Quality Control of Abrasive Blast Cleaning Operations

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Quality and Integrity Since 1949

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

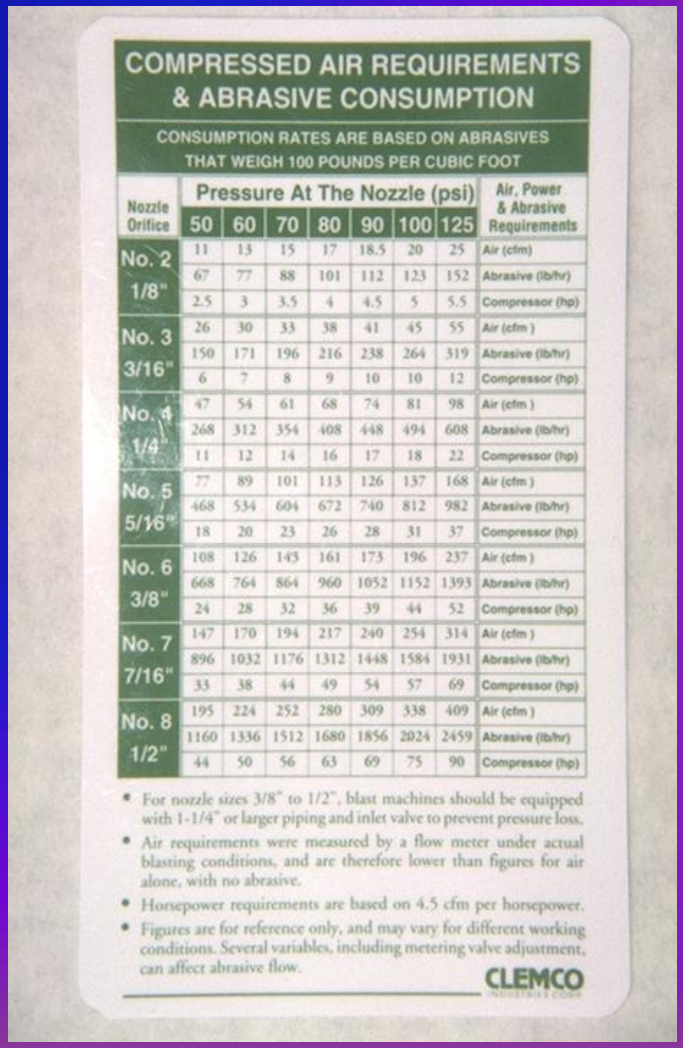
- ASTM Abrasive Cleanliness Standards
- ASTM Compressed Air Cleanliness Standard
- ASTM Surface Profile/Roughness Measurement Standards
- ISO Dust Assessment Standard
- SSPC Abrasive Standards
- SSPC/NACE Surface Cleanliness Standards
- SSPC Surface Profile Measurement Frequency Standard (draft)

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



COMPRESSED AIR REQUIREMENTS & ABRASIVE CONSUMPTION

CONSUMPTION RATES ARE BASED ON ABRASIVES THAT WEIGH 100 POUNDS PER CUBIC FOOT

Nozzle Orifice	Pressure At The Nozzle (psi) 50	60	70	80	90	100	125	Air, Power & Abrasive Requirements
No. 2 1/8"	11	13	15	17	18.5	20	25	Air (cfm)
	67	77	88	101	112	123	152	Abrasive (lb/hr)
	2.5	3	3.5	4	4.5	5	5.5	Compressor (hp)
No. 3 3/16"	26	30	33	38	41	45	55	Air (cfm)
	150	171	196	216	238	264	319	Abrasive (lb/hr)
	6	7	8	9	10	10	12	Compressor (hp)
No. 4 1/4"	47	54	61	68	74	81	98	Air (cfm)
	268	312	354	408	448	494	608	Abrasive (lb/hr)
	11	12	14	16	17	18	22	Compressor (hp)
No. 5 5/16"	77	89	101	113	126	137	168	Air (cfm)
	468	534	604	672	740	812	982	Abrasive (lb/hr)
	18	20	23	26	28	31	37	Compressor (hp)
No. 6 3/8"	108	126	143	161	173	196	237	Air (cfm)
	668	764	864	960	1052	1152	1393	Abrasive (lb/hr)
	24	28	32	36	39	44	52	Compressor (hp)
No. 7 7/16"	147	170	194	217	240	254	314	Air (cfm)
	896	1032	1176	1312	1448	1584	1931	Abrasive (lb/hr)
	33	38	44	49	54	57	69	Compressor (hp)
No. 8 1/2"	195	224	252	280	309	338	409	Air (cfm)
	1160	1336	1512	1680	1856	2024	2459	Abrasive (lb/hr)
	44	50	56	63	69	75	90	Compressor (hp)

- For nozzle sizes 3/8" to 1/2", blast machines should be equipped with 1-1/4" or larger piping and inlet valve to prevent pressure loss.
- Air requirements were measured by a flow meter under actual blasting conditions, and are therefore lower than figures for air alone, with no abrasive.
- Horsepower requirements are based on 4.5 cfm per horsepower.
- Figures are for reference only, and may vary for different working conditions. Several variables, including metering valve adjustment, can affect abrasive flow.

CLEMCO

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

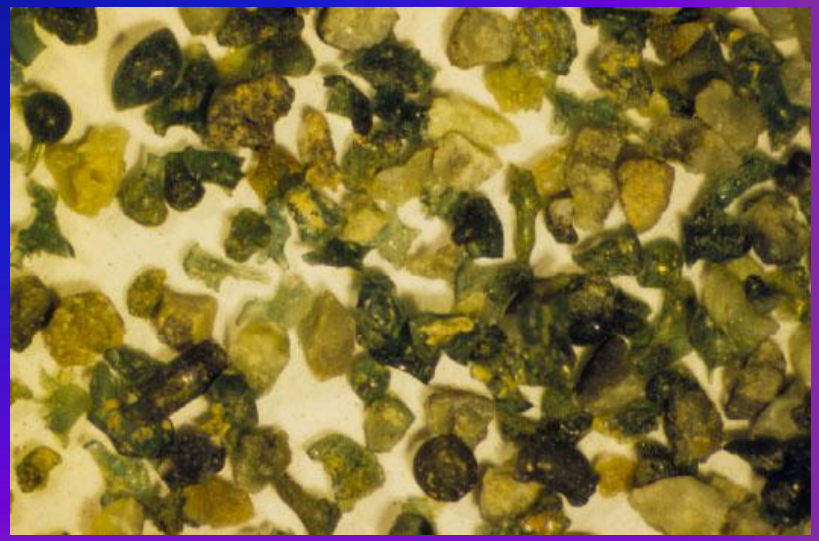
Quality of Abrasive Media

- 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

- 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

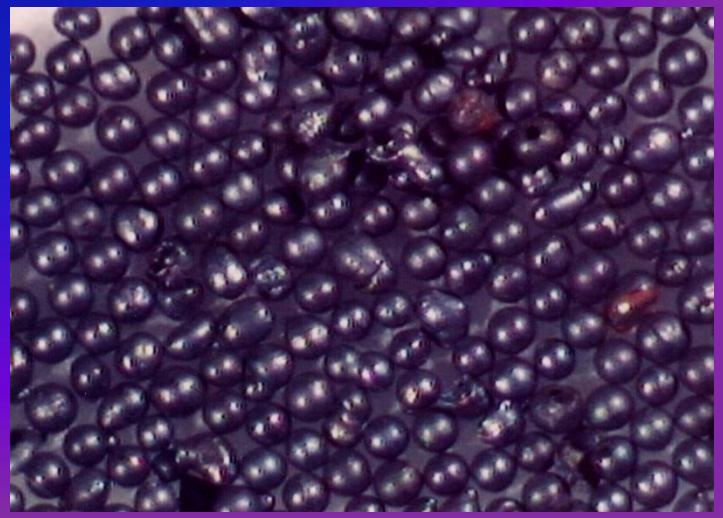
- SSPC-AB 2
  - Cleanliness of recycled metallic abrasives*
  - Testing for conformance
    - Non-abrasive residue
    - Lead content (laboratory only)
    - Water soluble contaminants
    - Oil content

** 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 Surface Cleanliness Standards
  - Oil per ASTM D 7393
  - "Vial test"
  - No "visually detectable oil"

Quality of Abrasive Media

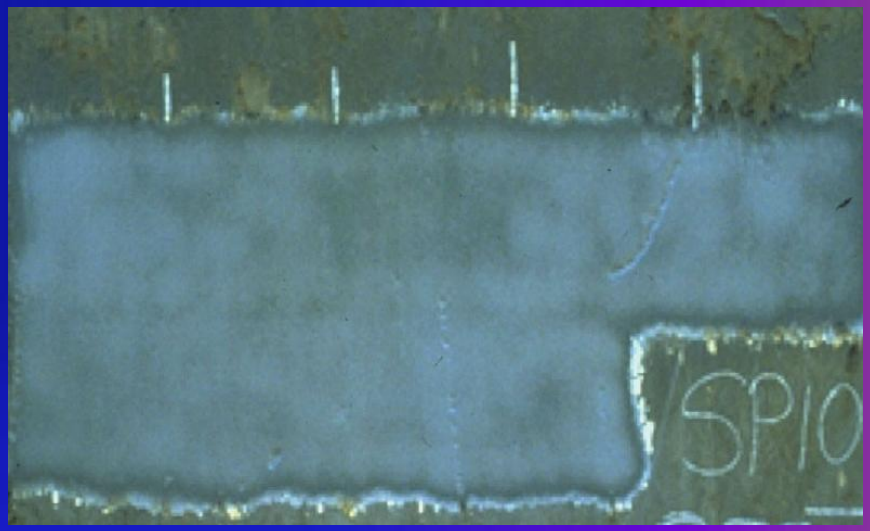
- Abrasive Cleanliness
  - Conductivity per ASTM D 4940
  - "Vial test"
  - No prescribed frequency
  - Threshold per SSPC AB standards is 1000 µS/cm
  - Automatically invoked by SSPC Surface Cleanliness Standards

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 in^2 of surface; stains are permitted on the remainder of the 9 in^2
- 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

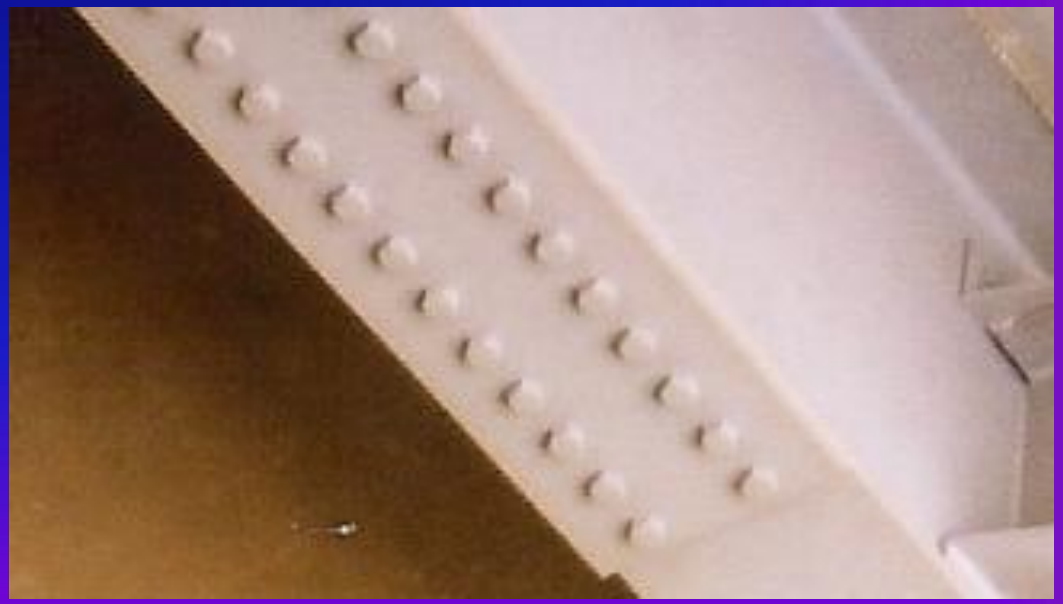
- Requires removal of all mill scale, rust and paint
- Staining from rust, paint and mill scale permitted, but must be evenly dispersed
- Staining cannot exceed 33% of each 9 in^2 of prepared surface
- Viewed without magnification

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

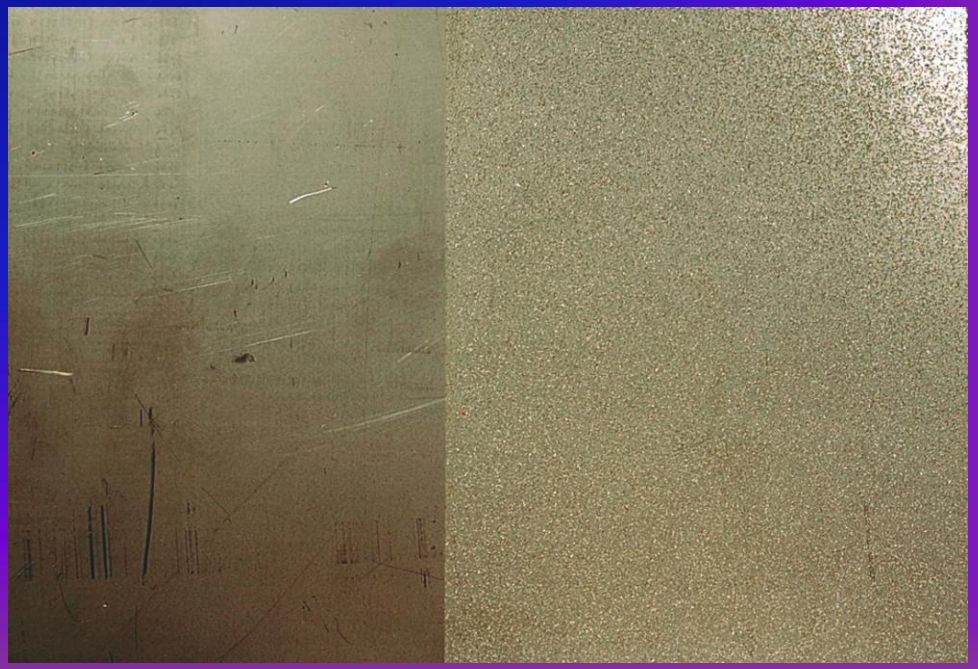
SSPC-SP 5/NACE No. 1, White Metal Blast Cleaning

- 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



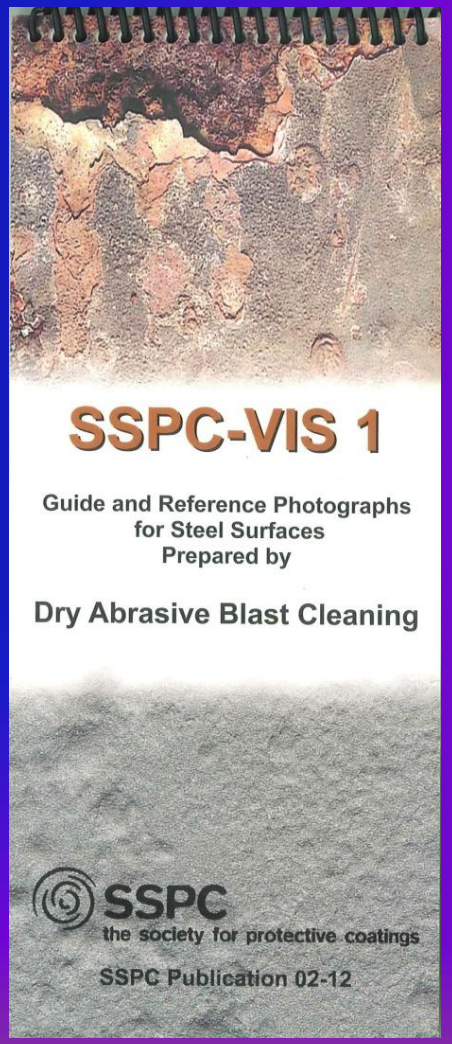
SSPC-SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels and Non-Ferrous Metals

- 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



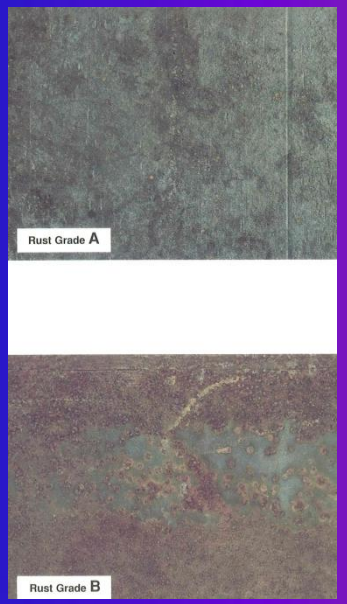
Using SSPC-VIS 1 Guide

- 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)



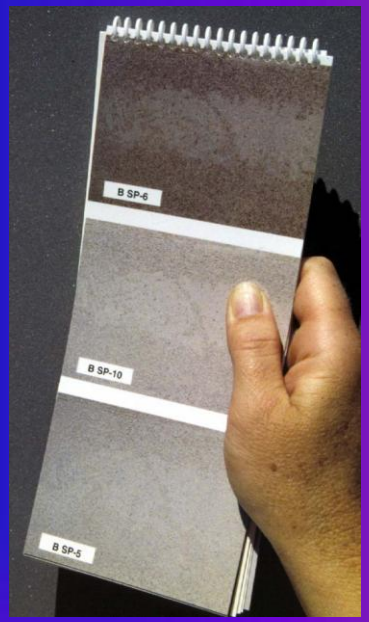
SSPC-VIS 1 – Initial Conditions

- 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

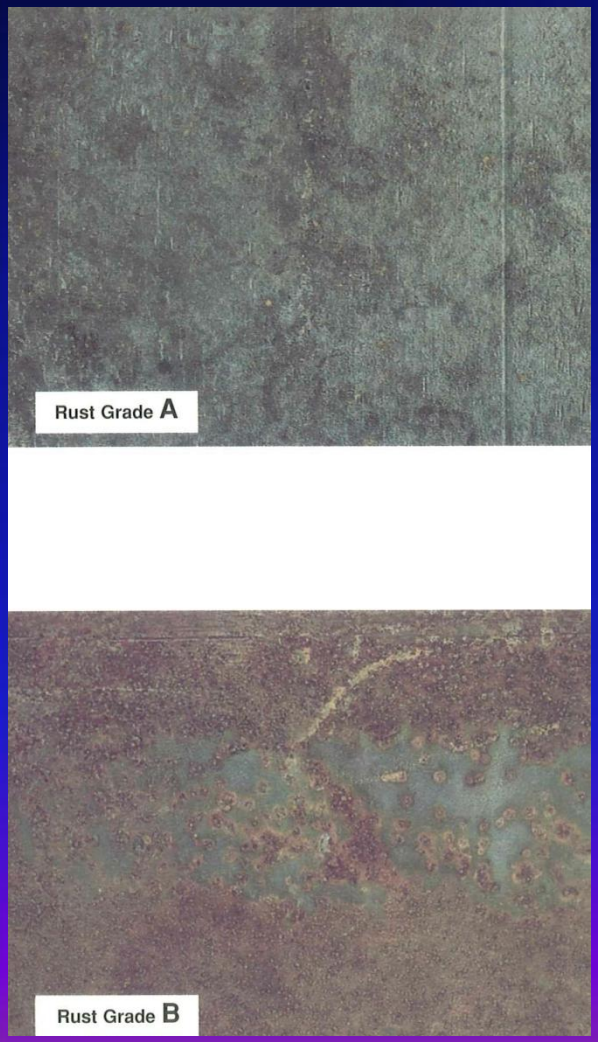


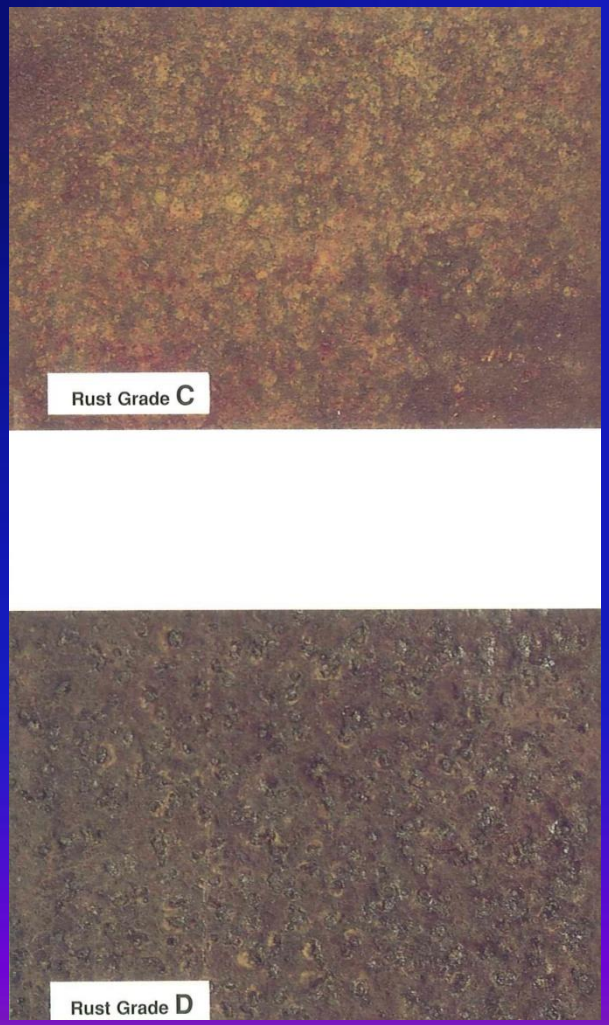
SSPC-VIS 1
Depictions of Cleaning

- 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

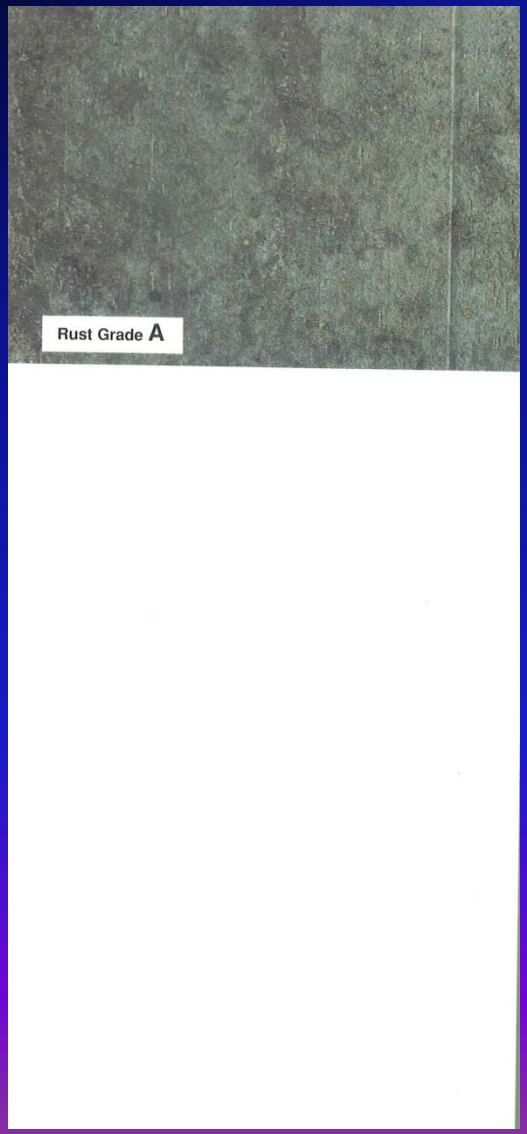




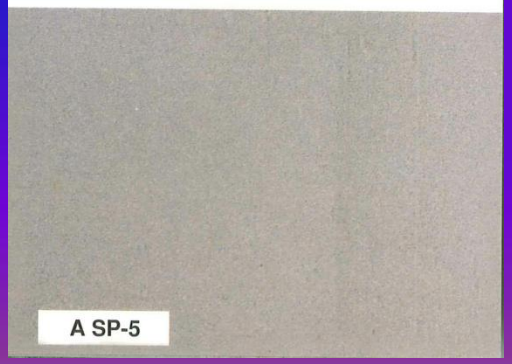
G_2 Initial Condition[2]

G_3 Initial Condition

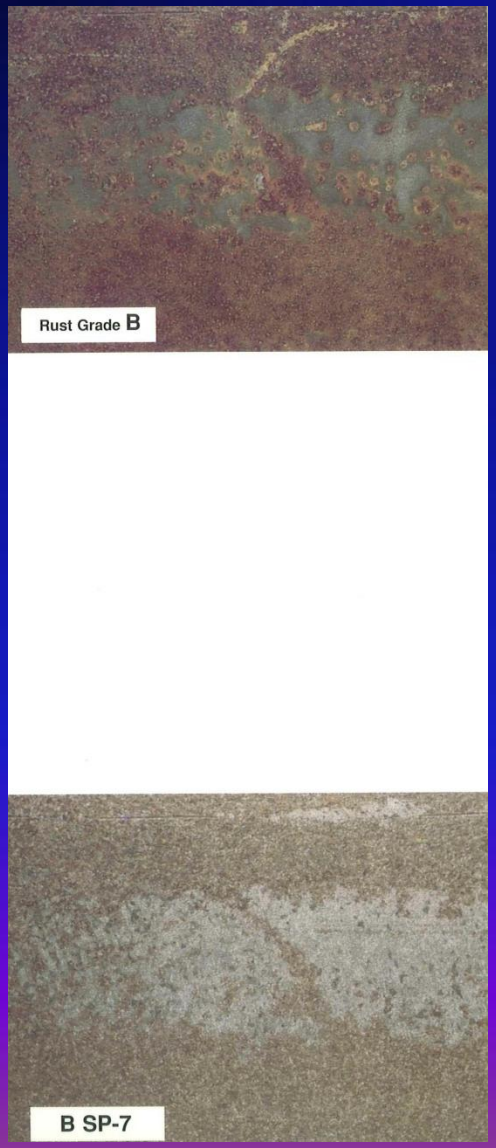
SSPC-VIS 1 Appearance of Cleaning – Condition A Steel

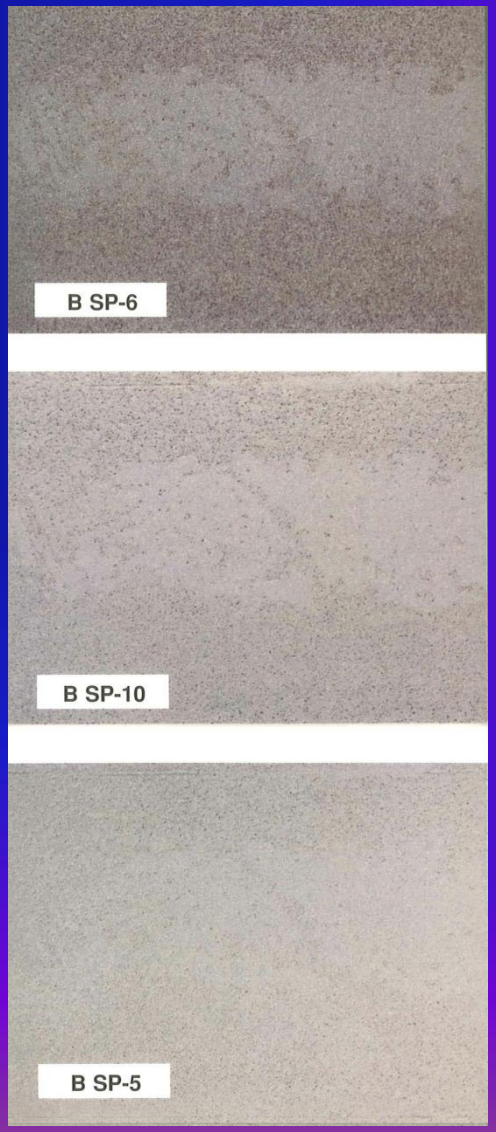


A SP-6
No photograph provided. The effort required to remove mill scale on Condition A steel typically results in less staining than the maximum 33% allowed by SP 6, approaching the photograph provided for A SP 10.

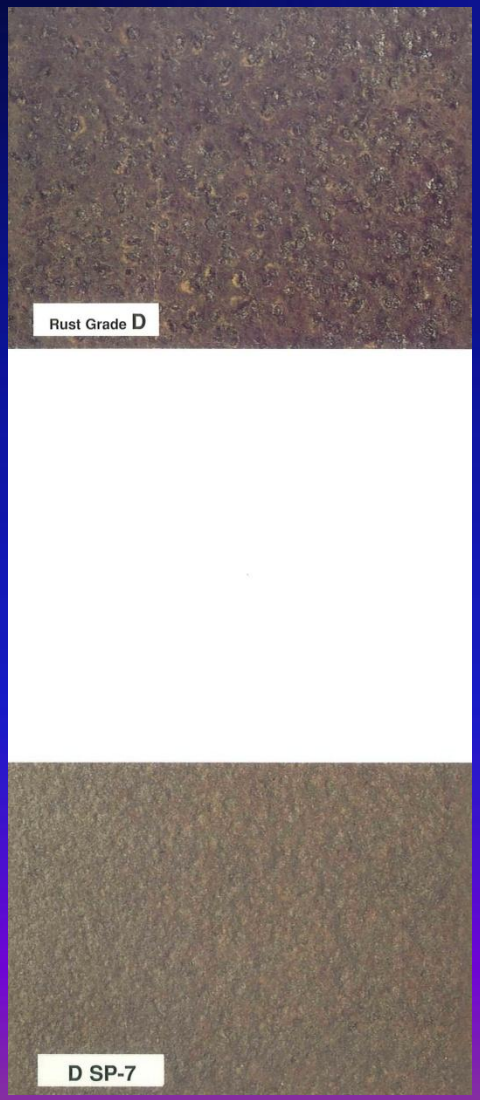


SSPC-VIS 1 Appearance of Cleaning – Condition B Steel

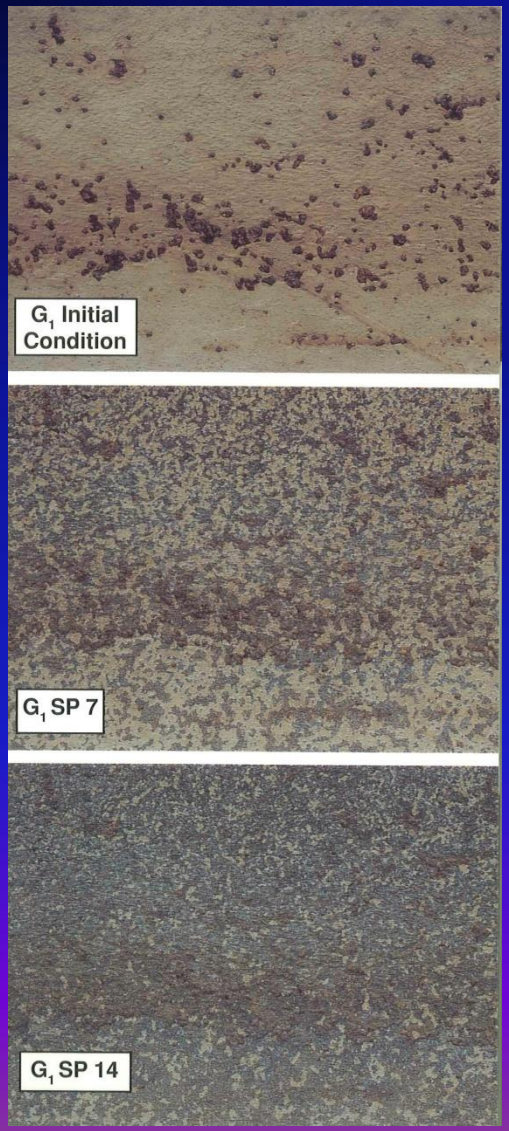


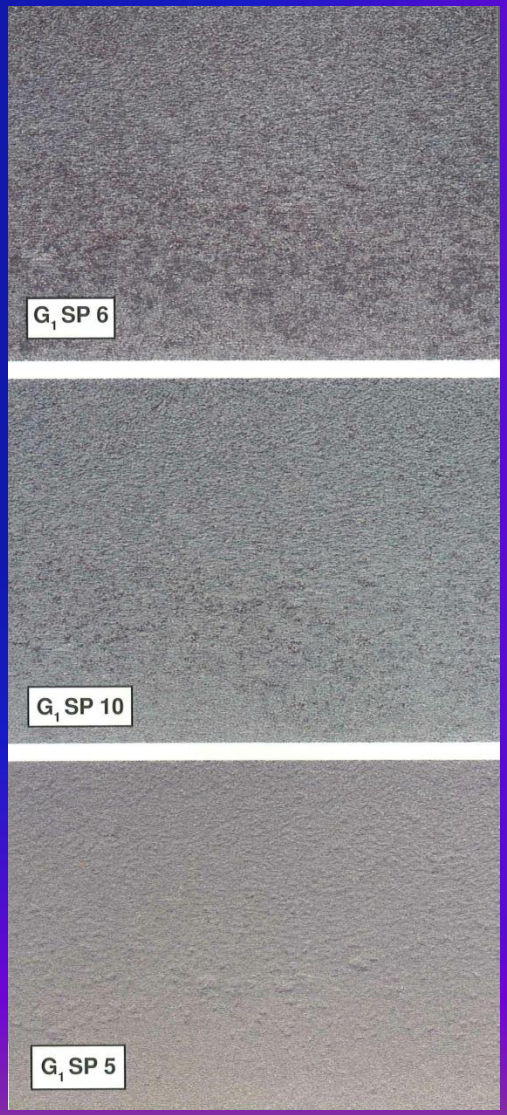


SSPC-VIS 1 Appearance of Cleaning – Condition D Steel



SSPC-VIS 1 Appearance of Cleaning – Condition G_1 Steel





SSPC-VIS 1 Appearance of Cleaning – Condition G_3 Steel

G_3 Initial Condition

G_3 SP 7

G_3 SP 14

G_3 SP 6

G_3 SP 10

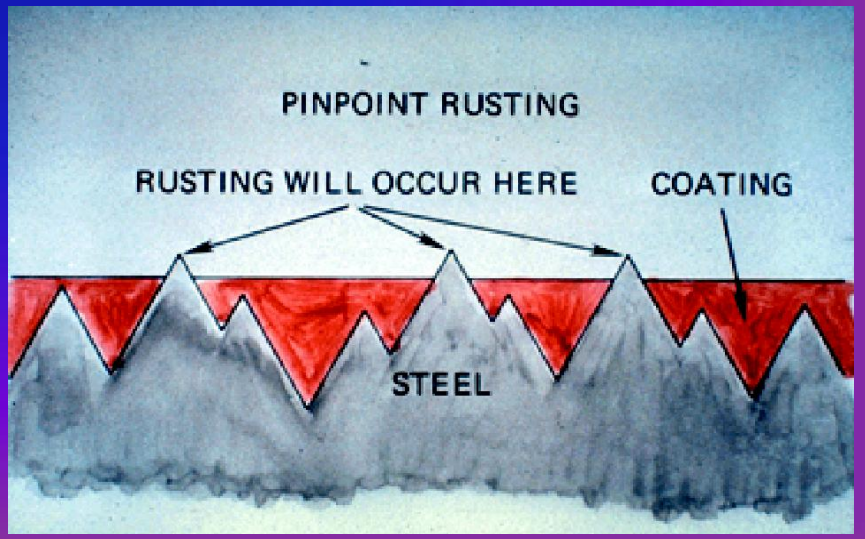
G_3 SP 5

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

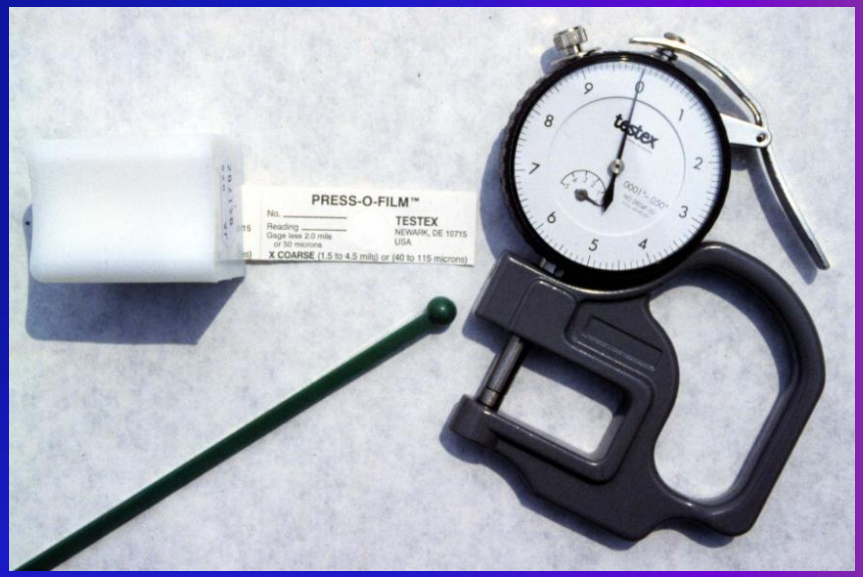
- Select Disc
- Attach Disc to Comparator
- Examine Surface
- Select Segment(s)
- Obtain "sufficient" no. of measurements

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®)

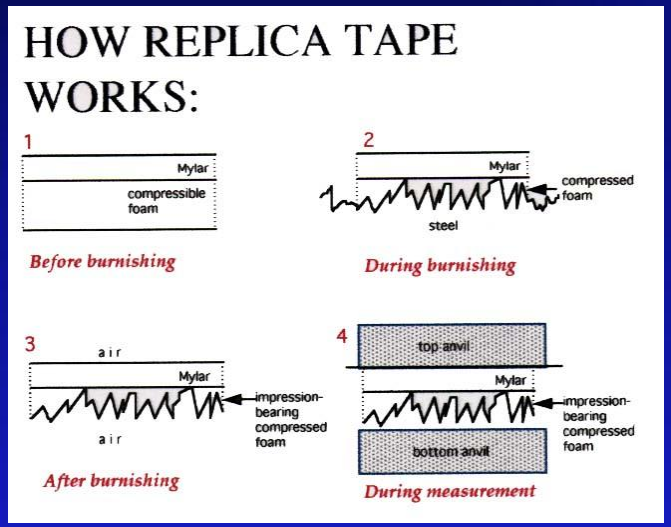


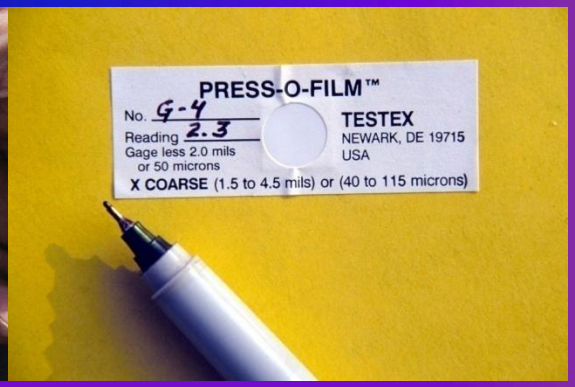
Measuring Surface Profile

- ✓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





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)

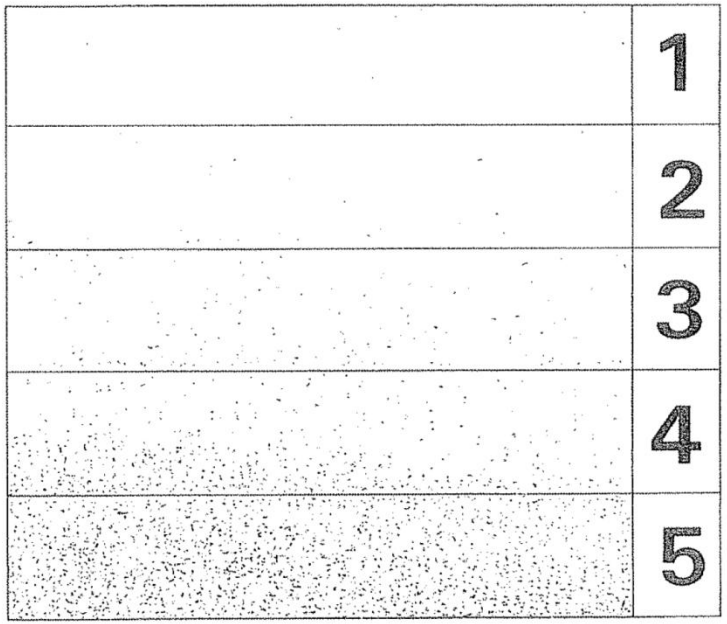


Figure 1 — Pictorial references corresponding to dust quantity ratings 1, 2, 3, 4 and 5

Table 1 — Dust size classes

Class	Description of dust particles
0	Particles not visible under × 10 magnification
1	Particles visible under × 10 magnification but not with normal or corrected vision (usually particles less than 50 µm in diameter)
2	Particles just visible with normal or corrected vision (usually particles between 50 µm and 100 µm in diameter)
3	Particles clearly visible with normal or corrected vision (particles up to 0 5 mm in diameter)
4	Particles between 0 5 mm and 2 5 mm in diameter
5	Particles larger than 2 5 mm in diameter

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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