# MEDIA SELECTION AND QUALITY

## 1. MEDIA TYPES:

There are a number of types of media used in peening operations to induce favorable compressive stresses in metal parts. among these, the most common are:

*Cast Steel Shot:* The most widely used medium for both ferrous and non-ferrous parts, for all peening intensities.

*Glass Beads:* Generally used when ferrous contamination may be a problem, and when low peening intensity is required.

*Cut Steel Wire Shot:* Used for all ferrous and non-ferrous parts, generally excluding those requiring the use of very small shot.

Stainless Steel Shot, Cast and Wrought is used for peening some non-ferrous and stainless steel parts. Ceramic Shot, generally tougher and much harder than glass beads, is used in applications in which ferrous contamination is a problem. Steel Balls, Carbon and Stainless are used especially in peen forming applications. Other peening media include copper and aluminum shot, gas or centrifugally atomized metallic powders, generally steel and polymers. These are used for special applications. Chilled and malleable iron shots are available, but have generally been replaced by cast steel shot. Ceramic shot is described in SAE specification J1830. Steel balls are described in aerospace materials specification SAE AMS 2431/5.

*Cast Steel Shot:* Manufactured in two different carbon ranges. Cast steel shot containing about 1.0% carbon, described in SAE specification J827 and Military specification MIL-S-851, is available in several hardnesses. Cast steel shot containing about 0.15% carbon, generally referred to as low-carbon shot, is available only at a hardness of about 42 HRC and is described in SAE specification J2175, which has just been approved for publication.

The manufacture of 1.0% carbon shot includes the following steps: Steel scrap is melted in electric furnaces, arc or induction. The composition of the melt is adjusted either in the furnace or a ladle and the melt is deoxidized using a suitable light metal, usually aluminum, or a light metal alloy.
A stream or streams of the melt are disintegrated by a jet or jets of water, or water/air mixture, into random sized droplets which solidify and cool in a water bath.
The shot is dried, austenitized to effect chemical homogeneity and grain size refinement and quenched. The quenched shot, about 65 HRC in hardness, is toughened by tempering to the desired hardness.
The pellets are screened to ranges of sized as described in SAE specification J444, Military specification MIL-S-13165 or special sizes.
Irregular shaped pellets are removed by spiral separators or by moving inclined belts.
Oversize and irregular pellets are crushed, as quenched, into grits.
The manufacture of low-carbon shot is very similar, except that the following steps are omitted: There are no austenitizing and tempering steps, since the hardness as

shotted is about 42 HRC. There is no crushing step, since shot of 42 HRC cannot be crushed easily.

*Glass Beads:* Manufacturing of glass beads includes the following steps: Suitable scrap glass in crushed in hammer mills or other crushers, the resulting fragments are screened to size. The sized fragments are introduced into vertical, gas fired furnaces where they liquefy, permitting surface tension to form the molten fragments into spheres, which are tempered and cooled. The cooled spheres are screened to final size. Irregular pellets and "twins" are removed.
Glass beads are described in SAE specification J1173 and in Military specification MIL-G-9954.

*Cut Steel Wire Shot:* Manufacturing of cut wire shot includes the following steps: Wire of suitable diameter and tensile strength is cut, on rotary shears, into cylinders, whose length is equal to their diameter. The cylinders are subjected to repeated, high velocity impacts, until they are cold worked into spheroids. The spheroids are then screened to remove any tramp materials. SAE specification J441 describes both cut carbon steel wire shot and cut stainless steel wire shot.

## 2. SELECTION OF A STEEL MEDIUM FOR SHOT PEENING / SHOT QUALITY

The selection of the type, size and hardness of the medium for any peening job is in general, dictated by the composition, the dimensions and the hardness of the part being peened. After the medium type has been selected, the cost and uniform effectiveness of the shot peening operation depend on the control of several variables:

*a) The volume of shot thrown*
*b) The shot velocity*
*c) The angle of impact*
*d) The quality of the shot*

Variables A,B and C are equipment related and as such are, or should be, relatively easily controlled by the peening machine operator. The control of variable D however, is exercised by the shot manufacturer.
What is a quality shot? It is a shot of the correct size, the correct hardness, the correct shape, and cost effective durability. Moreover, it is a shot that is uniform in these attributes, shipment after shipment. The following applies to all media, but is especially applicable to steel media.

Shot Size: The size of the shot is dictated by the part being peened, but is usually the smallest shot that will provide the required intensity, since the smaller the shot the greater the coverage, per unit time. A pound of S660 shot contains about 14,000 pellets, whereas a pound of S330 shot contains about 110,000 pellets. A rule of thumb suggests that the peening intensity, measured as Almen arc height, is related to shot diameter approximately as follows:

(A.H. 2 / A.H. 1) = (Shot Diameter 2 / Shot Diameter 1)

Shot size is readily determined, using procedures described in the specifications cited earlier. A word of caution is needed when one determines whether or not a sample complies with MIL-S-1365. Testing sieves are not the most precise measuring tools, and their permitted tolerances may result in widely varying results, on e test sieve to another, of the 50% minimum screen since the cumulative size distribution curve is sloping very sharply in the 50% range.
The size distribution of the incoming shot must meet the specification and should be uniform within the shipment and shipment to shipment.

*Shot Hardness:* Although even shot softer than the part being peened has the capacity to induce compressive stresses in the part, shot as hard or harder that the part is generally most desirable. With harder shot, less of the kinetic energy is lost in shot deformation, and the compressive stresses in the part are driven deeper. For best results, the shot hardness should be about one to four HRC units greater than the part hardness.
Shot hardness has a complex, non-linear effect on shot durability. Over the range HRC 40 to HRC 50, the breakdown rate of the shot is relatively constant even when hard parts are peened. However, as the shot hardness increases over the range HRC 50 to HRC 55 if the hardness of the part being peened is greater than HRC 45 then the breakdown rate increases rather rapidly. When the shot hardness is greater than HRC 55, even a small increase in hardness results in a dramatic increase in breakdown rate. It is for this reason that the range of hardnesses in hard shot should be narrow. Otherwise the operating mix will become increasingly soft, as the harder shot breaks down.
Deficiencies in shot hardness can be compensated for, to some extent, by increasing the shot velocity. However, the breakdown rate of shot increases exponentially with shot velocity according to the following approximation:

$$(\text{B.R. } 2 / \text{B.R. } 1) = (\text{Velocity } 2 / \text{Velocity } 1)$$

Shot hardness is readily determined using the procedures and equipment described in specifications cited earlier.

*Shot Shape:* Irregular, especially angular, particles in the shot may cause sharp indentations in the part which may promote early failure. Methods of evaluating shot for shape are described in the specification cited earlier.

*Shot Durability:* The cost of the peening operation is very significantly influenced by the relationship between the purchase price of the peening shot and it's durability. Cut steel wire shot is generally more durable than cast steel shot but is higher in price.
There are procedures and machines for testing shot durability in the laboratory. However, results of such tests must be regarded with a good deal of skepticism. Attempts to reconcile laboratory results with those observed in actual shot blast operations have seldom been successful.
Steel shot fails as a result of fatigue damage. Therefore, unless the effective shot velocity and the target hardness in the laboratory test machine are the same as the effective velocity and part hardness in the actual peening operation, the test results are

not likely to mean much. The SAE specification Shot and Grit Mechanical Testing, J445, includes this warning:

*Average life data may be used for control checking and for comparing abrasives of different types and from different sources, if the control screen aperture is approximately equal to the removal size in the blast operation, and if the test machine is adjusted to permit correlation with the blast equipment. The reader is cautioned against inferring that the peripheral speed of the abrasive impeller is an indication of correlation.*

Tests have shown that stress on the shot pellet from a low velocity impact against a hard target is not the same as that resulting from a high velocity impact against a soft target. If the target in the test machine is not similar in hardness to the part being peened, it may be impossible to obtain correlation. There is simply no valid, direct evaluation of comparative shot durability other than a test in production equipment. There are, however, indirect indications of cast shot durability described in SAE specifications J827 and J2175. These include tests of composition, microstructure and soundness. While compliance with the specifications should guarantee at least acceptable durability, it must be pointed out that sulfur and phosphorus contents and porosity (interdendritic voids) much lower than the acceptable maxima will result in much improved durability.

*The Operating Mix:* It should be remembered that it is not the shot in the bag which peens the part. It is the shot in the machine------the operating mix. The shot peener must exercise constant vigilance over the size distribution, angularity, and hardness of the mix.

*A Final Word:* There are a number of types of media available to the shot peener. The most commonly used of which are, the steel shots and the glass beads. These are described in specifications devised and published by the SAE and others. Steel media which comply with the specifications should provide at least acceptable performance. Cut steel wire shot, including cut stainless steel wire shot, offers the greatest durability. However, cast steel shot manufactured well within the specified tolerances, especially for hardness, porosity, sulfur and phosphorus, will provide excellent performance.

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November 1992