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American Galvanizers Association (720) 361-4486 technical@galvanizeit.org

Abrasive Blast Media for Preparing Duplex Systems

By Alana Fossa

Introduction

Inadequate preparation of a hot-dip galvanized (HDG) surface is the main cause for premature failure of any duplex system, also known as the application of a compatible paint or powder coating over HDG. As the popularity of duplex systems increases, there is a need within the coatings industry to evaluate successful techniques for sweep blasting hot-dip galvanized coatings providing sufficient surface profiling for industrial coating systems, and without excessive removal of zinc, to ensure long-term corrosion protection.

Currently ASTM D6386 Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Products and Hardware Surfaces for Painting, and SSPC-SP 16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals, recommend the use of abrasive blast media with a Mohs hardness of less than five to prevent damaging the galvanized coating during sweep blasting. However, the recommended blasting abrasives of low hardness are not always effective at producing significant angular peaks recommended by manufacturers of industrial coating systems (2.0–2.5+ mils or 50–60+ µm)[1]. To achieve such angular profile heights, Duplex System applicators have turned to a variety of harder abrasive materials that are readily available in the marketplace in order to achieve the increased profile height requirements for industrial coatings. Furthermore, industry research indicates peak density also impacts coating adhesion and performance in addition to peak height and angularity[2,3].

It can be challenging to select an appropriate abrasive blast media for preparing galvanized steel since the majority of studies on abrasives evaluate performance on black steel and not zinc surfaces. As a result, the purpose of this study is to evaluate the surface profile heights and peak densities achievable when sweep blasting HDG surfaces with alternative blast media to improve the specification of industrial coating systems over HDG.

Test Methodology

Test plates were hot-dip galvanized in accordance with ASTM A123 Specification for Zinc (Hot-dip Galvanized) Coatings on Iron and Steel Products, and coating thickness measurements were obtained by electronic magnetic coating thickness gauge prior to sweep blasting. For each blasting abrasive product, test plates were manually sweep blasted at approximately 30, 45, and 60 degree angles, with pressures ranging from 60 - 100 psi, and using venturi nozzles #5 through #8 to observe the effect of 60 different blast settings. A standoff distance of 1.5 feet was maintained[6]. Blasting efficiency, or optimal use of blast media per area of prepared surface, was not considered by this test. Coating thickness measurements were obtained after sweep blasting to quantify loss in galvanizing thickness. A visual inspection was performed to evaluate if any damage occurred due to over-blasting of the surface. The surface profile height and peak density were measured and recorded using optical-grade replica tape in conjunction with a PosiTector® RTR 3D (Replica Tape Reader). Replica tapes were analyzed using the replica tape reader and manufacturer software (PosiSoft Desktop) to obtain and record linearized peak height (H_L), areal peak density (peaks/mm^2), and a 3D image of the HDG surface[4].

Table 1: Blasting Abrasives Evaluated

No.	Blast Media Product	Blast Media Type	Mohs Hardness	Mesh Size
A	Starblast	Staurolite Sand	7.0 – 7.5	45/80
B	Barton 100 HPA Fine	Garnet	7.5 – 8.5	100
C	Black Beauty Fine	Coal Slag	6.0 – 7.0	20/40
D	Jetmag 60-B2	Synthetic Olivine Pyroxene Sand	7.0 – 7.5	60/B2
E	Starblast AlZiBlast	Aluminosilicate Mineral Sand	6.5 – 7.0	60/100
F	Starblast XL	Low Silica Sand	7.0 – 7.5	45/80
H	Tru Med/Course	Crushed Glass	6.0	20/40
I	Barton 80 HPA	Garnet	7.5 – 8.5	80
K	Jetmag 35-70	Synthetic Olivine Pyroxene Sand	7.0 – 7.5	35/70
L	Peerless SG	Steel Grit	Rc 42-48	G25
M	Starblast Course	Low Silica Sand	7.0 – 7.5	25/70
N	Starblast Ultra	Low Silica Sand	7.0 – 7.5	25/70
O	Tru Course	Crushed Glass	6.0	10/40

Results

The following parameters were evaluated for each blast media used to sweep blast galvanized steel with various blast settings. These parameters are associated with a potential impact on the performance or adhesion of a liquid coating system when applied over a galvanized surface.

A. Peak Height using Replica Tape

Replica tapes are used to obtain peak height (H), an average of the maximum peak to valley heights, by measuring the thickness of burnished replica tape(s) between the anvils of a spring micrometer minus the 2 mils (50.8 µm) of incompressible film. The PosiTector® RTR 3D records linearized peak height (H_L), a more accurate peak height measurement adjusted for replica tape non-linearity without the need to average two or more replica tapes[3].

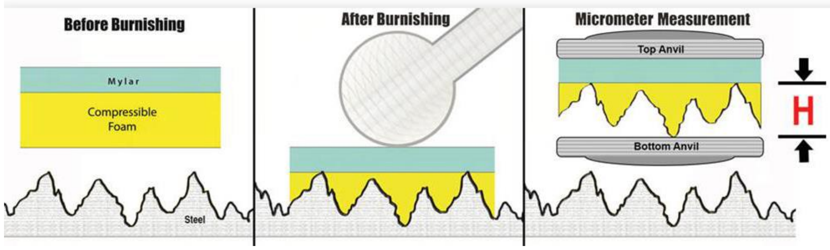

Figure 1: Use of Replica Tape to Obtain Profile Height of Roughened Surface[4]

Paint manufacturers typically recommend a profile height range associated with good adhesion and performance of a particular system. A profile height too low will result in low adhesion of the paint. A profile height too high means the surface may not be fully wetted by that paint which results in poor adhesion (gaps in valleys and potentially exposes peaks above the paint).

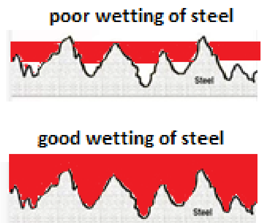

Figure 2: Poor vs. Good Wetting of Steel

When sweep blasting galvanized surfaces, there did not appear to be a strong correlation between blast nozzle size and peak height for most the abrasive blast media studied. Additionally, changing the blast angle did not appear to significantly affect peak height values for most abrasives. Increasing nozzle pressure generally resulted in increased peak height.

Table 2: Overall Increase in H_L when increasing blast pressure from 60 to 100 psi.

Blast Media Product	% Increase in H_L (60 to 100 psi)
(A) Starblast	26.30%
(B) Barton 100 HPA Fine	19.00%
(C) Black Beauty Fine	15.10%
(D) Jetmag 60-B2	8.50%
(E) Starblast AlZiBlast	20.90%
(F) Starblast XL	12.40%
(H) Tru Med/Course	2.00%
(I) Barton 80 HPA	18.00%
(K) Jetmag 35-70	14.10%
(L) Peerless SG	19.00%
(M) Starblast Course	2.90%
(N) Starblast Ultra	16.20%
(O) Tru Course	-16.10%

Typical values observed included 1 – 5µm (0.04 – 0.20 mil) for every 10 PSI increase in blast pressure. Table 2 describes the percent increase in linearized profile height observed when test plates were prepared using a nozzle pressure of 60psi in comparison to 100psi. When varying blast nozzle pressure from 60 to 100 psi, the maximum overall increase observed was 18µm (0.7 mils). However, occasionally a decrease in profile height was observed upon increasing the nozzle pressure. For larger or heavier abrasive blast media, blasting at lower pressures may not be practical as it can be difficult to expel these abrasives at reduced pressures.

The following chart shows the minimum, 25th percentile, median (50th percentile), 75th percentile, and maximum linearized peak height values for each blast media studied:

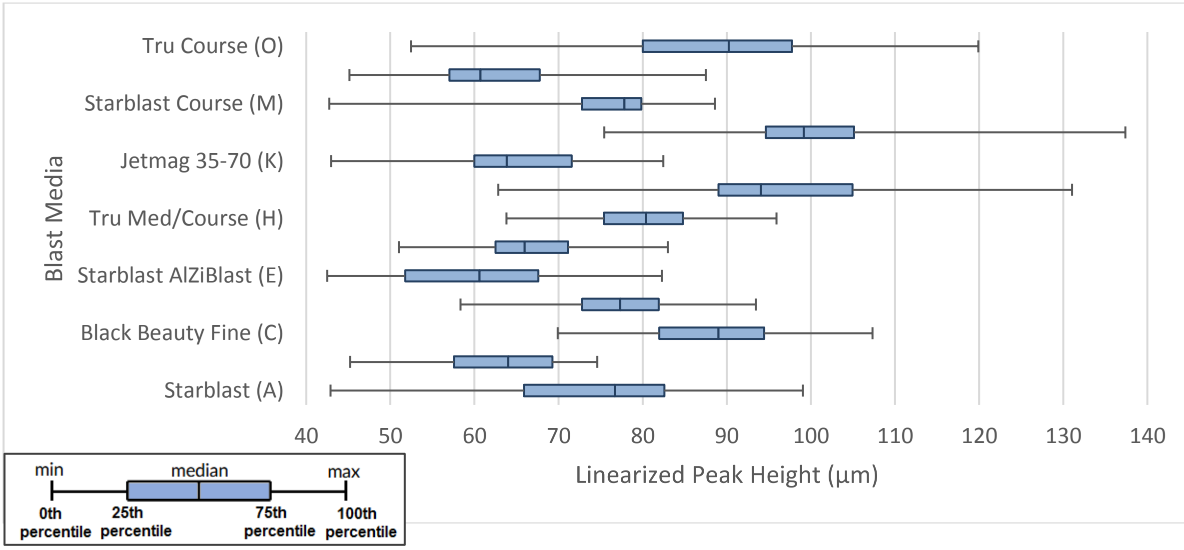

Figure 3: Linearized Peak Height (H_L) per Blast Media

B. Peak Density

Areal peak density (peaks/mm^2) in accordance with ASME B46.1 represents the number of roughness peaks per unit area. This is slightly different than "peak count" measured using a drag stylus which counts the number of peaks per unit length. A surface with increased peak density contains more peaks and valleys within a given area, meaning an overall increase in surface area for bonding to the liquid coating. A peak density which is too high may not allow the coating to reach the bottom of narrow and deep valleys across the surface, meaning complete wetting of the surface does not occur[6]. Paint manufacturers do not currently advise a range for recommended peak density at this time, but industry research indicates a strong positive correlation between peak density and adhesion[2,3]. For this reason, peak density values were obtained for information only until additional research into the relationship between peak density and overall coating performance is established.

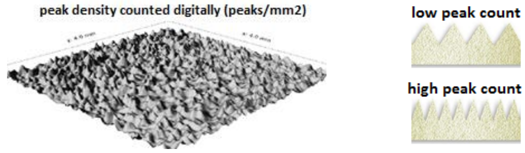

Figure 3: Peak Density vs. Peak Count

Changing the blast nozzle size did not have a consistent effect on peak density nor were any correlations observed in relation to peak density. Changes in blast angle were only capable of affecting peak count by maximum +/- 1 peak/mm^2. Generally, no significant change in peak count was observed when varying the blast angle for any given media. Finer-sized media were more likely to produce a surface with greater peak density. However, there was no relationship observed between hardness of the media and peak density.

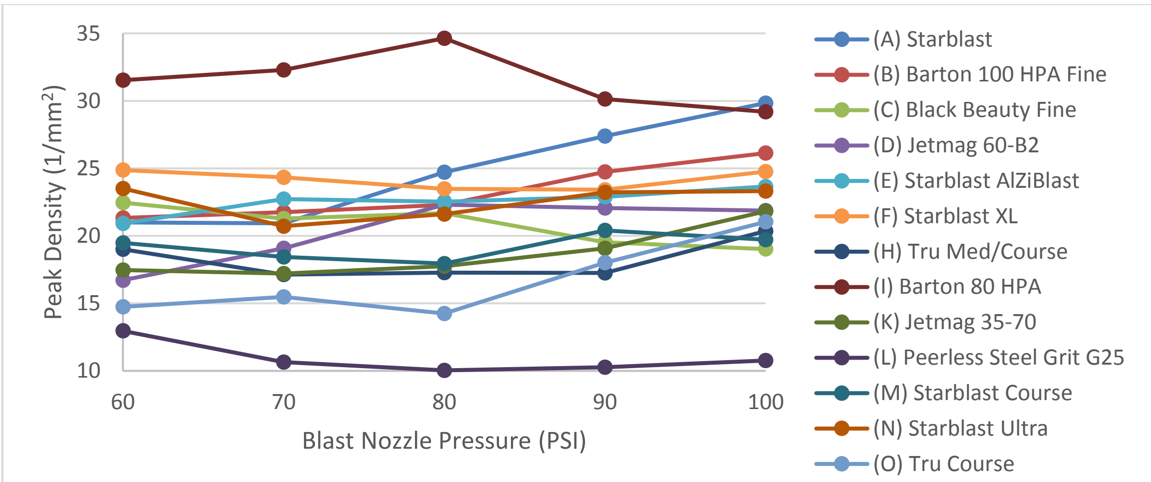

Figure 5: Influence of Blast Nozzle Pressure on Peak Density

The following chart shows the minimum, 25th percentile, median (50th percentile), 75th percentile, and maximum peak density values for each blast media studied:

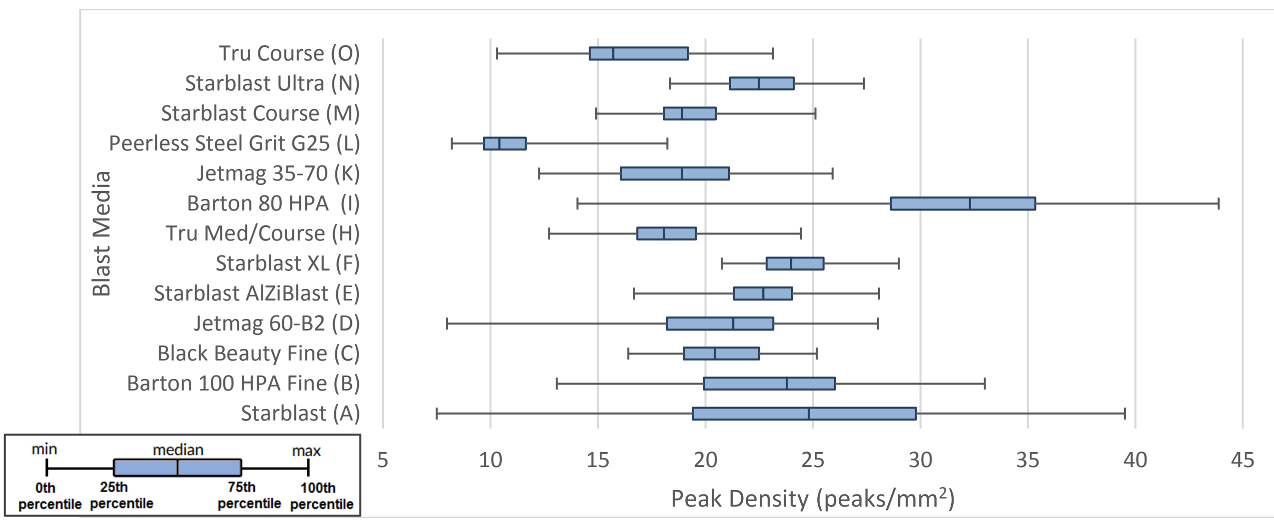

Figure 6: Peak Density (P_d) obtained per Blast Media

C. Coating Thickness

Coating thickness values were measured before and after sweep blasting to determine if coating thickness was reduced. Previous studies reported sweep blasting can reduce galvanized coating thickness by 10 – 25 µm (0.4 - 1.0 mils)[1,5]. The average reduction in coating thickness is provided in the table below for each blast media product (for all blast settings tested).

Table 3: Average Galvanized Coating Thickness Loss per Abrasive

No.	Blast Media Product	Media Type	Avg. Coating Loss µm (mils)
A	Starblast	Staurolite (Low Silica) Sand	-15.3 (-0.6)
B	Barton 100 HPA Fine	Garnet	-14.2 (-0.6)
C	Black Beauty Fine	Coal Slag	-2.4 (-0.1)
D	Jetmag 60-B2	Synthetic Olivine Pyroxene Sand	-9.6 (-0.4)
E	Starblast AlZiBlast	Aluminosilicate Mineral Sand	-13.8 (-0.5)
F	Starblast XL	Low Silica Sand	-15.6 (-0.6)
H	Tru Med/Course	Crushed Glass Grit	-8.8 (-0.3)
I	Barton 80 HPA	Garnet	-12.9 (-0.5)
K	Jetmag 35-70	Synthetic Olivine Pyroxene Sand	-9.2 (-0.4)
L	Peerless SG	Steel Grit	-9.3 (-0.4)
M	Starblast Course	Low Silica Sand	-9.2 (-0.4)
N	Starblast Ultra	Low Silica Sand	-13.9 (-0.5)
O	Tru Course	Crushed Glass Grit	-9.4 (-0.4)

D. Excessive Zinc Removal

A visual inspection was conducted and photos obtained to evaluate whether additional zinc removal by peeling/flaking occurred due to any over-blasting of the surface. The graphs represent the percentage of plates that experienced zinc removal for the specific blasting parameter listed on the X-axis. Zinc thickness in the overblasted area is approximately 0.1 - 0.2 mils with local roughness, meaning reduced corrosion protection and potential for poor adhesion of the paint in the areas of local roughness.

Figure 7: Example of Blasted Test Plates with Zinc Removal vs. No Zinc Removal

Anecdotal evidence collected from industry personnel indicate operator technique, standoff distance, and speed of movement with the nozzle can influence the amount or presence of excessive zinc removal. However, it was observed less damage typically occurred at lower pressures, while changes to nozzle size and blast angle had minimal impact on the presence of coating damage for most blast media. The use of finer blast media during sweep blasting typically resulted in fewer occurrences of coating damage.

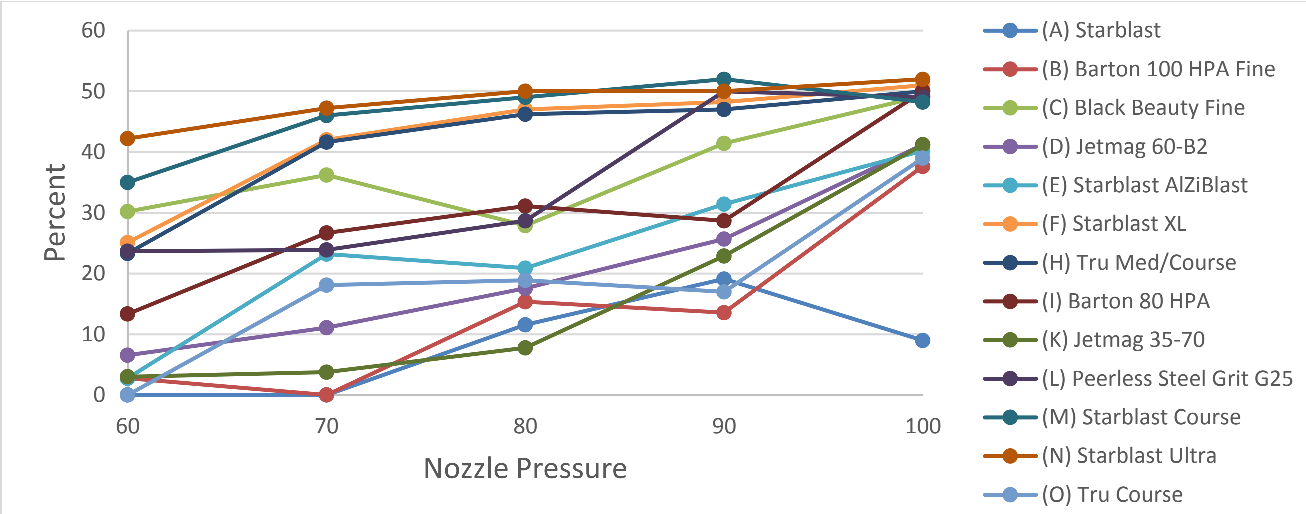

Figure 8: Influence of Blast Pressure on % Plates with Zinc Removal at that PSI

The following chart describes the relative occurrence of HDG coating damage based on only the blast media evaluated by this study:

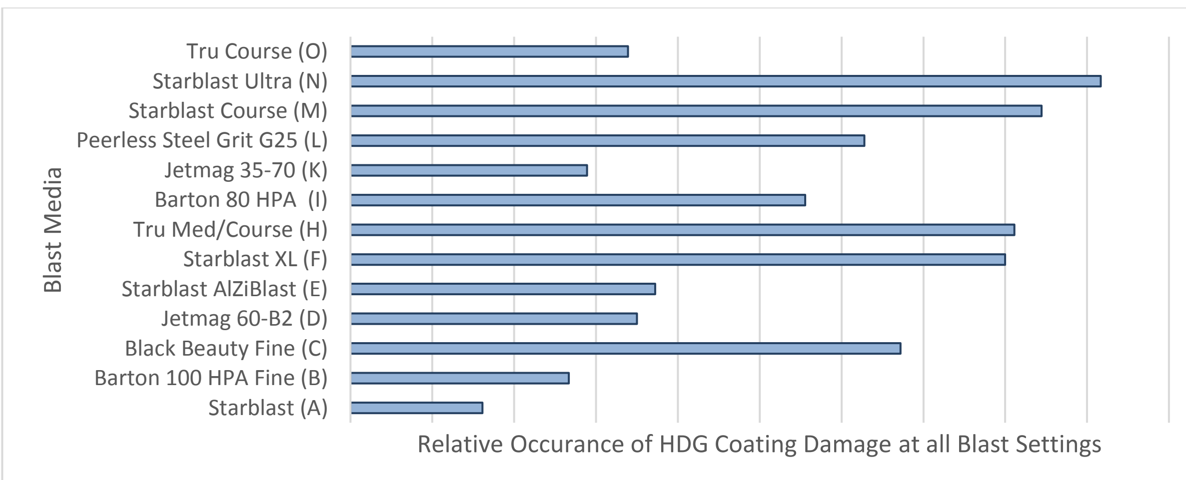

Figure 9: Relative Occurrence of HDG Coating Damage per Blasting Abrasive

Discussion & Observations

Specifiers may consider the impact of a potential reduction in coating thickness (0.4 – 0.6 mils) that can occur when sweep blasting with harder media. Practically speaking, most Duplex Systems are maintained for the purpose of aesthetics. If routine maintenance is performed on the paint or powder coating system, the overall coating system will last indefinitely since the base galvanizing is rarely exposed. Therefore, in such cases where the Duplex System will be maintained the potential reduction in coating thickness is acceptable.

A decrease in coating thickness that results in measurements below the minimum average requirements prescribed in the primary galvanizing specification will only impact the anticipated time to first maintenance if the galvanizing is left to weather after deterioration of the paint coating. The overall product will achieve maintenance-free corrosion protection for 1.5 to 2.3 times the sum of the paint life and the hot-dip galvanizing life based on final coating thickness after sweep blasting[5]. Refer to AGA guidance: Estimating Time to First Maintenance for Duplex Coating Systems for additional assistance in calculating this value. Further information can be acquired from Duplex Systems, Hot-Dip Galvanizing Plus Painting by J.F.H. van Eijnsbergen.

Both 2D and 3D images of all surfaces were obtained after sweep blasting using optical-grade replica tape in conjunction with a PosiTector® RTR 3D (Replica Tape Reader). When viewing different surfaces of similar profile height, the overall shape varied depending on the blasting abrasive used. The example below shows 2D and 3D images of two surfaces with similar peak heights prepared using steel grit and low silica sand where surfaces prepared with the steel grit sample resulted in decreased peak density and less evenly distributed peaks and valleys.

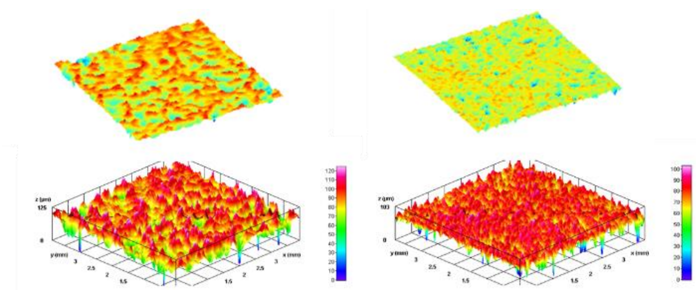

Figure 10: 2D and 3D Images of Galvanized Surface after Sweep Blasting with Steel Grit G25 (left) vs. a Low-Silica Sand (right)

There was also an observed potential for embedment of abrasive media in the surface layer of the zinc. For galvanized surfaces prepared with iron-containing abrasives such as steel grit, performance of the paint or powder coating system may be influenced by embedment of the abrasive and the chance for bi-metallic corrosion.

Conclusions & Recommendations

Blasting abrasives of Mohs hardness five or greater are capable of producing surfaces with increased peak heights for the application of many industrial coatings over hot-dip galvanizing. The following mitigations may be necessary to significantly reduce risk of damage when using such harder abrasives to achieve increased profile heights:

- Finer sized abrasives
- Reduced blast nozzle pressure (where practical)
- Increased distance between blast nozzle and galvanized surface (where practical)

To determine a suitable blasting abrasive based on the study results, each project must be evaluated individually based on the recommended peak height range value provided by the liquid coating manufacturer. Once this range is established, the example below explains how the following charts could be used to interpret the study results for the harder abrasive media evaluated.

Example: Marine-grade epoxy primer applied over HDG. Recommended profile height range obtained from coating manufacturer and/or Technical Data Sheet (TDS): 50 - 75 µm (2-3 mils). Refer to the following charts to determine which blasting abrasives evaluated in this study meet the above criteria with reduced likelihood of coating damage:

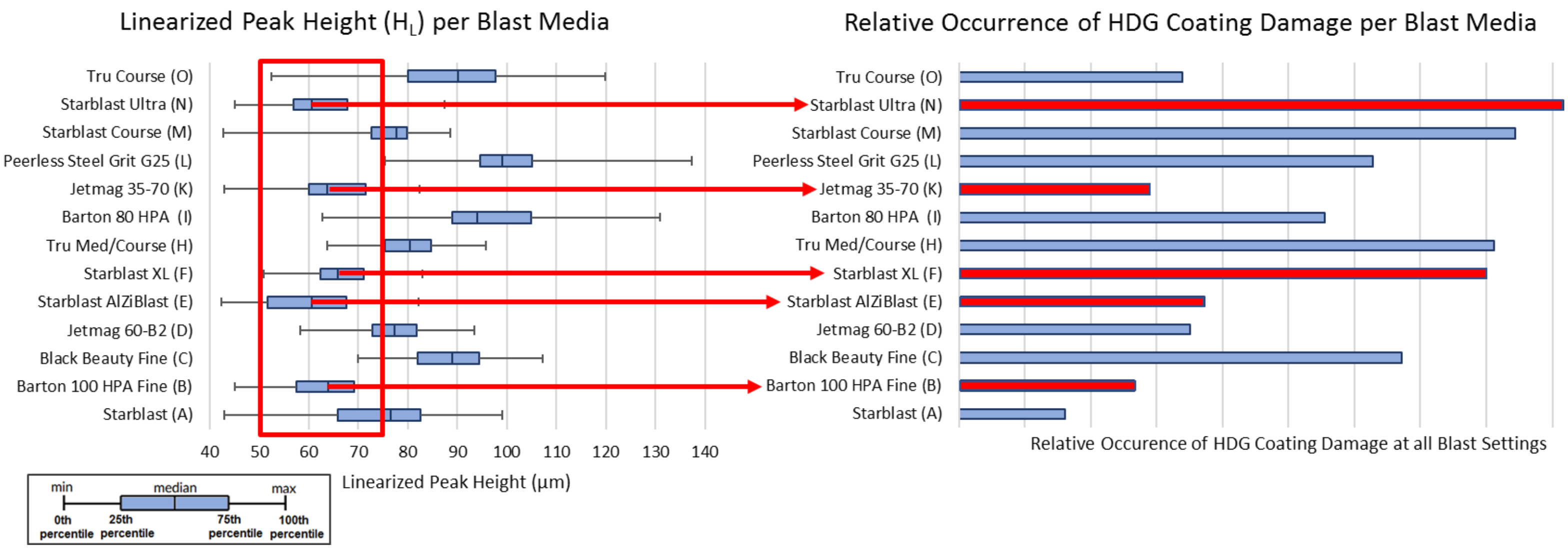

Figure 11: Example Evaluation of Blasting Abrasives

As a result, five abrasives (B, E, F, K, and N) were observed to achieve peak heights within the recommended range for the 25^{th} - 75th percentiles of the plates observed. Of these five abrasives studied, abrasives B, E, and K were less likely to damage the galvanized surface over the range of blast settings studied.

The below factors may contribute to further optimization and selection:

- Cost
- Recyclability
- Environmental, Health, and Safety concerns (silica dust content, disposal of media, etc.)
- Severity of coating thickness removal for plates, tubing, and other steels know to present challenges meeting A123 coating thickness minimum requirements
- Recommended ranges for peak density

Appendix – Detailed Summary of Blast Media Testing Results for Individual Media

A detailed summary of test results for each blast media product is available directly from the American Galvanizers Association (AGA) Technical Department:

technical@galvanizeit.org
720.554.0900

References

1. Application and Evaluation of Coatings over Hot-Dipped Galvanizing; Todd Williams, Ahren Olson; *SSPC*; Las Vegas, NV; February 2015
2. The Effect of Peak Count of Surface Roughness on Coating Performance; Hugh J. Roper, Raymond E.F. Weaver, Joseph H. Brandon; Journal of Protective Coatings & Linings, Volume 21, No. 6; June 2005
3. Replica Tape – Unlocking Hidden Information; David Beamish**;** Journal of Protective Coatings & Linings, Volume 31, No. 7; July 2015
4. Surface Profile - A Comparison of Measurement Methods; David Beamish; DeFelsko Corporation; web.
5. Duplex systems: Hot-Dip Galvanizing Plus Painting; Eijnsbergen, J. F.; Amsterdam: Elsevier; 1994.
6. SSPC-SP COM (latest revision), Surface Preparation, Commentary for Steel and Concrete Substrates (Pittsburgh, PA: SSPC)