Quality Control of Abrasive Blast Cleaning Operations

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Introduction

- Webinar Content:
  - Overview of dry abrasive blast cleaning operations
  - Introduction to industry standards for abrasive blast cleaning
  - Quality of equipment and abrasive media
  - Establishing process control to monitor quality
  - Effect of ambient conditions on final abrasive blast cleaning
  - Surface Cleanliness
  - Surface profile and roughness
  - Post-blast dust inspection
Learning Objectives/Outcomes

• Completion of this webinar will enable the participant to:
  
  ➢ Describe the industry standards that pertain to dry abrasive blast cleaning
  ➢ Describe the methods used to verify the quality of abrasive blast cleaning equipment and abrasives
  ➢ Establish process controls to monitor quality
  ➢ Document environmental conditions prior to final abrasive blast cleaning
  ➢ Evaluate surface cleanliness
  ➢ Measure surface profile and roughness
  ➢ Assess surface dust
Overview of Dry Abrasive Blast Cleaning Operations

• Purpose:
  ➢ Clean and roughen new and existing surfaces

• Responsibility for Quality:
  ➢ Contractor: Control Quality (and production)
  ➢ Facility Owner: Assure Quality
Introduction to Industry Standards for Abrasive Blast Cleaning

- ASTM Abrasive Cleanliness Standards
- ASTM Compressed Air Cleanliness Standard
- ASTM Surface Profile/Roughness Measurement Standards
- ISO Dust Assessment Standard
- SSPC Abrasive Standards
- SSPC/NACE Surface Cleanliness Standards
- SSPC Surface Profile Measurement Frequency Standard (draft)
Quality of Abrasive Blast Cleaning Equipment

- Maintain Project Schedule (production)
  - Compressor Capacity
  - Blast Nozzle Wear
  - Blast Nozzle Air Pressure

- Maintain Quality
  - Verify Clean, Dry Compressed Air
Quality of Abrasive Blast Cleaning Equipment

- Compressor Capacity
  - Requirements based on multiple factors/conditions
  - No. of operators, nozzle sizes and required pressure are important considerations
  - Equipment manufacturers publish charts for guidance
Quality of Abrasive Blast Cleaning Equipment

- Monitoring Blast Nozzle Wear
  - Abrasive wears opening, reducing productivity
  - Wear monitored using Pressure Blast Analyzer Gauge (nozzle orifice gauge)
Quality of Abrasive Blast Cleaning Equipment

- Monitoring Blast Nozzle Pressure
  - Reduction in nozzle pressure reduces productivity
  - Pressure monitored using hypodermic needle pressure gauge
Quality of Abrasive Blast Cleaning Equipment

- Monitoring Compressed Air Cleanliness
  - Oil or water in compressed air can contaminate abrasive and surfaces
  - “Blotter Test” performed per ASTM D 4285
  - Requirement of SSPC Abrasive Blast Cleaning Standards
Quality of Abrasive Media

- SSPC-AB 1 (Mineral & Slag Abrasives)
- SSPC-AB 2 (Cleanliness of Recycled Abrasive)
- SSPC-AB 3 (Ferrous Metal Abrasives)
- SSPC-AB 4 (Recyclable Encapsulated Media)
SSPC-AB 1 Specification for Mineral & Slag Abrasives

- Categorizes by Type, Class and Grade
  - Type I: Natural mineral
  - Type II: Slag
  - Class A: <1% crystalline silica
  - Class B: <5% crystalline silica
  - Class C: Unrestricted crystalline silica

- Grades:
  - Grade 1: 0.5-1.0 mil
  - Grade 2: 1.0-2.5 mils
  - Grade 3: 2.0-3.5 mils
  - Grade 4: 3.0-5.0 mils
  - Grade 5: 4.0-6.0 mils
SSPC-AB 1 Specification for Mineral & Slag Abrasives

- Testing for conformance
  - Specific gravity
  - Hardness
  - Weight change on ignition
  - Water soluble contaminants*
  - Moisture content
  - Oil content*
  - Crystalline silica content
  - Surface profile yield*
  - Particle size distribution (sieve analysis)

* Abrasive cleanliness invoked by SSPC Abrasive Blast Cleaning Standards
Specifications for Metallic Abrasives

- SSPC-AB 2
  - Cleanliness of recycled metallic abrasives*
  - Testing for conformance
    - Non-abrasive residue
    - Lead content (laboratory only)
    - Water soluble contaminants
    - Oil content

* Abrasive cleanliness invoked by SSPC Abrasive Blast Cleaning Standards
Specifications for Metallic Abrasives

• SSPC-AB 3
  ➢ Categorizes by Class
    • Class 1: Steel
    • Class 2: Iron
  ➢ Testing for conformance
    • Abrasive size
    • Specific gravity
    • Chemical composition
    • Hardness
    • Durability
    • Cleanliness*
    • Conductivity*

* Abrasive cleanliness invoked by SSPC Abrasive Blast Cleaning Standards
SSPC-AB 4 Recyclable Encapsulated Abrasive Media (Sponge)

- Alternative in applications where dust control is important
- Can reduce risk of damage to sensitive surroundings
- Type of media in composite will affect cleaning
- Quality
  - Classifier effectiveness
  - Oil and conductivity
Quality of Abrasive Media

- Abrasive Cleanliness
  - Automatically invoked by SSPC SurfaceCleanliness Standards
  - Oil per ASTM D 7393
  - “Vial test”
  - No “visually detectable oil”
Quality of Abrasive Media

- Abrasive Cleanliness
  - Conductivity per ASTM D 4940
  - “Vial test”
  - No prescribed frequency
  - Threshold per SSPC AB standards is 1000 µS/cm
  - Automatically invoked by SSPC Surface Cleanliness Standards
Establishing Process Control to Monitor Quality

- Purpose of a project-specific standard
- Documentation of critical variables
- Assessment of surface cleanliness and profile yield
- Preservation
Establishing Process Control to Monitor Quality

- Purpose of a project-specific standard
  - Represents the degree of cleanliness using the actual initial condition of the steel
  - Establishes the expectation of cleanliness prior to production work
  - Establishes the surface profile yield prior to production work
  - Serves as a reference throughout the project
Establishing Process Control to Monitor Quality

• Assessment of surface cleanliness and profile yield
  ➢ Measure surface profile using appropriate method (described later)
  ➢ Measure peak count (if required)
  ➢ Assess whether surface cleanliness was achieved using SSPC VIS 1 Guide (described later)
Establishing Process Control to Monitor Quality

Documentation of Critical Variables

- Blast nozzle type
- Blast nozzle size
- Abrasive manufacturer
- Abrasive type
- Abrasive size
- Air pressure at nozzle
- Nozzle distance to surface
- Nozzle angle to surface

- Blast hose length
- Blast hose diameter
- Compressor size (CFM)
- Air pressure at compressor
- Surface profile yield (in mils or micrometers)
- Relative Peak Count (if specified)
Establishing Process Control to Monitor Quality

• Preserving the Project-Specific Standard
  - May need to reference later in the project
  - Seal in non-glossy clear coat
  - Digital high resolution image (photograph)
Environmental Conditions for Surface Preparation

- “Rough” surface preparation work can occur when conditions are less than desirable (unless prohibited by contract)
- “Final” surface preparation work should occur when conditions preclude moisture formation on prepared surfaces
Measuring Ambient Conditions Prior to Final Surface Preparation

• If air temperature and relative humidity are such that moisture from the air condenses on the surface, the surface may rust bloom, or rust back prior to coating

• Recommend verifying that the temperature of the surface is at least 5°F (3°C) higher than the dew point temperature to preclude condensation (requirement may be invoked by specification)
Significance of 5°F (3°C)

- Theoretically, a small (<1°F) increase (surface temperature over dew point) will preclude moisture formation.
- Minimum increase of 5°F (3°C) compensates for:
  - Instrument tolerances
  - Varying conditions
  - Changing conditions
Dehumidification

- Dehumidification (DH) equipment removes air moisture, reducing opportunity for condensation.
- Conditions monitored using computer software (component to DH equipment) or by manual measurements.
- SSPC/NACE Joint Technical Report
  - SSPC-TR3/NACE 6A192, "Dehumidification and Temperature Control During Surface Preparation, Application and Curing for Coatings/Linings of Steel Tanks, Vessels and other Enclosed Spaces"
Dehumidification, con’t.

- DH accomplished by:
  - Compression
  - Refrigeration
  - Desiccation (liquid or solid sorption)
  - Combination of methods listed
  - Refrigeration and desiccation (solid sorption)
    - most common for field work
Surface Cleanliness

- **Pre-Blast:** SSPC-SP 1 (Solvent Cleaning)
- **Post-Blast:**
  - SSPC-SP7/NACE 4, Brush-Off Blast Cleaning
  - SSPC-SP14/NACE 8, Industrial Blast Cleaning
  - SSPC-SP6/NACE 3, Commercial Blast Cleaning
  - SSPC-SP10/NACE 2, Near-White Metal Blast Cleaning
  - SSPC-SP5/NACE 1, White Metal Blast Cleaning
  - SSPC-SP16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
- **Using SSPC VIS 1**
- **Governing document**
  - For dispute resolution, the written standard is the governing document; visuals are guides to the written standards
SSPC-SP 1 Solvent Cleaning

- Requires the removal of all visible grease, oil, lubricants, and cutting compounds from the surface
- Performed prior to mechanical methods of preparation
- An automatic requirement to most SSPC surface cleanliness standards (except SSPC-SP 13)
SSPC-SP 7/NACE No. 4
Brush-Off Blast Cleaning

- Requires “sweep” blasting the entire surface to remove loose rust, loose mill scale, and loose paint
- Tightly adherent material may remain
- Dull putty knife used to determine if remaining material is loose or tight
- Viewed without magnification
SSPC-SP 14/NACE No. 8, Industrial Blast Cleaning

- Requires removal of all loose rust, loose mill scale, and loose paint
- Traces of intact mill scale, intact rust, and intact paint may remain on up to 10% of each 9 in² of surface; stains are permitted on the remainder of the 9 in²
- Dull putty knife used to determine if remaining material is loose or tight
- Limited access areas are exempt from the 10% restrictions on intact material – intact material may remain provided the entire area is subjected to the abrasive blast
- Viewed without magnification
SSPC-SP 6/NACE No. 3, Commercial Blast Cleaning

- Requires removal of all mill scale, rust and paint
- Staining from rust, paint and mill scale permitted, but must be evenly dispersed
- Staining cannot exceed 33% of each 9 in\(^2\) of prepared surface
- Viewed without magnification
SSPC-SP10/NACE No. 2, Near-White Blast Cleaning

- Requires removal of all mill scale, rust and paint from the surface
- Staining from rust, paint and mill scale is permitted to remain, but must be evenly dispersed
- Staining cannot exceed 5% of each 9 in$^2$ of prepared surface
- Viewed without magnification
SSPC-SP 5/NACE No. 1, White Metal Blast Cleaning

- Requires removal of all mill scale, rust and paint from the surface
- Staining from rust, paint and mill scale are not permitted to remain
- Viewed without magnification
- Does not mean that the surface will be free of shadows – to evaluate, change viewing angle or lighting angle
SSPC-SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels and Non-Ferrous Metals

• Not for carbon steel
• Requires sweep blasting the entire surface to remove all foreign matter; paint may remain if it is tightly adherent
• Dull putty knife used to determine if remaining paint is loose or tight
• Dense and uniform surface profile is required
• Viewed without magnification
Using SSPC-VIS 1 Guide

- Reference photographs are divided into 4 sections:
  1. Appearance of SSPC-SP7, SP6, SP10, and SP5 on steel that has never been painted
  2. Appearance of SSPC-SP5 produced with different metallic and non-metallic abrasives
  3. Appearance of SSPC-SP7, SP14, SP6, SP10, and SP5 on previously painted steel
  4. Effect of surface profile depth, angle of view, and lighting on the appearance of SSPC-SP5

- Prior to 1989, SSPC used the Swedish Standards (now ISO 8501-1)
Photographs represent the appearance of surfaces both prior to and after abrasive blast cleaning

Surface conditions depicted prior to cleaning:

- Previously unpainted
  - Condition A - Intact mill scale
  - Condition B - Rust and mill scale
  - Condition C - Totally rusted
  - Condition D - Totally rusted and pitted

- Previously painted
  - Condition G_{1} – Aged coating with extensive pinpoint rusting
  - Condition G_{2} – Aged coating with moderating pitting
  - Condition G_{3} – Aged coating with severe pitting
SSPC-VIS 1
Depictions of Cleaning

• Degrees of cleaning depicted for previously unpainted steel:
  - SSPC-SP 7, Brush-Off Blast Cleaning
  - SSPC-SP 6, Commercial Blast Cleaning
  - SSPC-SP 10, Near-White Metal Blast Cleaning
  - SSPC-SP 5, White Metal Blast Cleaning

• Degrees of cleaning depicted for previously painted steel:
  - All of the above, plus
  - SSPC-SP 14, Industrial Blast Cleaning

• No photographs available:
  - SSPC-SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
SSPC-VIS 1 Initial Conditions

Rust Grade A

Rust Grade C

G\textsubscript{1} Initial Condition

Rust Grade B

Rust Grade D

G\textsubscript{2} Initial Condition\textsuperscript{2}

G\textsubscript{3} Initial Condition
SSPC-VIS 1 Appearance of Cleaning – Condition A Steel

A SP-6
No photograph provided. The effort required to remove mill scale on Condition A steel typically results in less staining than the maximum 33% allowed by SP 6, approaching the photograph provided for A SP 10.
SSPC-VIS 1 Appearance of Cleaning – Condition B Steel
SSPC-VIS 1 Appearance of Cleaning – Condition D Steel
SSPC-VIS 1 Appearance of Cleaning – Condition $G_1$ Steel
SSPC-VIS 1 Appearance of Cleaning – Condition $G_3$ Steel
Surface Profile/Roughness

- Purpose of surface profile
- Effect of profile on surface area
- Consequences of (and remedies for) insufficient/excessive surface profile
- Measuring surface profile
- Measuring surface roughness
- Pending SSPC standard for assessing surface profile conformance
Surface Profile/Roughness

- Maximum peak-to-valley depth
- Increases surface area
- Anchors the coating system to the substrate
- Insufficient profile depth could result in poor coating adhesion
- Too much profile depth could cause pinpoint rusting
Correcting Profile Depth

- Insufficient surface profile depth
  - Re-blast with larger abrasive
  - Should provide blaster with visual evidence of re-blast

- Excessive surface profile depth
  - Re-blast with smaller abrasive (rarely effective)
  - If re-blast, should provide blaster with visual evidence
  - More effective to apply additional thickness
Measuring Surface Profile Depth - Standards

- ASTM D 4417
  - Method A (visual comparator)
  - Method B (depth micrometer)
  - Method C (replica tape)
- NACE RP0287 (replica tape)
- ASTM D 7127
  - Portable stylus instrument for surface roughness, including peak count
- Standards do not provide acceptance criteria
Measuring Surface Profile

• ASTM D4417, Method A: Visual Comparator
  ➢ 5-10X illuminated magnifier
  ➢ Comparator Disc
Measuring Surface Profile

- Three Comparator Discs
  - S: Sand
  - G/S: Grit/Slag
  - SH: Shot

- Stencil Code
  - Profile depth (2)
  - Abrasive Type (Sand)
  - Year reference (1970)
Measuring Surface Profile

Method A: Visual Comparator

- Select Disc
- Attach Disc to Comparator
- Examine Surface
- Select Segment(s)
- Obtain “sufficient” no. of measurements
Measuring Surface Profile

- **Method B: Depth Micrometer**
  - Instrument foot sets on peaks of the profile while a conical-shaped pin projects into the valleys
  - Obtain minimum of 10 readings per “area”
  - Verify “zero” on float glass plate before use
Measuring Surface Profile

- Method C: Replica Tape
  - Testex Tape used in conjunction with a spring-loaded micrometer
  - Compressible foam attached to 2 mils of polyester film (Mylar®)
Measuring Surface Profile

- Coarse Minus (0.5-0.8 mil)
- Coarse (0.8-2.5 mils)
- X-Coarse (1.5-4.5 mils)
- X-Coarse Plus (4.0-5.0 mils)

- Tape is most accurate mid-range
- New “HT” version up to 140°F
- The thickness of the Mylar® is always 2 mils
Measuring Surface Profile Using Replica Tape

HOW REPLICA TAPE WORKS:

1. Mylar
   compressible foam
   Before burnishing

2. Mylar
   compressed foam
   steel
   During burnishing

3. Mylar
   impression-bearing compressed foam
   air
   After burnishing

4. Mylar
   impression-bearing compressed foam
   During measurement

PRESS-O-FILM™

Reading: Gage less 2.0 mils or 50 microns
X COARSE (1.5 to 4.5 [mils] or 40 to 115 microns)

TESTEX
NEWARK, DE 19715
USA
Measuring Surface Profile Using HT Replica Tape

- Obtain measurement with X-Coarse replica tape
  - If reading is 2.6-4.5 mils, record the measurement
  - If reading is between 1.5-2.5 mils, obtain a second reading (same location) with the Coarse tape
  - If the reading with the Coarse tape is also within 1.5-2.5 mils inclusive, average the two values
Measuring Surface Profile

- Measuring Peak Count
  - ASTM D 7127
  - Peak density can improve adhesion & undercutting resistance
  - Retractable arm with diamond point stylus
  - Arm is automatically retracted
  - No. of peaks read from display
  - Obtain minimum of 5 measurements
Measuring Surface Profile

- SSPC Draft Standard, “Procedure for Determining Conformance to Steel/Profile Surface Roughness Requirements”
  - Draft crafted in September 2008
  - Revised drafts prepared in:
    - October 2009
    - July 2010
    - November 2010
    - March 2011
  - Resolving comments from June 2011 ballot
  - Re-ballot planned for later this year
Post-Blast Dust Inspection

• ISO 8502, Part 3 – Assessment of Dust on Steel Surfaces Prepared for Painting

• Equipment:
  - Clear, pressure sensitive tape (25 mm wide)
  - Spring-tensioned roller (if required)
  - 10x illuminated magnifier
  - White backer (card stock)

![Table 1 — Dust size classes](image)

<table>
<thead>
<tr>
<th>Class</th>
<th>Description of dust particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Particles not visible under ×10 magnification</td>
</tr>
<tr>
<td>1</td>
<td>Particles visible under ×10 magnification but not with normal or corrected vision (usually particles less than 50 µm in diameter)</td>
</tr>
<tr>
<td>2</td>
<td>Particles just visible with normal or corrected vision (usually particles between 50 µm and 100 µm in diameter)</td>
</tr>
<tr>
<td>3</td>
<td>Particles clearly visible with normal or corrected vision (particles up to 0.5 mm in diameter)</td>
</tr>
<tr>
<td>4</td>
<td>Particles between 0.5 mm and 2.5 mm in diameter</td>
</tr>
<tr>
<td>5</td>
<td>Particles larger than 2.5 mm in diameter</td>
</tr>
</tbody>
</table>

Figure 1 — Pictorial references corresponding to dust quantity ratings 1, 2, 3, 4 and 5
Summary

• During this webinar, we have:
  - Overviewed dry abrasive blast cleaning operations
  - Introduced the industry standards for abrasive blast cleaning
  - Described the importance of the quality of equipment and abrasive media
  - Discussed establishing process controls to monitor quality
  - Described the effect of ambient conditions on final abrasive blast cleaning
  - Described procedures for assessing surface cleanliness
  - Described procedures for measuring surface profile and roughness
  - Described post-blast dust inspection procedures
Quality Control of Abrasive Blast Cleaning Operations

THE END

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