ONE PASS

5. NOTES

5.1 Marginal Indicia

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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