



SSPC-VIS 4

Guide and Reference Photographs for
Steel Surfaces Prepared by
WATERJETTING

NACE VIS 7

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**Guide and Reference Photographs for
Steel Surfaces Prepared by Waterjetting**

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Guide to SSPC-VIS 4/NACE VIS 7

Reference Photographs for Steel Surfaces Prepared by Waterjetting Disclaimer

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1. SCOPE

1.1 This Guide describes the use of Reference Photographs depicting the appearance of unpainted rusted carbon steel and painted carbon steel, with or without rust, prior to and after cleaning by waterjetting (WJ). The Reference Photographs are intended to supplement the written standard SSPC-SP 12/NACE No. 5.¹ Pictures and descriptions of flash rusting are included for illustrative purposes. The written standards are the primary means to determine conformance with cleaning requirements. The photographs should not be used as a substitute for these standards.

2. DESCRIPTION

2.1 The Reference Photographs consist of a series of 1:1 (actual size) color photographs that represent various conditions of unpainted and painted carbon steel surfaces prior to and after waterjet cleaning. (See Section A.1.)

2.1.1 The user of this Guide should designate the degree of cleaning as WJ-1 (Clean to Bare Substrate), WJ-2 (Very Thorough Cleaning), WJ-3 (Thorough Cleaning), or WJ-4 (Light Cleaning) of SSPC-SP 12/NACE No 5. (See Section 4.2.)

2.1.2 This Guide can be used to clarify the acceptable level of flash rusting allowed prior to the application of protective coatings. The coating manufacturer should be contacted to verify that the coating material selected is suitable for application over the maximum allowable degree of flash rusting that has been specified. (See Sections A.3, A.4, A.5, A.6, and A.7.)

2.1.3 The user of this Guide should designate the maximum degree of flash rust permissible as None (the condition immediately after cleaning), Light (L), Moderate (M), or Heavy (H) Flash Rust. (See Section 4.4.)

2.1.4 The two series of flash rust photographs are illustrative of steel substrates cleaned by wet methods specified in WJ-1, WJ-2, WJ-3, or WJ-4 of SSPC-SP 12/NACE No. 5, not just for the conditions illustrated herein. Illustrative photos are included for Conditions C and D but not for Conditions A and B.

3. REFERENCED PUBLICATIONS

3.1 The publications referenced in this Guide are listed in Section 3.3 and are necessary for proper use of this Guide.

3.2 The latest issue, revision, or amendment of the referenced publications in effect on the date of invitation to bid shall govern unless otherwise specified.

3.3 SSPC AND NACE INTERNATIONAL REFERENCED PUBLICATIONS:

SSPC-SP 12/NACE No. 5 Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Waterjetting Prior to Recoating

SSPC-SP 1² Solvent Cleaning

4. CONDITIONS DEPICTED

4.1 INITIAL CONDITIONS: The Reference Photographs illustrate five of the seven initial conditions⁽¹⁾ before surface preparation as follows (see Section A.1):

Condition A (not illustrated): Steel surface completely covered with adherent mill scale; little or no rust visible.

Condition B (not illustrated): Steel surface covered with both mill scale and rust.

Condition C: Steel surface completely covered with rust; little or no pitting visible. The area includes an example of a discoloration caused by heat. (Rust Grade C)

Condition D: Steel surface completely covered with rust; pitting visible. The area includes an example of foreign matter. (Rust Grade D)

Condition E: Previously painted steel surface; light-colored paint applied over blast-cleaned surface; paint mostly intact.

Condition F: Previously painted steel surface; zinc-rich paint applied over blast-cleaned steel; paint mostly intact.

Condition G: Painting system applied over mill scale bearing steel; system thoroughly weathered, thoroughly blistered, or thoroughly stained.

Condition H: Degraded painting system applied over steel; system thoroughly weathered, thoroughly blistered, or thoroughly stained.

4.1.1 Other Conditions: When waterjetting is used to remove paint and other contaminants from mill scale bearing steel (Conditions A, B, and G), the mill scale is not usually removed. In that case, the appearance of the cleaned steel would be very similar to Initial Condition A or B.

⁽¹⁾ Initial Conditions A, B, C and D are sometimes referred to as Rust Grades A, B, C, and D, respectively.

4.2 END CONDITION: The various degrees of cleaning, with no flash rust, are described in SSPC-SP 12/NACE No. 5 (see Section A.2) as:

WJ-1	Clean to Bare Substrate
WJ-2	Very Thorough or Substantial Cleaning
WJ-3	Thorough Cleaning
WJ-4	Light Cleaning

4.3 Steel surfaces show variations in texture, shade, color, tone, pitting, flaking, and mill scale, which should be considered when making comparisons with the reference photographs. Acceptable variations in appearance that do not affect surface cleanliness include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill fabrication marks, heat treating, heat affected zones, and differences caused by the initial abrasive blast cleaning technique or by the cleaning pattern. (See Sections A.1 and A.8.)

4.4 FLASH RUST: The Reference Photographs also illustrate three degrees of flash rust. Flash rust or rust bloom is a light oxidation of the steel, which occurs as waterjet-cleaned steel dries off. It quickly changes the appearance. The color of the flash rust may vary depending on the age and composition of the steel and the time-of-wetness of the substrate prior to drying. (See Sections A.3, A.4, and A.5.)

Four series of photographs depict previously painted steel cleaned by waterjetting to produce WJ-1, WJ-2, WJ-3, and WJ-4 of SSPC-SP 12/NACE No. 5. Four initial conditions for paint applied over blast cleaned steel (Conditions E, F, G, and H, defined in Section 4.1) are depicted at each level of visible cleanliness.

4.4.1 No Flash Rust: A surface which, when viewed without magnification, exhibits no visible flash rust.

4.4.2 Light Flash Rust (L): A surface which, when viewed without magnification, exhibits small quantities of a yellow/brown rust layer through which the steel substrate may be observed. The rust or discoloration may be evenly distributed or present in patches, but it is tightly adherent and not easily removed by light wiping with a cloth.

4.4.3 Moderate Flash Rust (M): A surface which, when viewed without magnification, exhibits a layer of yellow/brown rust that obscures the original steel surface. The rust layer may be evenly distributed or present in patches, but it is reasonably well adherent and lightly marks a cloth that is lightly wiped over the surface.

4.4.4 Heavy Flash Rust (H): A surface which, when viewed without magnification, exhibits a layer of heavy red/brown rust that hides the initial surface condition completely. The rust may be evenly distributed or present in patches, but

the rust is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface. (See Sections A.5 and A.6.)

4.5 APPEARANCE: It is generally true that, when the surface is still damp or wet, it appears darker, and defects and variations in shading are magnified. As the surface is drying, streaks form which are not necessarily depicted in these small unit size photographs, but which may be clearly seen on larger areas. Whether or not streaks are acceptable should be addressed between the contracting parties. An example of streaking can be seen in C WJ-3 L and C WJ-2 M.

5. Procedures

5.1 DETERMINE INITIAL CONDITION: If the steel has not been previously painted, proceed to Paragraph 5.1.1. If it has been painted, proceed to Paragraph 5.1.2. Steel to be cleaned may contain more than one of the initial conditions. (See Sections A.1 and A.8.)

5.1.1 Unpainted Steel: Select the photograph of initial condition (C or D) that most closely represents the appearance of the unpainted steel to be cleaned.

5.1.2 Painted Steel: Select the photograph of the initial condition (E, F, G, or H) that most closely represents the appearance of the previously painted steel to be cleaned.

5.2 SELECT PHOTOGRAPH: Refer to Table 1 to select which reference photograph depicts the finished surface corresponding to the condition determined from Section 5.1 and the degree of cleaning specified in the procurement document.

5.3 DEGREE OF CLEANING: Immediately after waterjetting, but before the surface has flash rusted, compare the prepared surface with the photograph selected in Paragraph 5.2. The degree of cleaning should conform to WJ-1, WJ-2, WJ-3, or WJ-4 of SSPC-SP 12/NACE No. 5 as specified in the procurement document. (See Sections A.6, A.7, A.9, and A.10.)

5.4 DEGREE OF FLASH RUST: Prior to painting, compare the flash-rusted surface with the flash rust photographs. The list of flash rust photographs is given in Table 2. For non-pitted surfaces, use the C flash rust photographs for either painted or unpainted initial conditions. For pitted surfaces, use the D flash rust photographs for either painted or unpainted initial conditions. For example, if WJ-2 is specified and the steel is pitted, use D WJ-2 L, D WJ-2 M, or D WJ-2 H to evaluate the degree of flash rust that has occurred.

5.5 APPEARANCE IMMEDIATELY PRIOR TO COATING: The degree of flash rust specified shall be in accordance with Section 4.4. If no flash rust is acceptable, the surface

shall conform to Section 4.4.1 immediately prior to coating. The coating manufacturer may be contacted to verify that the coating material selected is suitable for application over the degree of flash rust that has occurred. (See Sections A.1, A.3, A.4, A.5, A.6 and A.7.)

5.6 ADDITIONAL CONSIDERATIONS: The Reference Photographs shall be used only in conjunction with the written surface preparation specifications. The photographs are based upon appearance only, are for illustrative purposes, and do not address other factors necessary for compliance with the written specification. (See Sections A.9 and A.10.)

Condition C contains an example of heat-affected discoloration. Condition D contains an example of foreign matter. Condition G is a degraded system of gray primer, red intermediate, and cream topcoat. The photos G WJ-3 and G WJ-2 show islands of black, tightly adherent mill scale that were uncovered during the cleaning. In G WJ-1, the mill scale has been removed but the discoloration pattern remains.

Condition G illustrates a non-brittle paint system that can be feathered. Condition H shows a brittle paint system in which the paint edges remain sharp.

REFERENCES

- ¹ SSPC-SP 12/NACE No. 5 (latest revision), "Surface Preparation of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
- ² SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pittsburgh, PA: SSPC).
- ³ SSPC Painting Manual, Volume 2, *Systems and Specifications* (latest revision), "Surface Preparation Commentary" (Pittsburgh, PA: SSPC).

APPENDIX A: EXPLANATORY NOTES

A.1 INITIAL CONDITIONS: Initial Conditions C and D are "new construction" surface conditions, and are defined in the SSPC Surface Preparation Commentary, where they are referred to as "Rust Grades."³ Waterjetting can also be used to remove contaminants or paint from the surface of mill scale bearing steel (Condition A or B). Photos are not included because the appearance after cleaning is reasonably similar to the initial condition.

Conditions E, F, G, and H are "maintenance" surface conditions. Conditions E and F represent surfaces having aged coatings originally applied over blast-cleaned steel on which the paint is mostly intact. Condition G is deteriorated paint over mill scale bearing steel; Condition H represents surfaces

having deteriorating aged coatings. Although many surfaces encountered in practice may not closely correspond to conditions E, F, G, or H, careful extrapolation of the photographs can aid in determining conformance with the cleaning requirements.

A.2 In 2001, SSPC and NACE are exploring the possibility of splitting SSPC-SP 12/NACE No. 5 into four separate standards such that WJ-1 will be a different standard than WJ-2, and so on. At the time of publication of this visual standard, the four degrees of cleaning by waterjetting are included in SSPC-SP 12/NACE No. 5.

A.3 TEMPERATURE: The temperature of steel substrates can rise during the waterjetting process. Compression of the water to reach jetting pressure creates a temperature increase in the water itself. The water transfers energy to the steel resulting in an increase in the steel's temperature. This temperature increase can be substantial, and may help waterjetted surfaces dry off more quickly, with a corresponding reduction in the severity of flash rust. (See Section A.5).

A.4 REMOVAL OF FLASH RUST: Drying with hot-air blowers or the use of a vacuum are methods to reduce the severity of flash rust. When flash rust is too heavy for a coating application, some coating manufacturers permit its reduction or removal by using clean, hand-held wire brushes or by pressure washing with fresh water. Pressure washing (low-pressure water cleaning) at pressures above 7 MPa (1,000 psi), using either the rotational nozzles or fan jet lances of the waterjetting equipment itself, is a preferred method. It causes the area to re-rust, but it is possible to reduce the degree of flash rust from heavy to light using this method. The appearance of new flash rust resulting from the pressure washing generally does not look like the original flash rust resulting from waterjetting. Hand wire or bristle brushing to remove heavy flash rust may be acceptable for small areas. For large surfaces, mechanical cleaning with power tools can produce acceptable results when the cleaning yields an anchor profile, either imparted or existing, necessary for coating adhesion.

A.5 CHEMICAL CORROSION INHIBITORS: Flash rust can be prevented by the use of corrosion inhibitors. These inhibitors may leave contaminants on the steel surface as the water evaporates. If coatings are applied over this type of surface, a loss of adhesion and/or osmotic blistering can occur. If inhibitors are used, they should be thoroughly washed off with fresh water. It is strongly recommended that the coating manufacturer be contacted to assure the rust inhibitor is compatible with the specific coating system being applied.

A.6 INSPECTING WATERJET CLEANED SURFACES PRIOR TO FLASH RUST: When large areas are cleaned by waterjetting, flash rusting may occur, obscuring the level of visual cleanliness before an inspection can be carried out. The

establishment of the required visual cleanliness, by cleaning and drying a small representative test area prior to production, may help, providing the rest of the job is cleaned to the same degree. Methods for ensuring that the rest of the job is cleaned to the same degree vary from project to project.

A.7 INSPECTING AREAS OF DIFFICULT ACCESS:

Special attention must be given to areas that are difficult to access, such as the backs of stiffening bars. Water cannot be ricocheted into these areas in the same manner as abrasives. Instead, specially designed angled nozzles should be used. These areas should be inspected carefully.

A.8 DISCOLORATION OF CORRODED AND PITTED

STEEL: The gray/brown to black discoloration seen on corroded and pitted steel after waterjetting cannot be removed by further waterjetting. Analysis shows that this thin film consists mainly of ferric oxide which is an inert material. Because it is tightly adherent, it does not present a serious contamination problem.

A.9 REMOVAL OF OIL AND GREASE: The waterjetting process can emulsify and remove oil and grease from a surface as it is cleaned. However, this does not preclude the need for proper degreasing procedures as specified in SSPC-SP 1 (Solvent Cleaning)², prior to waterjetting.

A.10 REMOVAL OF SOLUBLE CONTAMINANTS: This Reference Photograph series makes no attempt to define levels of soluble contaminants (salts) remaining on surfaces cleaned by waterjetting, or to relate degrees of flash rust to remaining soluble contaminants. However, the ability to remove chemical contaminants (salts), particularly from badly pitted and corroded steel, is a major advantage of the waterjetting process.

ACKNOWLEDGMENTS

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Members of the SSPC/NACE Steering Committee who directed this activity included:

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Wallace Cathcart	Trinity Industries, Inc.
Monica Chauviere	ExxonMobil Refining and Supply Co.
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Butterworth Jetting Systems, Inc.

NLB Corporation

Nozl-Tech, Inc.

Table 1
List of Reference Photographs (Without Flash Rust)
for Various Initial Conditions and for Four Degrees of Cleaning

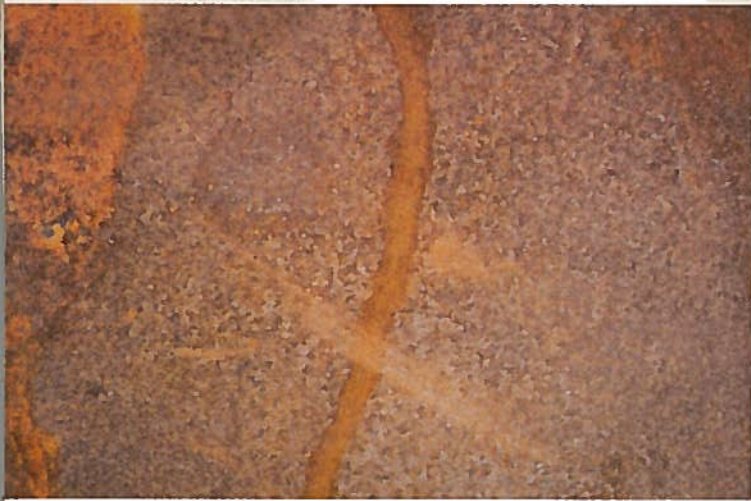
Initial Surface Condition	Condition C 100% Rust	Condition D 100% Rust with pits	Condition E Light-colored paint applied over blast- cleaned steel	Condition F Zinc-rich paint applied over blast- cleaned steel	Condition G Multicoat non-brittle painting system applied over mill scale- bearing steel	Condition H Deteriorated brittle multicoat painting system
Degree of Cleaning						
WJ-1	C WJ-1	D WJ-1	E WJ-1	F WJ-1	G WJ-1	H WJ-1
WJ-2	C WJ-2	D WJ-2	E WJ-2	F WJ-2	G WJ-2	H WJ-2
WJ-3	C WJ-3	D WJ-3	E WJ-3*	F WJ-3	G WJ-3	H WJ-3
WJ-4	C WJ-4	D WJ-4	E WJ-4	F WJ-4	G WJ-4	H WJ-4

* E WJ-3 ALT is an alternate illustration of this condition.

Table 2
List of Reference Photographs Showing Levels of Flash Rust*

Degree of Cleaning	Initial Surface Condition			
	Condition C 100% Rust		Condition D 100% Rust With Pits	
	WJ-2	WJ-3	WJ-2	WJ-3
No Flash Rust	C WJ-2	C WJ-3	D WJ-2	D WJ-3
Light Flash Rust	C WJ-2 L	C WJ-3 L	D WJ-2 L	D WJ-3 L
Moderate Flash Rust	C WJ-2 M	C WJ-3 M	D WJ-2 M	D WJ-3 M
Heavy Flash Rust	C WJ-2 H	C WJ-3 H	D WJ-2 H	D WJ-3 H

* The reference photographs illustrate two initial conditions (rust grades) of mill scale-free, previously unpainted, rusted carbon steel before surface preparation. Each of the photographs showing the initial conditions was selected to show the variations which can be found within the rust grade C and D definitions. The initial condition surfaces are not necessarily the same areas which are depicted in the cleaned condition photographs.



INITIAL CONDITION C



C WJ-4



C WJ-3

C WJ-2

C WJ-1



INITIAL CONDITION D



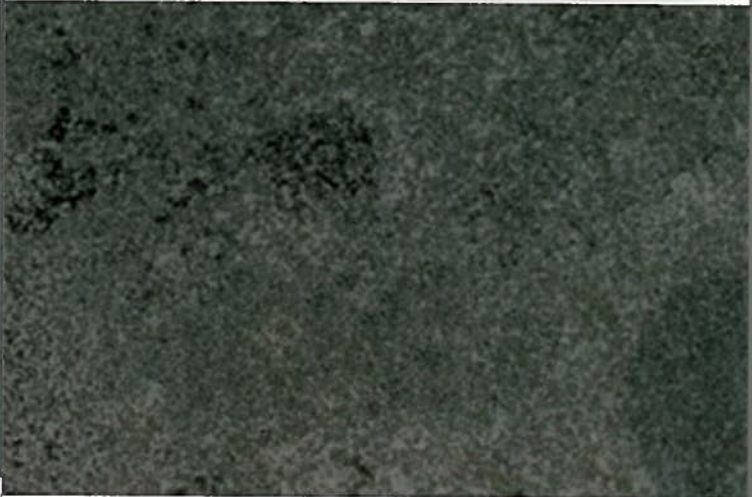
D WJ-4



D WJ-3



D WJ-2

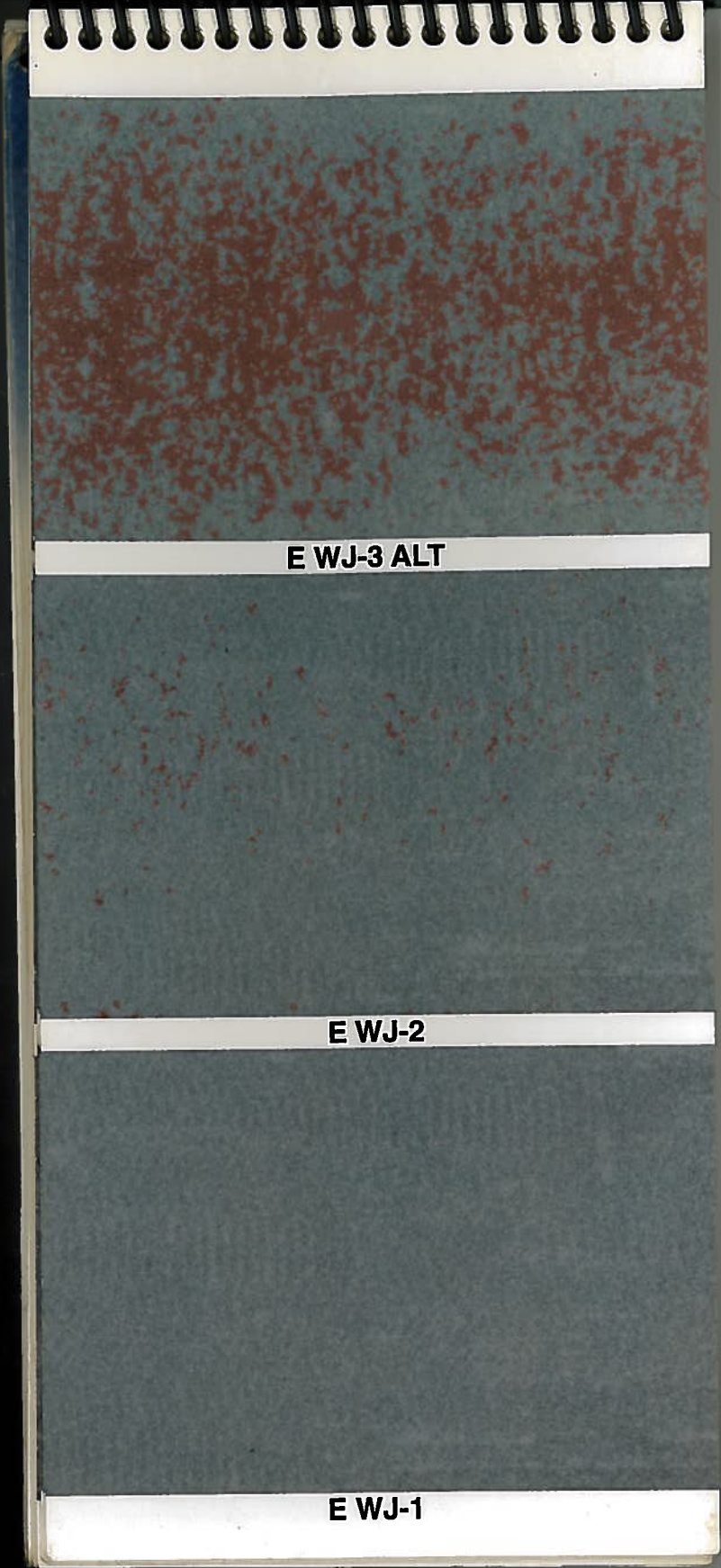


D WJ-1

INITIAL CONDITION E

E WJ-4

E WJ-3

A spiral-bound notebook is shown vertically, featuring three distinct color swatches. The top swatch is a mottled mix of reddish-brown and greyish-blue. The middle and bottom swatches are a solid, dark greyish-blue. Each swatch is separated by a white horizontal band containing black text. The notebook is set against a dark background on the left and a light grey background on the right.

E WJ-3 ALT

E WJ-2

E WJ-1

INITIAL CONDITION F

F WJ-4

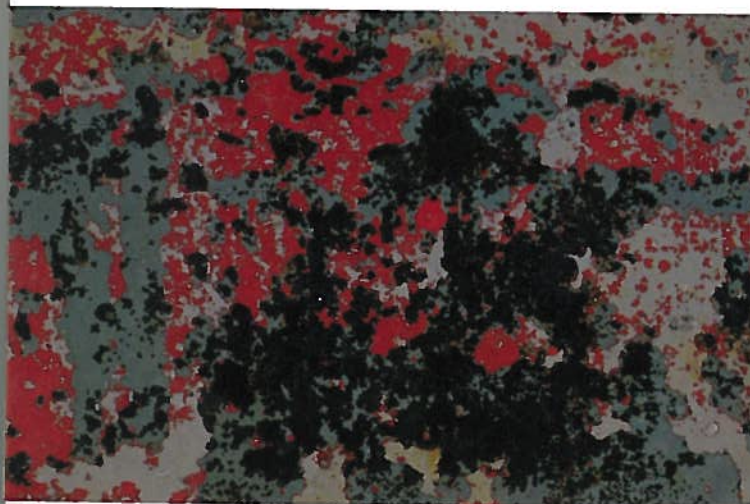
F WJ-3

F WJ-2

F WJ-1

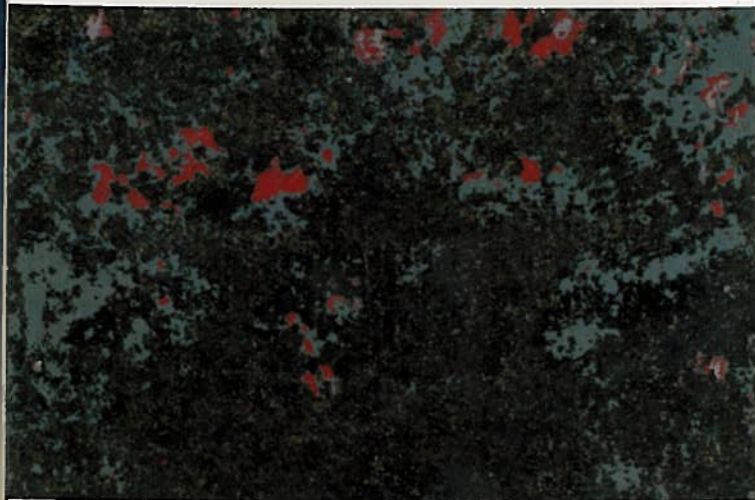


INITIAL CONDITION G



G.WJ-4





G WJ-3



G WJ-2



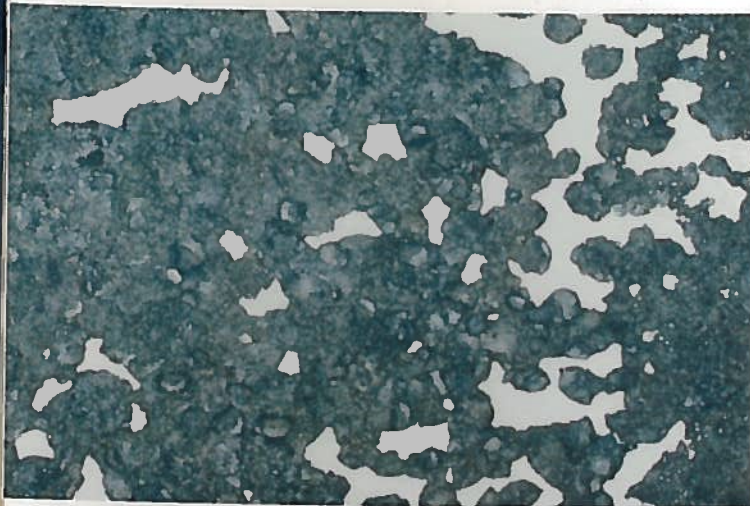
G WJ-1



INITIAL CONDITION H



H WJ-4



H WJ-3



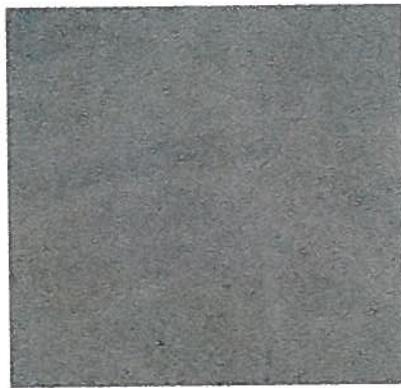
H WJ-2



H WJ-1



INITIAL CONDITION C



C WJ-2



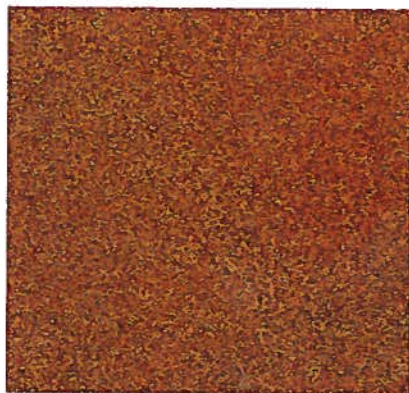
C WJ-2 L



C WJ-2 M



C WJ-2 H



INITIAL CONDITION C



C WJ-3



C WJ-3 L



C WJ-3 M



C WJ-3 H



INITIAL CONDITION D



D WJ-2



D WJ-2 L



D WJ-2 M



D WJ-2 H



INITIAL CONDITION D



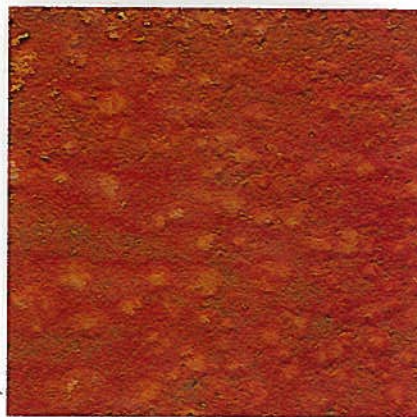
D WJ-3



D WJ-3 L



D WJ-3 M



D WJ-3 H