

# Defining Mechanical Surface Preparation Standards with Power Tools

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**SUMMARY:** This paper examines current mechanical surface preparation methods with power tools and standards to help define requirements for applicators using less costly and simpler methods of inspection.

**Keywords:** Steel, Profile, Power Tool, Protective coating, Adhesion.

## 1. INTRODUCTION

Power tool cleaning of steel surfaces prior to coating application is permitted in certain circumstances on Shipbuilding projects particularly where abrasive blasting poses hazards to installed electrical and mechanical equipment in-situ, and where access is restricted for abrasive blasting, or for small spot repairs.

The specification requirement for mechanically prepared (Power Tool Clean) surfaces, is for the surface meet to St3 of AS 1627.2, and to provide a consistent angular surface profile of 50-100 microns in critical areas (Bilges, immersed tanks). This requirement is to ensure that the prepared areas are not polished as required by the paint manufacture's recommendation.

The Power tool cleaning standard specified in AS1627.2 st3 [1], does not specify a surface profile as such and refer to descriptions of cleanliness with pictorial standards as visual aids.

To measure the surface profile with replica tape (Testex) [2] across numerous localised repair areas poses a costly and labour-intensive inspection process. Numerous spot repairs are necessary in Bilge and immersed tank spaces due to coating damage sustained during construction and consolidation joints. Abrasive blasting is not practical in these spaces due to machinery and equipment installed and limited dust/abrasive extraction is possible in restricted spaces.

Trials on different material grade plates and different Power Tool Cleaning preparation methods were used to compare replica tape readings with visual appearance and texture. A coating of approximately 200-300 microns of abrasion resistant Aluminium epoxy was applied, which is used in the Bilges and machinery spaces. This coating was later assessed with adhesion pull off tests to ascertain coating adhesion performance against differently prepared surfaces.

## 2. EXPERIMENTAL DETAILS- SURFACE PREPARATION OF TEST PLATES

### 2.1 Preparation of Test Plates

Test plates (approximately 200mm x 200mm x 5mm) were prepared from 3 different material grades used on the project, as they have different hardness properties, which usually affects the degree of cleaning required:

- 250 Grade Carbon Steel 250 MPa yield
- DH 36 Steel 355 MPa yield
- DH 55 Steel 550 MPa yield

The initial condition of the plates was Grade A-B according to AS 1627 Part 4, and were prepared using rotating machine tools using 3 different abrasive discs, (see images 1-3), to achieve an approximate 50 micron surface profile using replica tape:

- Grinder sanding disc- #36 Grit
- Flapper disc grinder #40 Grit
- Bristle Blaster Disc

All 3 different material grade plates were subjected to the 3 different abrasive discs, see example images (4-6) of DH 55 steel prepared (hardest steel), noting a grit blast comparator placed to obtain an idea of the textural feel by hand rather than a visual one



Figure 1- Grinder #36 sanding disc



Figure 2- Flapper disc #40 Grit



Figure 3- Bristle Blaster disc.



Figure 4- DH55- #36 Die Grinder blaster

Testex readings 30-40 microns



Figure 5- DH55 – Flapper disc #40

Testex readings 30-40 microns



Figure 6- DH55 material- Bristle

Testex readings 50-80 microns

After the surfaces were prepared they were coated with 200-300 microns of the Aluminium Abrasive resistant epoxy coating. Three pull off testing dollies were glued to the cured coating (after one week), see figure 7.



Figure 7- Pull off Dollies were glued several days before the 1.3.2018

### 3. RESULTS

#### 3.1 Adhesion Pull off Test Results

All 9 plates were subjected to pull off adhesive tests [1], with most failures occurring cohesively in the coating, with a small percentile with less than <20% of the dolly areas exhibiting adhesive failures to the prepared surfaces, see example pull off test dollies on D55 material in figures 8, 9 & 10 for each preparation method.

The adhesion values were well above the minimum 5 Mpa requirement for the coating using all preparation methods. The Bristle blaster gave less variation of pull off Adhesion values than the other 2 methods, see graphic figure 11. The bristle blaster gave a variation of approximately 2-3Mpa, whereas the # 36 grit grinder and #40 flapper disc grinder variations were greater (approximately 5Mpa).

When comparing preparation methods and adhesion values across the 3 different material groups, the DH 36 adhesion values appeared in the lower adhesion ranges, with the 250 and DH 55 grade material pull off adhesion values appearing in the higher ranges.

The surface profile values of the Bristle blaster were consistently above 50 microns, whereas the other methods measured profiles ranging from 30-40 microns, below the manufacturer's recommendation.

However, the lower measured profiles of the grinding discs were still able to produce compliant adhesion values.



Figure 8- DH55 Pull off test on #36 grit grinder wheel

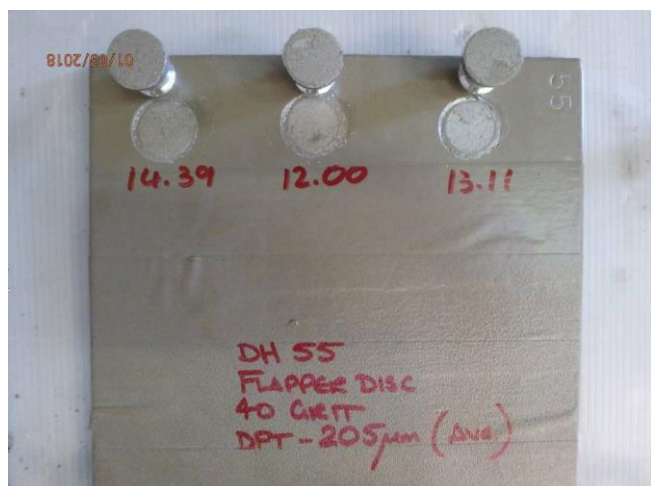


Figure 9- DH 55 pull off test #40 flapper disc grinder

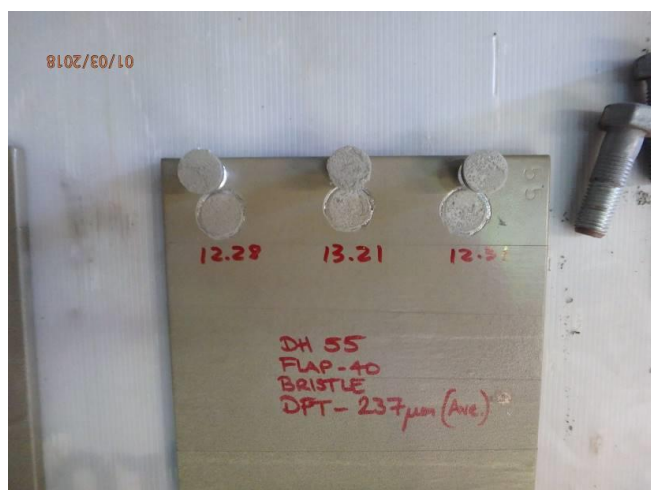


Figure 10- DH55 - pull off test Bristle Blaster

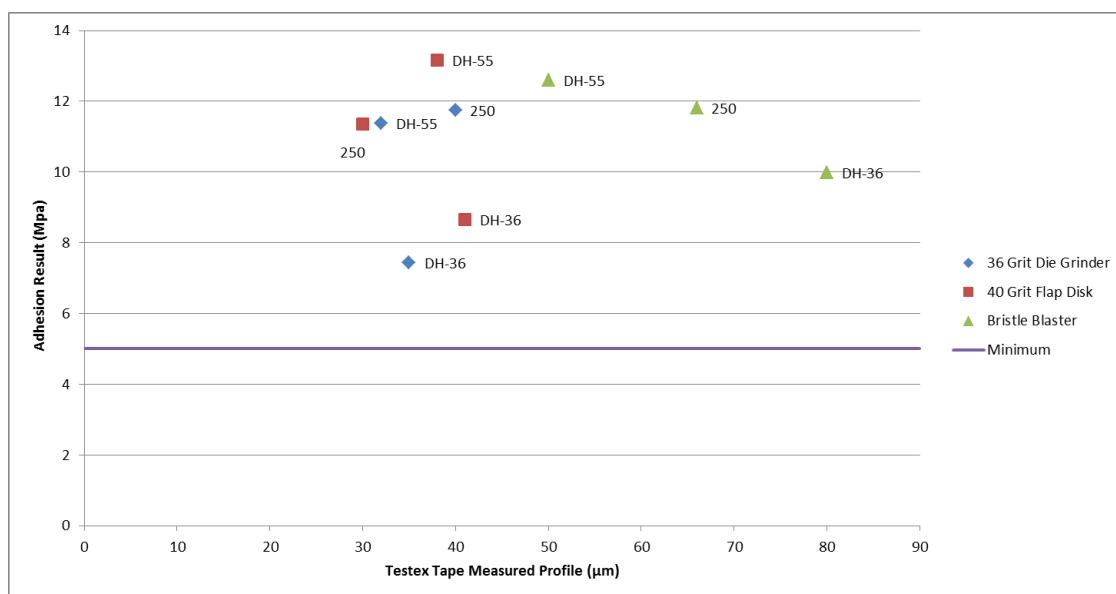


Figure 11- Adhesion values recorded against profile and method - all 3 material groups (250, DH 36, DH 55)

## 4. DISCUSSION

### 4.1 Power Tool Cleaning Standards

The power tool cleaning standards specified by the paint manufacturer list the following as acceptable for spot or localised repairs:

- Pt 3 (JSRA SPSS:1984)- [4]
- SSPC-SP11- [5]

However, some shipbuilding Coating specifications lists the applicable standard for power tool cleaning as AS1627.2 st3 (ISO 8501-1), which is not consistent with the coating manufacturer's recommendations.

When comparing the 3 standards below, only the SSPC-SP11 specifies a minimum surface profile value of 1 mill (25 microns). Table 1 gives a pictorial representation and description of the 3 standards used for power tool cleaning.

The visual appearances in Table 1 across the ISO 8501-1, SSPC-SP11 and JSRA SPSS mechanical preparation standards are significantly different, particularly ISO 8501-1, where the description for st3 preparation compared to the image is inconsistent with 'very thorough cleaning producing a metallic sheen'.

SSPC-SP11 section 3.4 provides more definitive surface preparation methods for producing a surface profile and refers to the use of replica tape to measure surface profile as detailed in section A.6. The visual standard (VIS-3) images are consistent with the descriptions, with the quality of the preparation photographs being very good.

The JSRA SPSS also provides good quality photographs that are consistent with the surface preparation descriptions, however with no mention of surface profile values.

In comparing the surface preparation methods used in the trial, the Bristle blaster disc gave the better surface profile and a more consistent surface texture than the rotary flapper and sanding discs. The Bristle blaster is more suited to preparing welds and edges due to the wire prongs being more flexible to follow shapes and contours.

The rotary and sanding discs gave a lesser profile compared to the bristle blaster but visually appeared brighter and shinier, indicating a more polishing effect.




The Pull-off adhesion test results do not show a clear correlation between the adhesion pull off values across the 3 preparation methods against profile height (microns) as shown in figure 11, other than the range (spread) of adhesive values was narrower for the Bristle Blaster compared to the grinding discs.

The adhesion values across the 3 different material grades were not showing distinctive groupings other than DH36 material showing the lowest band of adhesion values across all preparation methods. No clear explanation could be deduced on the why the 250 grade and DH55 materials were producing higher adhesion values than DH36, considering that the 250 grade material is a softer hardness grade, compared to the DH55 being the hardest grade.

The Bristle Blaster surface appearance closely resembles the grit comparator and measured surface profile values on the test plates.



**Table 1- Comparison of Power Tool Cleaning Standards**

<b>Power tool Cleaning Standard</b>	<b>Definition/Description</b>	<b>Pictorial- for Grade B steel</b>	<b>Remarks</b>
AS 1627.2 st3 (ISO-8501-1)- Australian Standard- Metal Finishing- Preparation and pre- treatment of surfaces Part 2: Power tool cleaning	Very thorough hand and power tool cleaning when viewed without magnification, the surfaces shall be free from visible oil, grease and dirt and from poorly adhering mill scale, rust, paint coatings and foreign matter. But the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate	 <p>B St 3</p> <p>Courtesy ISO-8501-1</p>	<p>The pictorial standard image does not match the description. Hand and power tool cleaning methods are not separated.</p> <p>Power tool methods are described that include; rotary wire brushes, needle guns, abrasive grinders, flap wheels etc.</p>
SSPC- SP11(VIS 3)  The Society for Protective Coatings  Surface Preparation Specification no. 11- Power Tool cleaning to Bare Metal.	Metallic surfaces When viewed without magnification shall be free from all visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter. Slight residues of rust and paint may be left in the lower portion of pits if the original surface is pitted.	 <p>B SP 11</p> <p>Courtesy SSPC-SP11-VIS 3</p>	<p>The standard states that if the surface is to be painted, it shall be roughened to a degree suitable for the paint system. The surface profile shall not be less than 1 mil (25 microns).</p> <p>Preparation Methods are listed and include; needle gun, rotary impact flap assemblies, coated abrasive discs.</p>
Pt 3 (JSRA SPSS:1984)- Japanese Shipbuilding Research Association  Standard for the preparation of steel surface prior to painting	Surface from which rust and other foreign matter are removed by thorough preparation of disc-sander to the extent that the surface has a uniform metallic sheen.	 <p>JB Pt3</p> <p>Courtesy JSRA</p>	<p>JB- is to denote the steel surface has been exposed to weather for approximately 1.5 months.</p> <p>The surface is covered with red rust, but there remains mill scale without pitting underneath the red rust.</p> <p>Preparation Methods are listed and include disc sanding and rotary wire brushing.</p>

## 5. CONCLUSIONS

Bristle blasting was able to produce a consistent profile meeting the shipbuilding coating specification on bare steel and more consistent coating adhesion properties across a variety of material grades, and is more suitable for welds and contours.

The comparison of the SSPC, AS/ISO and JSRA pictorial standards are widely different than the appearances shown in the trials. The SSPC- SP11 standard and corresponding SSPC-VIS 3 pictorial images provide a greater ability for visual assessment of prepared surfaces due to better representational images and more detailed information contained in the pictorial standards.

Shipbuilding coating specifications need to be written to be consistent with the coating manufacturer's recommendations to ensure consistency and clarity on acceptance criteria of surface preparations. The ISO 8501-1 pictorial standard is not considered appropriate to use in lieu of SSPC-SP11 or JSRA SPPS due to the pictorial quality of the st3 power tool cleaning not consistent with its description of 'very thorough cleaning producing a metallic sheen'.

The Bristle blast texture closely resembles the grit comparator and can be used in lieu of using replica tape for surface preparation profile assessment for localised or spot repairs on bare steel.

## 6. ACKNOWLEDGMENTS

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## 7. REFERENCES

- [1] AS1627.2- Metal Finishing- Preparation and pre-treatment of surfaces Part 2: Power tool cleaning.
- [2] AS3894.5- Site Testing of protective coatings, Method 5: Determination of surface profile.
- [3] ISO 4624- Paints and varnishes- Pull-off test for adhesion.
- [4] Japanese Shipbuilding Research Association (JSRA)-Standard for the Preparation of Steel Surface prior to Painting
- [5] The Society for Protective Coatings (SSPC)-Surface Preparation Specification no. 11- Power Tool cleaning to Bare Metal.

## 8. AUTHOR DETAILS



The author has had over 35 years' inspection experience in the construction and maintenance of; ships, submarines, oil and gas facilities, pipelines and civil structures.

Roman is the Principal Inspection Consultant of his company Asset Inspection Consultants, that provides inspection services to industry. Roman holds inspection certifications in coatings (NACE level 3), welding (WTIA, IIW), pressure equipment (AICIP) and Fireproofing & Insulation (Icorr level 2). Roman is the Chair of the recently reformed ACA Defence Technical Group and is a past ACA National President (2010).



Daniel Fosdike is the Senior Engineer for materials and coatings at ASC Ship building. In this role, Daniel is responsible for the prevention of corrosion on the Hobart Class Air Warfare Destroyers currently under construction for the Royal Australian Navy.

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