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FACULTAD DE INGENIERÍA QUÍMICA
ESCUELA PROFESIONAL DE INGENIERÍA QUÍMICA

TRABAJO DE SUFICIENCIA PROFESIONAL

“PREPARACIÓN DE SUPERFICIE DEL ACERO PARA MANTENIMIENTO EN LA APLICACIÓN DE RECUBRIMIENTOS”

PARA OPTAR EL TITULO PROFESIONAL DE

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PRESENTADO POR

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PERÚ

PRÓLOGO DEL JURADO

El presente Trabajo de Suficiencia Profesional fue expuesto por la Bachiller **BERROSPI TAPIA MARIELA EULALIA** ante el Jurado de Exposición del Informe de Trabajo de Suficiencia Profesional conformado por los siguientes docentes ordinario de la Universidad Nacional del Callao:

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INTRODUCCIÓN

Las superficies de acero deben prepararse antes de aplicar los recubrimientos protectores para poder obtener buenos resultados. Los recubrimientos modernos requieren una superficie limpia y rugosa para que logren una estabilidad a largo plazo, a menos que estén diseñados específicamente para aplicarse sobre preparaciones de superficies mínimas. Se ha estimado que hasta 75% de todas las fallas prematuras de recubrimientos son causadas casi por completo o en parte, por una inadecuada o inapropiada preparación de la superficie.

En el caso de estructuras ya pintadas y deterioradas por descuido en la protección, el acondicionamiento de la superficie resulta más largo y costoso que la misma aplicación de pintura. Cuando el mantenimiento es cuidadoso y permanente, resulta muy fácil y económico.

Prácticamente para cada proceso de recubrimientos, la limpieza inicial y la preparación de la superficie que será recubierta son un paso del cual depende el éxito subsecuente del sistema de recubrimientos. Limpiar el material de toda impureza que pueda ocasionar fallas prematuras en el sistema de recubrimientos (pinturas), una superficie con un perfil de anclaje adecuado, permite que el recubrimiento pueda impregnarse fácilmente para una buena adherencia.

Algunos contaminantes típicos que se deben eliminar durante la preparación de superficie son los visibles (aceite, grasa, óxidos, suciedad) y no visibles (sales solubles)

I. ASPECTOS GENERALES

1.1. Objetivos

Cumplir con la protección anticorrosiva de la superficie inspeccionada y alargar el tiempo de vida útil del elemento a recubrir con el sistema de protección con pinturas liquidas.

Inspeccionar la superficie e identificar el grado de corrosión actual.

Diseñar el sistema de protección para alargar el tiempo de vida útil del elemento metálico.

Identificar la preparación de superficie idónea de acuerdo con las condiciones de operación de la planta.

1.2. Organización de la empresa

Corporación Peruana de Productos Químicos (CPPQ) es una empresa producto de la fusión de: Compañía Peruana de Pinturas y Uniquímica (1996), un año más tarde, la Compañía Industrial Pólux representante de Ameron International Protective Coatings Group en el Perú pasa a ser parte del Grupo. En el año 2000 se compra la marca FAST; con lo cual CPPQ logra la importante participación en el mercado de pinturas y revestimiento industrial y marítimo. La tecnología de vanguardia desarrollada por AMERON permite a los usuarios contar con los últimos desarrollos para la protección de sus instalaciones.

En el año 2010 AMERON cambia de nombre por AMERCOAT ® y pasa a formar parte de PPG Protective & Marine Coatings (PMC) quien es el líder mundial en acabados protectores y marinos. Los productos AMERCOAT son ampliamente especificados en todo el mundo para proteger bienes en los ambientes y condiciones más demandantes Amercoat ® protege una amplia variedad de proyectos en distintos mercados: marino, infraestructura, energía, minería, transporte y petroquímica.

Los productos Amercoat ® están especialmente posicionados dentro de la familia PMC para proveer productos y tecnologías probadas. Desde la tecnología patentada PSX® Polysiloxane, imprimantes epoxy con altos porcentajes de sólidos y poliuretanos, todos tienen gran historia alrededor del mundo por su extraordinaria calidad.

CPPQ fabricaba y comercializaba los productos AMERCOAT en Perú hasta el año 2012.

II. FUNDAMENTACION DE LA EXPERIENCIA PROFESIONAL

2.1. Marco Teórico

2.1.1. Protección del acero

En el ambiente industrial y marítimo, gran parte de las estructuras que conforman sus instalaciones están compuestos por acero al carbono, el cual es un material relativamente económico y resistente para diferentes tipos de operaciones o actividades que se realizan.

Es así que las estructuras metálicas son protegidas con recubrimientos adecuados que permiten aislar el sustrato del medio ambiente y de esa manera evitar que se produzca la corrosión del acero. Debido a ello, las diferentes empresas siempre cuentan con un plan de mantenimiento que asegure la vida útil del acero por un largo tiempo.

Para ello, la limpieza adecuada de las superficies, especialmente el acero usado (mantenimiento), es esencial para lograr un desempeño apropiado del sistema de recubrimientos seleccionado. La naturaleza y condición de la superficie que será preparada y pintada afecta el grado del trabajo de preparación de la superficie que se realizará.

2.1.2. Recubrimientos

Un ambiente severo, marino o químico, normalmente exige un mayor grado de limpieza para asegurar el buen desempeño del sistema de recubrimientos. Un ambiente más rural – con menos contaminación – permitirá un mejor desempeño del mismo sistema de recubrimientos o el mismo desempeño si se aplica a un menor grado de preparación de la superficie.

Los sistemas de recubrimientos varían significativamente en su habilidad para unirse al acero. Algunos recubrimientos con buenas propiedades de humectación, como los epóxicos mastic, los alquídicos, y algunos productos bituminosos, se adhieren mejor que otros a una superficie no tan completamente limpia. Mientras que los productos del tipo epóxicos fenólicos, epóxicos novalacas, y las del tipo rico en zinc, se adhieren mejor en una superficie completamente limpia. Sin embargo, todos los sistemas tendrán un mejor desempeño en una superficie bien preparada, con un buen perfil de anclaje.

2.1.3. Técnicas de preparación de superficie

Las técnicas más comunes que se usan para la preparación de la superficie del acero son:

2.1.3.1. Limpieza con solventes

Es el método que se utiliza para eliminar de la superficie la presencia de grasas, aceites y contaminantes visibles, así como compuestos de marcaje o corte, y otros contaminantes solubles de las superficies de acero.

La SSPC SP1 es la única norma que normalmente rige la limpieza con solventes para eliminar los contaminantes mencionados. Un ejemplo se muestra en la **Figura Nº 1 (Ver pág. Nº 8)** más información al detalle de la norma SSPC SP1 se presenta en el **Anexo Nº 1**

2.1.3.2. Limpieza con herramientas manuales

La limpieza con herramientas manuales es un método para preparar las superficies de acero mediante instrumentos no motorizados. Este tipo de limpieza puede eliminar el *mill scale* (cuando el acero es laminado a altas temperaturas y durante su proceso de enfriamiento se forma una lámina delgada de color grisáceo azulado inestable), óxido, pintura y otra materia perjudicial extraña que estén sueltos o mal adheridos. El *mill scale*, el óxido y la pintura se consideran bien adheridos al sustrato si no pueden removerse con una espátula sin punta.

Figura Nº 1 *Solventes usados según SSPC SP1*

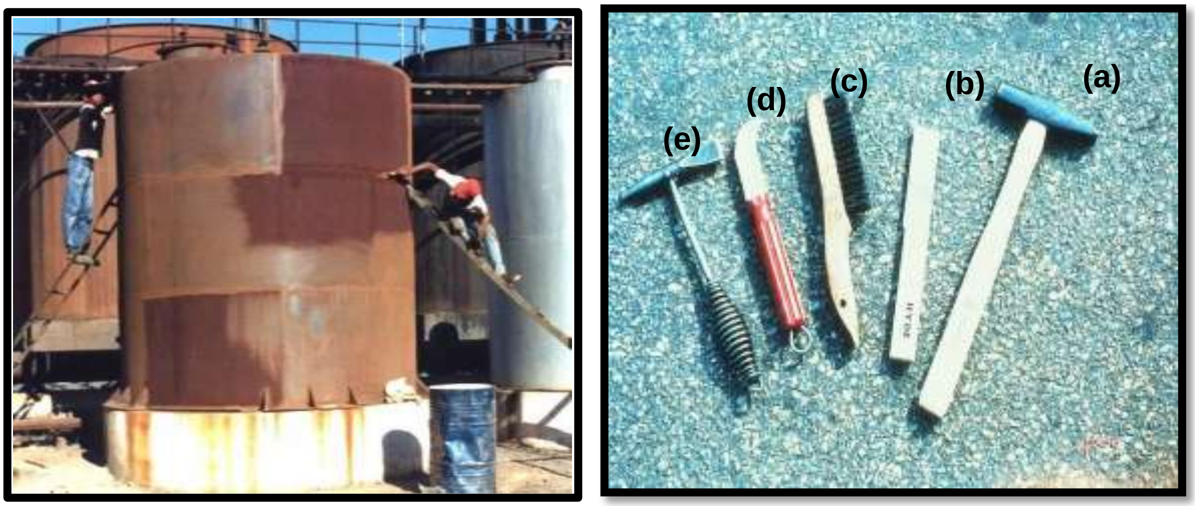
Almacenes de producto terminado de CPPQ

Las herramientas manuales de mayor uso son (algunos de ellos se muestran en la **Figura Nº 2 (ver pág. Nº 9**):

1) Piquetas (a)
2) Cuchillos y espátulas (b)
3) Raspadores (lijas) y cepillos de alambre (c)
4) Cinceles (d)
5) Martillos y combas (e)

Una norma que se usa comúnmente para controlar el proceso en mención es "Limpieza con Herramientas Manuales", SSPC SP2. Los estándares visuales como SSPC VIS3 o cualquier otro estándar visual acordado por las partes contratantes, puede usarse para especificar el acabado superficial requerido o para verificar la condición alcanzada.

Figura Nº 2 *Preparación de superficie del exterior de un tanque con herramientas manuales (izquierda), algunas de las herramientas que se usan (derecha)*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 10: Preparación de la Superficie, página 10 – 33

Nota : Se sabe que algunos inspectores usan una espátula afilada, lo cual va en contra de la norma.

Ambas normas definen el uso de una espátula sin punta para determinar si los contaminantes están firmemente adheridos o no. Más información al detalle de la norma SSPC SP2 se presenta en el **Anexo Nº 2**

La limpieza manual es el método más lento y quizás el menos satisfactorio para la preparación de la superficie. Además de requerir mano de obra intensa y costosa, es prácticamente imposible quitar todo el *mill scale* y óxido con este método. Se usa a menudo cuando:

1) No se dispone de equipos mecánicos.

2) El trabajo es inaccesible para las herramientas de poder.

3) El trabajo es demasiado pequeño para garantizar el uso de herramientas de poder.

2.1.3.3. Limpieza con herramientas mecánicas

La limpieza con herramientas de mecánicas es un método para preparar las superficies de acero usando herramientas impulsadas por una fuente de poder. Estas herramientas son básicamente similares a las usadas para la limpieza manual, pero se emplean con una fuente de poder como electricidad o aire comprimido.

Este proceso puede eliminar el *mill scale*, óxido, pintura y otra materia extraña perjudicial suelta, pero no está diseñado para removerlos en caso estuvieran bien adheridos. Al igual que en la norma SSPC SP2, se consideran bien adheridos si no pueden removerse levantándolos con una espátula sin punta. La norma más usada para regir el proceso de este tipo de limpieza es la SSPC SP3.

La limpieza con herramientas de mecánicas se usa frecuentemente en operaciones de mantenimiento. Además este método puede usarse para remover restos de soldadura, salpicaduras de soldadura, laminaciones y para alisar soldaduras rugosas y redondear muescas antes de la limpieza abrasiva. Las herramientas mecánicas comúnmente usadas y que parte de ellas se muestran en la **Figura Nº 3 (Ver pag. Nº 11)** son:

1) Cepillo de alambre rotatorio (a)
2) Pistola de aguja, cincel de pistón, raspador rotatorio (b)
3) Discos de corte, de abrasivos y lijadoras (c)

Figura Nº 3 *Preparación de superficie en el interior de un ángulo (izquierda), algunas de las herramientas que se usan (derecha)*

National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 10: Preparación de la Superficie, página 10 – 35

Una desventaja mayor de usar herramientas mecánicas probablemente es el efecto de bruñido que se produce en la superficie de metal. Este efecto de pulido, inherente a las herramientas mecánicas, es el rasgo menos satisfactorio de este método. Una superficie pulida afecta la calidad de la adhesión de la pintura y el efecto debería evitarse si se van a aplicar recubrimientos. Se usan a menudo la limpieza con herramientas manuales y mecánicas cuando un sistema de recubrimientos existente se va a renovar o reparar, y puede ser la opción apropiada cuando hay una cantidad limitada de degradación del sistema de recubrimientos existente. Información al detalle de la norma SSPC SP3 se presenta en el **Anexo Nº 3**

2.1.3.4. Limpieza con herramientas de poder al metal desnudo

Cuando se requieren o se especifican los más altos niveles de preparación de la superficie, la producción de un perfil de anclaje es una parte obligatoria, es por ello por lo que este tratamiento, define una limpieza con herramientas de poder en donde se desea una superficie del metal desnudo, limpio y rugoso. Las superficies metálicas preparadas, cuando se observan sin magnificación, estarán libres de todo aceite visible, grasa, suciedad, polvo, *mil scale*, óxidos, pintura, productos de la corrosión y otra materia extraña. La norma más usada para regir el proceso de este tipo de limpieza es la SSPC SP11

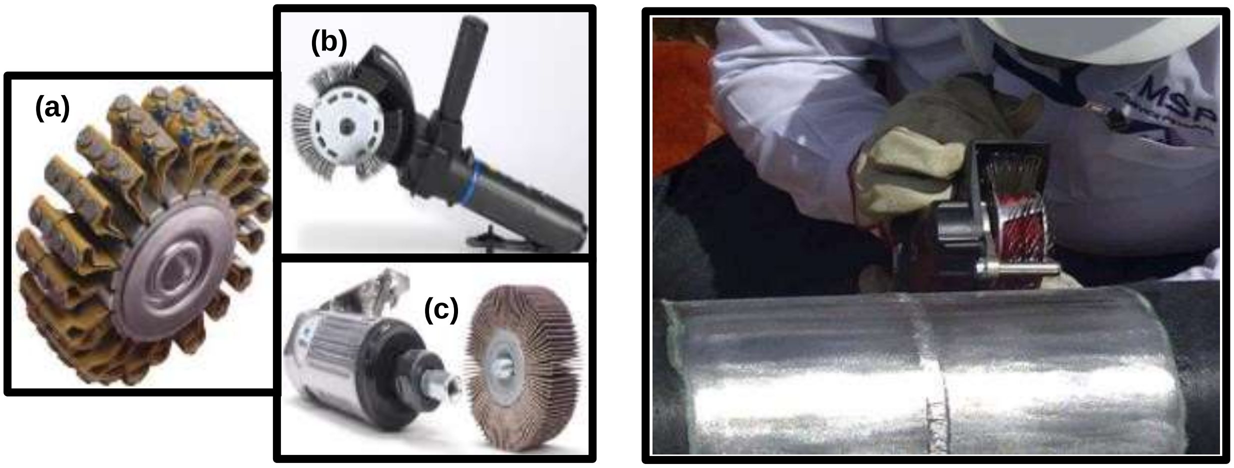
Los residuos ligeros de óxido y pintura pueden quedar en la porción inferior de las picaduras, si la superficie original está picada. Si se especifica el pintando, la superficie debe hacerse rugosa a un grado conveniente para la aplicación de un determinado sistema de pintura, con un perfil de anclaje no menos de 1 mils (25,4 µm). La limpieza con herramientas de poder que cumple con la norma SSPC SP11 produce un grado mayor que el mencionado en la norma SSPC SP3

Aunque este método produce superficies que asemejan el chorreo abrasivo al grado casi blanco o comercial, no son necesariamente equivalentes a las superficies producidas por la limpieza abrasiva. Las herramientas de mayor uso para obtener superficies conformes con SSPC SP11 son:

1) 3M Heavy Duty Roto–Peen flap assembly (a)
2) MBX Blister Blaster (b)
3) Ruedas Grind–O–Flex (c)
4) Numatic air–inflated wheels (d)

Parte de estas herramientas se muestran en la **Figura Nº 4 (Ver pag. Nº 10)** Aunque es más rápido que las herramientas manuales, el trabajo sigue siendo intenso y relativamente caro. La remoción de herrumbre y otra contaminación del fondo de picaduras e irregularidades en la superficie son muy difíciles. Más información al detalle de la norma SSPC SP11 se presenta en el **Anexo Nº 4**

Figura Nº 4 *Imagen a, b y c son algunas de las herramientas que se usan, preparación de superficie del exterior de una tubería al metal desnudo (derecha)*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 10: Preparación de la Superficie, página 10 – 42

2.1.3.5. Limpieza por chorro abrasivo seco

El método más usado para la preparación de la superficie para la aplicación de recubrimientos es la limpieza abrasiva seca. De hecho, cuando se aplican modernos recubrimientos sofisticados para la protección de la superficie, no existe ningún proceso alternativo verdaderamente satisfactorio o con su equivalente económico. La limpieza abrasiva seca es una corriente extremadamente concentrada de partículas abrasivas relativamente pequeñas proyectadas contra la superficie a ser preparada, desgastándola por el impacto a alta velocidad de las partículas abrasivas, removiendo *mil scale*, óxido, pintura antigua u otros contaminantes, creando una superficie con un perfil de anclaje adecuado para la adhesión del sistema de pintura.

Se han definido varios grados, o normas, de limpieza superficial obtenidos mediante limpieza abrasiva. Las normas de limpieza abrasiva para el acero que normalmente se usan en estas aplicaciones son elaboradas por NACE, SSPC e ISO. Las más usadas para la limpieza abrasiva son:

1) SSPC SP5 “Limpieza Abrasiva a Metal Blanco”
2) SSPC SP10 “Limpieza Abrasiva a Metal Casi Blanco”
3) SSPC SP6 “Limpieza Abrasiva Comercial”
4) SSPC SP7 “Limpieza Abrasiva Superficial o Brush–Off”

Más información al detalle de las normas SSPC en mención se presenta en el **Anexo Nº 5**. Cada sistema de normas sólo representa una escala progresiva de apariencia visual, y el mejor grado se muestra primero en cada caso. La calidad de la limpieza abrasiva se determina visualmente y por lo general se usan estándares visuales para propósitos de comparación, como por ejemplo la SSPC VIS1

No hay ninguna correlación entre el grado de limpieza abrasiva y el perfil de anclaje producido, y ninguna correlación específica con la remoción de contaminación química (o sales no visibles). Para estos problemas, deben usarse otras normas y técnicas de medición. En la **Figura Nº 5 (Ver pág. Nº 15)** se muestra el proceso del chorreo abrasivo seco.

2.1.3.6. Limpieza por chorro abrasivo húmedo

Esta preparación de la superficie para la aplicación del recubrimiento se le conoce también como *wet blasting*, es un método de limpieza que consiste en inyectar agua en el corriente aire/abrasivo que es impulsado por un equipo convencional generador de aire presurizado tal como se menciona en la norma SSPC TR2 y que se desarrolló por dos razones principales.

Figura Nº 5 *Preparación de superficie por chorro abrasivo seco de juntas (izquierda) y del exterior de un molino (derecha)*

National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 10: Preparación de la Superficie, página 10 – 47

Primero, la presencia de agua reduce las emisiones de polvo y permite el uso de técnicas de limpieza abrasiva en lugares donde el polvo es considerado una molestia o un peligro. Segundo, el agua puede tener el efecto de lavar contaminantes solubles que la limpieza abrasiva seca no puede quitar fácilmente.

Los componentes peligrosos del residuo, incluyendo emisiones de polvo, son muy reducidos, hasta 75% del polvo no puede escapar de la corriente de agua y es, en teoría, incapaz de entrar en el ambiente circundante inmediato. En la **Figura Nº 6 (Ver pag. Nº 16)** se muestra el proceso del chorreo abrasivo húmedo.

Las desventajas incluyen el problema de remover el abrasivo usado en su forma húmeda) y la necesidad de usar un inhibidor en el agua para evitar que la superficie se oxide cuando se usa para limpiar el acero.

El perfil de anclaje de la superficie es similar al logrado con la limpieza abrasiva en seco pero, por supuesto, la superficie queda húmeda. Las presiones de limpieza son casi iguales a las del chorro abrasivo seco, hasta 690 kPa (100 psi., 6,9 bar), y las tasas de producción son similares. El tiempo de limpieza es probablemente mayor, debido a la dificultad de eliminar el abrasivo humedecido. Más información al detalle de la norma SSPC TR2 se presenta en el **Anexo Nº 6**

Figura Nº 6 *Preparación de superficie por chorro abrasivo húmedo*

Limpieza abrasiva a chorro húmedo Parte 1 de 3
https://www.youtube.com/watch?app=desktop&v=q9M5z74VgvY

2.1.3.7. Limpieza con agua

Este tipo de preparación de superficie describe el uso solamente de agua para lograr un grado definido de limpieza de las superficies antes de la aplicación de un sistema de recubrimiento o revestimiento protector. Estos requisitos incluyen la condición final de la superficie más los materiales y procedimientos necesarios para verificar la condición final. Esta limpieza se categoriza por los siguientes métodos:

a) **Limpieza con agua**.- También conocido como *Water Cleaning* (WC), que es el uso de agua presurizado para la preparación de superficie para eliminar la materia no deseada de una superficie. Éstas se clasifican en:
   1) **Limpieza con agua a baja presión**. - También conocido como *Low – Pressure Water Cleaning* (LP WC), limpieza realizada a presiones menores de 34 MPa (5 000 psi).
   2) **Limpieza con agua a alta presión**. - También conocido como High – *Pressure Water Cleaning (*HP WC), limpieza realizada a presiones de 34 a 70 MPa (5 000 a 10 000 psi)

b) **Limpieza por chorro de agua**. - También conocido como *Waterjetting* (WJ), que es el uso de agua presurizada para la preparación de superficie a presiones de 70 MPa (10 000 psi) o mayor para preparar una superficie para el recubrimiento o inspección. La velocidad del agua que sale del orificio de la boquilla es mayor que 340 m/s (1 100 pies/s).
   1) **Chorro de agua a alta presión**. - También conocida como *High – Pressure Waterjetting (*HP WJ), limpieza realizada a presiones de 70 a 210 MPa (10 000 a 30 000 psi)
   2) **Chorro de agua a ultra alta presión**. - También conocida como *Ultra High – Pressure Waterjetting* (UHP WJ), limpieza realizada a presiones por encima de 170 MPa (30 000 psi)

La preparación de superficie por chorro de agua a ultra alta presión, que es el método de limpieza por chorro de agua más usada para el mantenimiento del acero, se dividen en cuatro grados de limpieza, las que son mencionadas en las siguientes normas :

a) NACE WJ1 / SSPC SP–WJ1 “limpieza al sustrato desnudo”
b) NACE WJ2 / SSPC SP–WJ2 “limpieza muy minuciosa”
c) NACE WJ3 / SSPC SP–WJ3 “limpieza profunda”
d) NACE WJ4 / SSPC SP–WJ4 “limpieza ligera”.

Más información al detalle de la norma en mención se presenta en el **Anexo Nº 7**

Las ventajas del chorro de agua a ultra alta presión incluyen:

a) El uso del agua como material de limpieza, porque por lo general se dispone de cantidades grandes y económicas.
b) Carencia de contaminación de las áreas circundantes porque no hay ninguna partícula abrasiva.
c) Carencia de polvo y riesgos de chispa.
d) Remueve las sales solubles que posteriormente pueden causar la formación de ampollas osmóticas del recubrimiento.

Las desventajas del chorro de agua a ultra alta presión incluyen:

a) Puede ser necesario adicionar inhibidores de corrosión al agua para prevenir el *flash rust* (óxido instantáneo) del acero. Los inhibidores de corrosión no son requeridos para algunos recubrimientos protectores y puede en algunos casos también producir la formación de ampollas.
b) No producen perfil de anclaje, pero pueden exponer o recuperar un perfil anterior.

En la **Figura Nº 7 (Ver pag. Nº 19)** se muestran ejemplos de preparación de superficie por chorro de agua a ultra alta presión (UHP WJ)

2.1.4. Inspección de las condiciones iniciales del sustrato

Las evaluaciones de las condiciones iniciales en que se encuentra el sustrato (acero) se realizan mediante métodos que se rigen por normas, las cuales se mencionan a continuación.

Figura Nº 7 *Las bridas de un tanque (izquierda) y la preparación de superficie por chorro de agua a ultra alta presión del techo (derecha)*

National Asociation Corrosion Engineer (NACE); Programa de Inspectores de Recubrimientos Nivel 2; Tipos de Recubrimientos y criterios de inspección. Año 2013, Capitulo 7: Chorro de Agua, Pagina 7 – 14

2.1.4.1. Grado de oxidación

Se toma como referencia la norma ASTM D610 "*Standard Test Method For Evaluating Degree of Rusting on Painted Steel Surfaces"* ("Evaluación del grado de oxidación en superficies de acero pintadas"), que describe un método para la evaluar por comparación con una serie de figuras, utilizando un sistema de designación del grado de herrumbe u oxidación que presenta un sustrato de acero pintado (con recubrimiento), según como se muestra en la **Tabla Nº 1 (Ver pag. Nº 19)**

Además, según el tipo de distribución del óxido superficial visible se usan las designaciones: *Spot* (concentrado en pocas áreas), *General* (generalizado), *Pinpoint* (concentrado en muy pequeñas áreas) y *Hybrid* (más de uno de los tipos anteriormente descritos), cuyas abreviaturas asignadas son: S, G, P y H respectivamente. En la **Figura Nº 8 (ver pag. Nº 21)** se muestran ejemplos de grados de corrosión. Más información al detalle de la norma se presenta en el **Anexo Nº 8**

Tabla Nº 1 *Relación entre el grado de oxidación y porcentaje del área afectada, según norma ASTM D610*

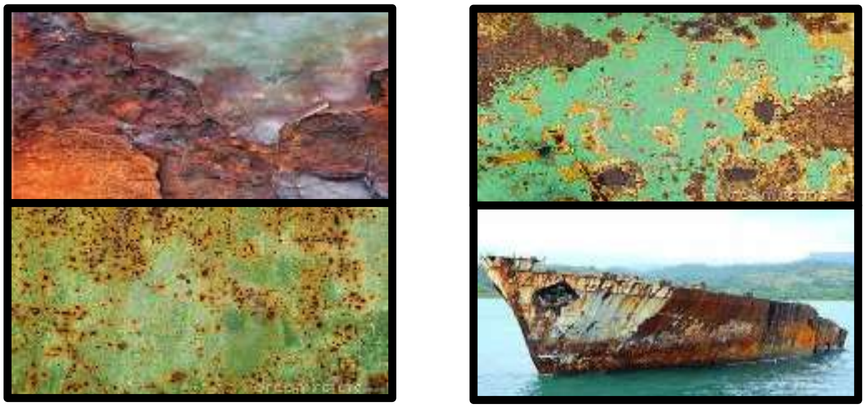
Grado de Oxidación	Porcentaje de Área Afectada
10	Menor o igual al 0,01% del área herrumbrada
9	Mayor de 0,01% hasta 0,03%
8	Mayor de 0,03% hasta 0,10%
7	Mayor de 0,10% hasta 0,30%
6	Mayor de 0,30% hasta 1,00%
5	Mayor de 1,00% hasta 3,00%
4	Mayor de 3,00% hasta 10,00%
3	Mayor de 10,00% hasta 16,00%
2	Mayor de 16,00% hasta 33,00%
1	Mayor de 33,00% hasta 50,00%
0	Mayor del 50,00% del área de herrumbre u óxido

Norma ASTM D610: "Evaluating Degree of Rusting on Painted Steel Surfaces" ("Evaluación del grado de oxidación en superficies de acero pintadas"), pagina 2

2.1.4.2. Grado de ampollamiento

Se toma como referencia la norma ASTM D714 "*Standard Test Method for Evaluating Degree of Blistering of Paint"* ("Evaluación del grado de formación de ampollas en la pintura"), que describe un método para evaluar por comparación con una serie de figuras, utilizando un sistema de designación del tamaño y densidad de formación de ampollas que presenta un sistema de recubrimiento, tal como se muestran en las **Tablas Nº 2 (Ver pág. Nº 21) y Nº 3 (Ver pág. Nº 22)**

Figura Nº 8 *Diferentes grados de corrosión en superficies de aceros pintadas*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 2: Corrosion, página 2 – 14

Cuando la distribución de las ampollas no es uniforme, se les designa como: Small Clusters (zonas pequeñas) Large Patches (zonas grandes), cuyas abreviaturas asignadas son SC y LP respectivamente. En la **Figura Nº 9 (Ver pag. Nº 22)** se muestran ejemplos de grado de formación de ampollas. Más información al detalle de la norma se presenta en el **Anexo 9**

Tabla Nº 2 *Relación entre el grado de formación de ampollas y su tamaño, según norma ASTM D714*

Grado	Tamaño (mm)
10	0
8	(0 – 1)
6	(1 – 2)
4	(2 – 3)
2	(3 – 5)
0	Mayor de 5

Norma ASTM D714: "Evaluating Degree of Blistering of Paints" ("Evaluación del grado de formación de ampollas en las pinturas"), página 1

2.1.4.3 Grado de craqueo (agrietamiento)

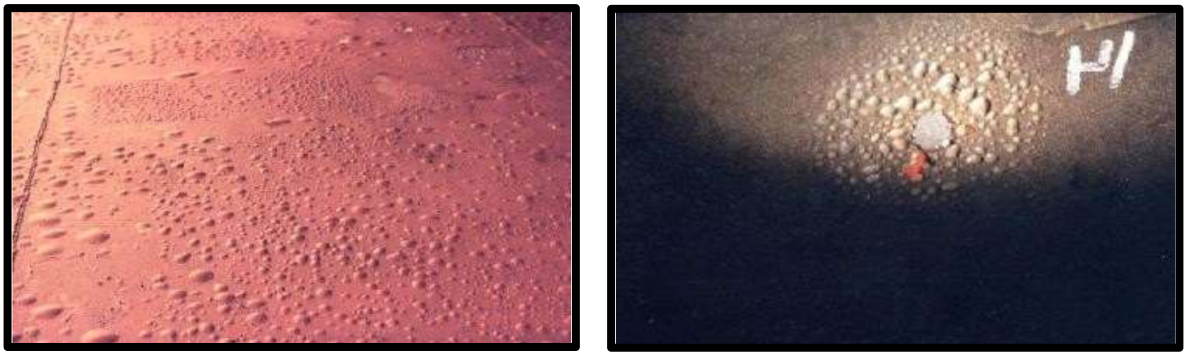
Usualmente se toma como referencia la norma ISO 4628–4 *“Assessment of degree of cracking”* (“Evaluación del grado de craqueo”), que describe un método para evaluar por comparación con una serie de figuras, utilizando un sistema de designación para las cantidades y tamaños de defectos en la apariencia en el sistema de recubrimiento, tal como se indica en las **Tablas Nº 4 y Nº 5 (Ver pag. Nº 23)**

Tabla Nº 3 *Densidad de la formación de ampollas, según norma ASTM D714*

Densidad	Descripción
0	Sin ampollas
F	Poca
M	Media
MD	Medio Densa
D	Densa

Norma ASTM D714: “Evaluating Degree of Blistering of Paints” (“Evaluación del grado de formación de ampollas en las pinturas”), página 1

Figura Nº 9 *Diferentes grados de formación de ampollas en interior de un tanque*



Norma ASTM D714: “Evaluating Degree of Blistering of Paints” (“Evaluación del grado de formación de ampollas en las pinturas”), pagina 2

Tabla Nº 4 *Rango que designa la cantidad de craqueo, según norma ISO 4628–4*

Rango	Cantidad de Craqueo
0	Ninguno, es decir, grietas no detectables
1	Muy poco, es decir, grietas apenas significantes
2	Poco, es decir, pequeño pero significativo número de grietas
3	Moderado número de grietas
4	Considerable número de grietas
5	Patrón denso de grietas

Norma ISO 4628–4: "Assessment of degree of cracking" ("Evaluación del grado de craqueo o agrietamiento"), página 2

Tabla Nº 5 *Rango que designa el tamaño de craqueo, según norma ISO 4628–4*

Rango	Tamaño de Craqueo
0	No visible, bajo magnificación con lupa de 10x
1	Solo visible con una lupa magnificación de 10x
2	Casi visible sin magnificación
3	Claramente visible sin magnificación
4	Grietas en general hasta un ancho inferior a un 1 mm
5	Grietas muy grandes en general muy largo con un ancho superior a 1mm

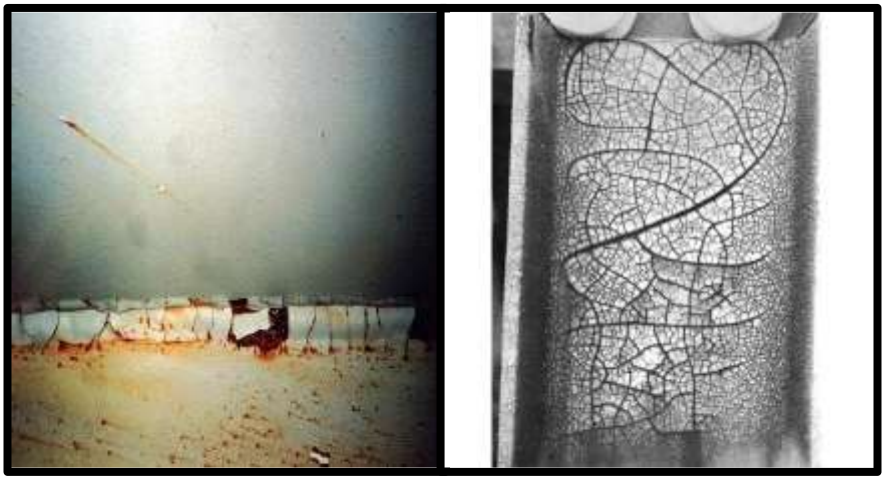
Norma ISO 4628–4: "Assessment of degree of cracking" ("Evaluación del grado de craqueo o agrietamiento"), página 2

En la **Figura 10 (Ver pag. Nº 24)** se observa unos ejemplos de craqueo (agrietamiento) en recubrimientos. Más información al detalle de la norma se presenta en el **Anexo Nº 10**

2.1.4.4 Grado de descascarado (desconchado)

Para este tipo de evaluaciones se usa mayormente como referencia la norma ISO 4628–5 *"Assessment of Degree of Flaking"* ("Evaluación del grado de descascarado"), que describe un método para evaluar por comparación con una serie de figuras, utilizando un sistema de designación para las cantidades y tamaños de defectos en la apariencia en el sistema de recubrimiento, tal como se indican en las **Tablas Nº 6 y Nº 7 (Ver pág. Nº 25)**

Figura Nº 10 *Presencia de craqueo de la pintura en cordones de soldadura (izquierda) y en el alma de una viga (derecha)*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 20: Defectos de Recubrimientos, página 20 – 10

Tabla Nº 6 *Rango que designa la cantidad de descascarado, según norma ISO 4628–5*

Rango	Área descascarada (%)
0	0,0
1	0,1
2	0,3
3	1,0
4	3,0
5	15,0

Norma ISO 4628–5: "Assessment of degree of flaking" ("Evaluación del grado de descascarado o desconchado"), página 2

Tabla N° 7 *Rango que designa el tamaño de descascarado, según norma ISO 4628–5*

Rango	Tamaño de área descascarada (dimensión a lo largo)
0	No visible, bajo magnificación con lupa de 10 x
1	Hasta 1 mm
2	Hasta 3 mm
3	Hasta 10 mm
4	Hasta 30 mm
5	Mayor a un largo de 30 mm

Norma ISO 4628–5: "Assessment of degree of flaking" ("Evaluación del grado de descascarado o desconchado"), página 2

En la **Figura Nº 11 (ver pag. Nº 26)** se observan unos ejemplos de recubrimiento descascarado. Mayor información al detalle de la norma se presenta en el **Anexo Nº 11**

2.1.4.5 Grado de tizamiento o caleo

Se toma como referencia la norma ISO 4628–6 "*Assessment of degree of chalking"* ("Evaluación del grado de caleo"), que describe el método de la cinta para evaluar mediante comparaciones con una serie de figuras el grado de caleo (desintegración en polvo) de un sistema de recubrimiento expuesto a los rayos ultravioletas del Sol.

En la **Figura Nº 12 (ver pag. Nº 26)** se muestra un ejemplo de formación de caleo en un recubrimiento del tipo epóxico. Más información al detalle de la norma se presenta en el **Anexo Nº 12**

Figura Nº 11 *Presencia de recubrimiento descascarado*

National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 20: Defectos de Recubrimientos, página 20 – 11

Figura Nº 12 *Presencia de formación de caleo en el recubrimiento*

National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 20: Defectos de Recubrimientos, página 20 – 5

2.1.5. Aspectos que influyen en la preparación de superficie para el mantenimiento del acero

Durante la preparación de superficie para mantenimiento del acero se tienen varios aspectos que pueden influir en el grado de preparación de superficie, como por ejemplo problemas de diseño y defectos de fabricación.

2.1.5.1. Problemas de diseño

En muchas ocasiones los encargados de diseñar las estructuras no tienen en cuenta la preparación de superficie y de pintado para futuros mantenimientos después del montaje, quedando lugares como:

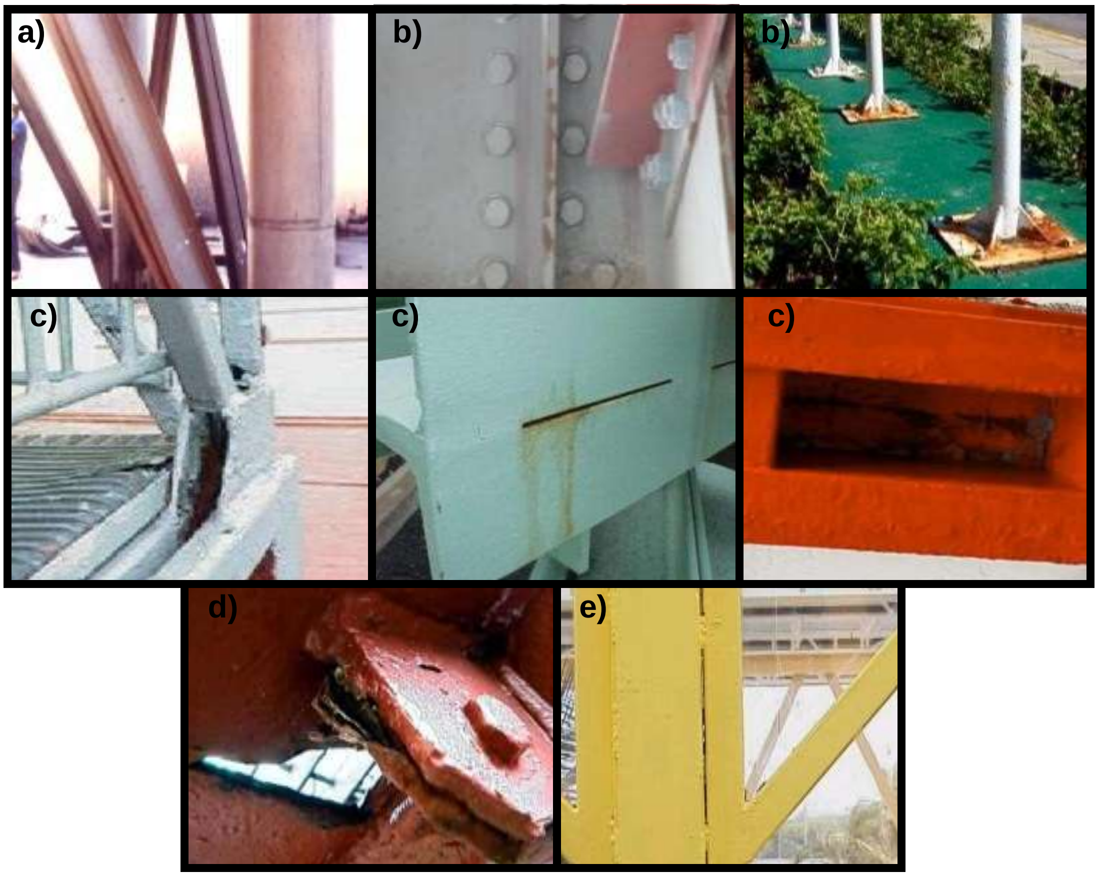
a) Zonas inaccesibles o difíciles de alcanzar (a)
b) Remaches, pernos, etc. (b)
c) Orificios o espacios estrechos, hendiduras ciegas (c)
d) Superposición o unión solapada de superficies (d)
e) Soldaduras no continuas (e)
f) Materiales diferentes (f)

En la **Figura Nº 13 (ver pag. Nº 28)** se muestran algunos de estos problemas de diseño.

2.1.5.2. Defectos de fabricación

Durante las evaluaciones e inspecciones que se realizan a las estructuras metálicas que se requieren darles mantenimiento, se encuentran en muchas ocasiones defectos de fabricación, los cuales son focos permanentes de corrosión prematura, como, por ejemplo:

Figura Nº 13 *Problemas de diseño*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 20: Defectos de Recubrimientos, página 20 – 15

a) Bordes y esquinas afilados (a)

b) Ayudas en la construcción (b)

c) Soldaduras imperfectas (c)

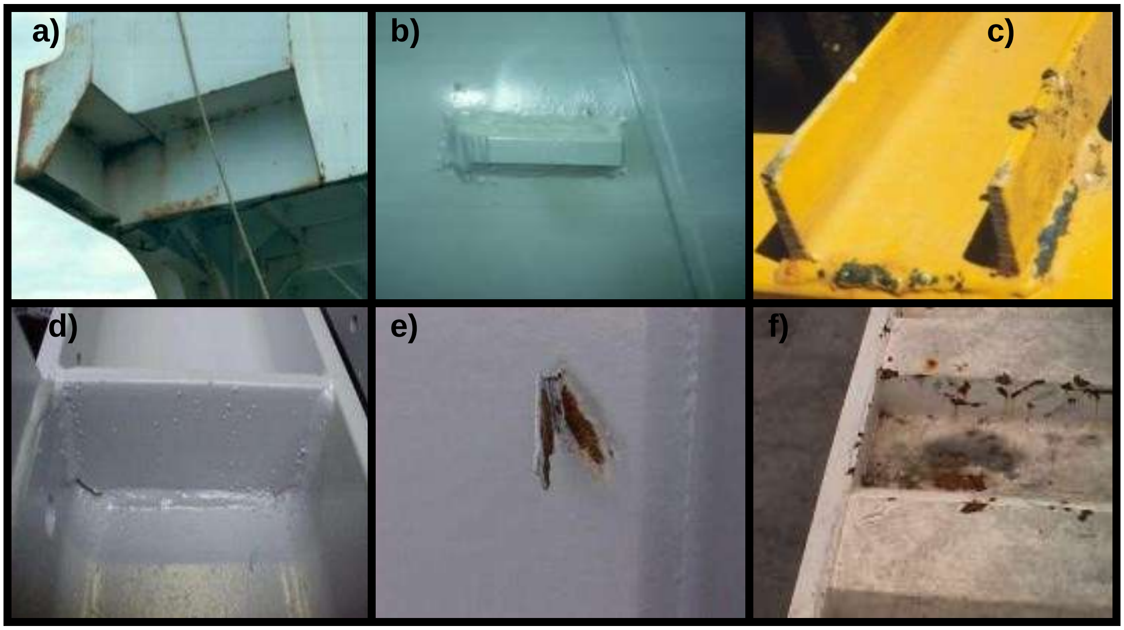
d) Salpicaduras de soldaduras (d)

e) Laminaciones (e)

f) Daños sobre la superficie

En la **Figura Nº 14** se muestran algunos de los defectos de fabricación en mención.

Figura Nº 14 *Defectos de fabricación*



National Asociation Corrosion Engineer (NACE); Manual del estudiante del programa de certificación de inspectores de recubrimiento Level 1 – Capítulo 10: preparación de superficie, página 10 – 20 hasta 10 – 25

2.1.5.3. Medio ambiente de exposición

Para este punto se tiene como referencia la norma ISO 12944–2 "*Classifications of environments*" ("Clasificaciones de los entornos ambientales"), que se ocupa de la clasificación de los principales entornos en que las estructuras de acero están expuestas, y la agresividad de estos ambientes, además de definir las categorías de corrosividad atmosférica y describir los ambientes atmosférico naturales típicos a los que están expuestas las estructuras de acero. También describe las diferentes categorías de medio ambiente para las estructuras de acero sumergidas en agua o enterrados en el suelo.

Esta norma no se ocupa de la clasificación de esos ambientes que constan de atmósferas especiales (por ejemplo, aquellos en los alrededores de plantas químicas y metalúrgicas). Más información al detalle de la norma se presenta en el **Anexo Nº 13**

2.2. Descripción de las actividades desarrolladas

En este capítulo se presentan dos ejemplos de preparación de la superficie del acero que se ajustan para el mantenimiento adecuado en la aplicación de recubrimientos.

Los ejemplos que se tratan a continuación son:

a) Vopak Perú SA es una empresa transnacional que almacena hidrocarburos, la que se encontraba situada en la Av. Néstor Gambeta N° 1265 – Callao y que en el 2012 requirió el mantenimiento del interior del tanque N° 51, el cual almacena como combustible Diesel 2

b) Southern Perú Copper Corporation es una empresa multinacional, dedicada a la exploración, transporte, refinación, distribución y comercialización de cobre, molibdeno, zinc, plomo, carbón y plata. Como parte de sus planes del 2011, Southern procedió con el mantenimiento del Colvox de la planta de oxígeno N° 01 de la planta de Fundición.

En cada caso se mencionará el tiempo que estuvo expuesto al entorno ambiental, la evaluación del estado del recubrimiento antiguo tomando como referencias las normas mencionadas en el marco teórico para luego proceder a un análisis de los resultados obtenidos y finalmente recomendar el tipo de preparación de superficie adecuada para el mantenimiento respectivo.

III. APORTES REALIZADOS

3.1. Caso I – Actividades cotidianas

3.1.1. Preparación de superficie para el mantenimiento en el interior del tanque N° 51 de Vopak Perú SA

El interior del tanque N° 51 fue evaluado en Mayo del 2012, luego de 10 años en operación. El entorno ambiental al cual estuvo expuesto el interior del tanque fue de inmersión en combustible Diesel 2

3.1.2. Resultados de las evaluaciones en el interior del tanque

Los resultados de las evaluaciones en el interior del tanque, que tuvieron como referencia las normas mencionadas en el capítulo II, fueron los siguientes:

a) Oxidación del 40% con una distribución generalizada del área inspeccionada (1, G) con socavaciones antiguas del 80% y presencia parcial de oxidación por debajo del recubrimiento antiguo. Formación de ampollas en el fondo principalmente, con tamaños que van entre 2 a 3 mm y con una distribución densa del área inspeccionada (4, D)

b) Considerable número de agrietamientos (craqueo) y claramente visible sin magnificación (4, 3); con una cantidad del 1% del área descascarado con tamaños de hasta 10 mm (3, 3). Adicionalmente el recubrimiento antiguo presenta un aspecto de pérdida parcial del brillo y amarillamiento en su totalidad.

c) Se verificó que la adherencia en general era buena a regular, sin embargo, en los accesorios (soportes y tuberías) se obtenía una mínima adherencia. Los espesores de película seca (EPS) en el primer anillo y el fondo estaban entre 9,5 a 11,8 mils y en los accesorios estaban entre 7,0 a 9,2 mils.

3.1.3. Análisis de los resultados de las evaluaciones en el interior del tanque

El porcentaje alto de corrosión visible puede deberse que el recubrimiento antiguo cumplió su tiempo de vida útil, mientras que el óxido parcial por debajo de éste se debe que en el transcurso del tiempo el combustible permeó a través del recubrimiento, originando la corrosión de las planchas de acero que conforman el tanque.

La formación de ampollas pudo deberse a:

a) Alta concentración de sales (principalmente cloruros), originando ampollamiento osmótico.

b) Contaminación por materias extrañas como polvo, grasa, aceite, óxido, solvente retenido, humedad interna.

El craqueo (agrietamiento), puede deberse a aplicaciones :

a) Antes de cumplir con el tiempo de repintado mínimo de los recubrimientos

b) De recubrimientos muy rígidos de poca flexibilidad, que no resisten al ciclo de elongación y contracción del acero

c) Sistema de recubrimiento puesto en condiciones de operación sin haber cumplido su tiempo de curado completo

d) Envejecimiento del recubrimiento antiguo (tiempo de vida útil).

El descascarado (desconchado) y la mala adherencia puede deberse a aplicaciones de recubrimientos :

a) Sobre contaminación como por ejemplo polvo, suciedad, exceso de humedad, grasa

b) Sobre preparación de superficie no adecuada

c) Después del tiempo de repintado máximo permisible entre capas

d) Sistema de recubrimiento puesto en condiciones de operación sin haber cumplido su tiempo de curado completo

3.1.4. Recomendaciones para el mantenimiento en el interior del tanque

Como la gran mayoría de combustibles tiene un porcentaje de agua en su composición y que, por ser más denso, se concentra en las partes inferiores del tanque, el mantenimiento en el interior del tanque solo se hizo para el fondo, primer anillo y accesorios que lleguen hasta ese nivel.

El sistema de recubrimiento de la **Tabla Nº 8**, se recomendó por ser resistente al combustible que almacenará el tanque, una vida útil no menor de 5 años y una buena flexibilidad para los ciclos de elongación y contracción del acero.

Tabla Nº 8 *Sistema de recubrimiento para el interior del tanque*

N° de Capa	Producto	EPS (mils)
1ra	Amerocat 90 HS, epóxico	**5,0**
Stripe Coat	Amercoat 90 HS, epóxico	**-**
2da	Amercoat 90 HS, epóxico	**5,0**
	EPS Total	**10,0**

Hoja Técnica del Producto AMEROCAT 90 HS

Donde EPS es el espesor de película seca del recubrimiento o pintura y *Stripe Coat* es la capa de refuerzo que también se le conoce como capa de franjeo o cordoneo que se aplica a los bordes, esquinas, cordones de soldadura y zonas de difícil acceso o maniobridad.

La preparación de superficie de la **Tabla Nº 9 (ver pág. Nº 31)** se recomendó una pre – limpieza, para eliminar con ayuda de agua potable, la grasa, combustible y sales para que de esa manera no se produzcan fallas prematuras por aplicaciones sobre contaminantes. Se escogió una limpieza por chorro abrasivo seco al grado cercano al metal blanco por el alto porcentaje de oxidación, ampollas y formación de craqueo (agrietamiento) y descascarado (desconchado), por lo que la eliminación total del recubrimiento antiguo era la mejor opción, teniendo en cuenta que por buenas prácticas, no se recomienda aplicar un nuevo sistema de recubrimiento sobre uno antiguo para un entorno de constante inmersión. Finalmente, luego del proceso del chorro abrasivo, se eliminó en zonas puntuales las partículas del abrasivo que se incrustaron en el acero y que el aire a presión no podía removerlos, como también la eliminación o corrección de defectos de fabricación con herramientas motorizadas.

Tabla Nº 9 *Preparación de superficie para el interior del tanque*

Superficie	Tipo de Preparación	Grado de Preparación
Fondo, primer anillo y accesorios	Limpieza con agua potable (SSPC SP1)	Eliminación de grasa, combustible, sales
	Chorro abrasivo seco (SSPC SP10)	Limpieza cercano al metal blanco
	Limpieza manual (SSPC SP2)	Eliminación de partículas del abrasivo incrustados en el acero (puntual)
	Limpieza motorizada (SSPC SP3)	Eliminación o corrección de defectos de fabricación

Elaboración propia

3.2. Caso II – Aportes realizados en beneficio de la empresa

3.2.1 Preparación de superficie para el mantenimiento del colvox de la planta de oxígeno N° 01 – fundición de Southern Perú Copper Corporation

El colvox fue evaluado en Noviembre del 2011, luego de 3 años en operación. El entorno ambiental al cual estuvo expuesto fue C5–M (exposición en un ambiente marino, concentración de rayos ultravioletas del Sol, alta concentración de humedad y sales cloruros) El colvox consiste en 4 niveles, en los primeros tres se encuentran con equipos frágiles de mediciones de temperatura y presión, mientras que en el cuarto nivel solo consiste en un piso de acero estriado.

3.2.2 Resultados de las evaluaciones del colvox

Los resultados de las evaluaciones del colvox, que tuvieron como referencia las normas mencionadas en el capítulo II, fueron los siguientes:

a) En sus tres primeros niveles presenta una oxidación visible no mayor del 10% con una distribución del tipo híbrida (4, H); en el cuarto nivel presenta una oxidación visible no mayor del 33% con una distribución del tipo generalizado (2, G), verificando que se aplicó el recubrimiento sobre el sustrato con *mill scale*; y en las escaleras presenta una oxidación visible no mayor del 50% con una distribución del tipo híbrida (1, H). Gran parte de la oxidación visible se presenta en los cordones de soldadura, bordes, esquinas, zonas de difícil acceso.

b) En los tres primeros niveles la cantidad de agrietamientos (craqueo) es poca, es decir, pequeño pero significativo número de agrietamientos que tienen un tamaño en general hasta un ancho inferior de un 1 mm; con una cantidad del 15% descascarado con tamaños mayores a un largo de 30 mm (5, 5); y con presencia generalizada de caleo (3,0) con pérdida de brillo, amarillamiento en su totalidad. En zonas puntuales la discontinuidad de la película del recubrimiento se presenta como *pinhole* (huecos de alfiler). En el nivel 4 no presenta este tipo de fallas.

c) Se verificó que en los niveles 1, 3 y 4 el recubrimiento antiguo tenía una mala adherencia porque se retiraba con facilidad, mientras que en el nivel 2 el recubrimiento antiguo tenía una buena adherencia. Los espesores de película seca (EPS) en el nivel 1 fue de 30 – 45 mils, en el nivel 2 de 25 – 42 mils, en el nivel 3 de 29 – 36 mils y en el nivel 4 de 2,4 – 4,0 mils, verificando que, en el transcurso de los años, se estuvo realizando mantenimientos sin eliminar los recubrimientos antiguos.

3.2.3 Análisis de los resultados de las evaluaciones en el colvox

La oxidación visible puede deberse a:

a) No se aplicó el *stripe coat* en los cordones de soldadura bordes, esquinas, que por su geometría y por la tensión superficial del recubrimiento cuando es aplicado por pulverización, durante su proceso de secado, tiende a retirarse o encogerse quedando dichas zonas con un espesor de película seca por debajo de lo requerido.

b) Aplicaciones sobre óxido.

c) Preparación de superficie no adecuada.

El craqueo (agrietamiento), puede deberse a :

a) Aplicaciones antes de cumplir con el tiempo de repintado mínimo de los recubrimientos.

b) Recubrimientos muy rígidos de poca flexibilidad, que no resisten al ciclo de elongación y contracción del acero.

c) Sobre espesores.

El descascarado (desconchado) y la mala adherencia puede deberse a:

a) Aplicaciones sobre contaminación como por ejemplo polvo, suciedad, exceso de humedad, grasa, aceite, óxido.

b) Preparación de superficie no adecuada.

c) Tiempo excedido para el repintado máximo permisible entre capas.

d) Sobre espesores.

e) Incompatibilidad entre los recubrimientos aplicados.

El caleo (tizamiento) y amarillamiento se debe a:

a) Degradación que sufren los recubrimientos por acción de los rayos ultravioletas del Sol, principalmente las de resinas epóxicas.

b) No se aplicó como acabado un recubrimiento adecuado que tenga buena resistencia a los rayos ultravioletas del Sol.

Las discontinuidades pueden deberse a:

a) Aplicaciones sobre contaminación como por ejemplo polvo, suciedad, exceso de humedad, grasa, aceite, óxido.

b) Dilución no adecuada del recubrimiento.

c) Incompatibilidad entre los recubrimientos aplicados.

3.2.4 Recomendaciones para el mantenimiento del colvox

El sistema de recubrimiento de la **Tabla Nº 10**, que se recomendó fue por ser resistente al entorno ambiental marino y además de incluir una capa de acabado resistente a los rayos ultravioletas del Sol.

Tabla Nº 10 *Sistema de recubrimiento para el colvox*

N° de Capa	Producto	EPS (mils)
1ra	AMERCOAT 385, epóxico	**3,0**
Stripe Coat	AMERLOCK 400, epóxico	**-**
2da	AMERLOCK 400, epóxico	**5,0**
3ra	AMERCOAT 450 HS, poliuretano	**2,0**
	EPS Total	**10,0**

Elaboración propia de acuerdo con las hojas técnicas de los productos AMERCOAT 385, AMERLOCK 400 y AMERCOAT 450 HS

La preparación de superficie de la **Tabla Nº 11** se recomendó una pre-limpieza con ayuda de agua potable, para eliminar grasa, aceite, polvo, sales, y prevenir fallas prematuras por aplicaciones sobre contaminantes. Debido principalmente por sobre espesores y falta de adherencia del recubrimiento antiguo se deberá de eliminar, sin embargo por pedido de Southern que no desea que sus equipos y accesorios del colvox sufran algún tipo de daños, no se podrá preparar la superficie ni por chorro abrasivo (seco o húmedo) ni tampoco es viable el uso de chorro de agua a ultra alta presión, por lo que la opción sugerida fue una limpieza con herramientas motoras para eliminar todo el recubrimiento mal adherido y el uso de herramientas manuales para nivelar los bordes del recubrimiento antiguo bien adherido al sustrato y a la vez crear una rugosidad adecuada para promover la adherencia del nuevo sistema de recubrimiento recomendado.

Tabla Nº 11 *Preparación de superficie del colvox*

Superficie	Tipo de Preparación	Grado de Preparación
Colvox	Limpieza con agua (SSPC SP1)	Eliminación de grasa, aceite, sales, polvo
	Limpieza mecánica (SSPC SP3)	Eliminación total del recubrimiento antiguo mal adherido
	Limpieza manual (SSPC SP2)	Nivelación y promotor de rugosidad para la adherencia del recubrimiento

Elaboración propia

III. CONCLUSIONES

1) Con la ayuda de la normativa técnica presentada en el capítulo N.º 5 se realizó la inspección de la superficie y se identifico el grado de corrosión actual del elemento a recubrir. Se identifica las zonas con presencia de mill scale (cascarilla de laminación), donde se puede concluir que no se realizó la preparación de superficie adecuada, por ello el sistema de protección fallo.

2) De acuerdo con las condiciones de operación, el ambiente corrosivo donde están ubicados los elementos metálicos, identificando si es interior o exterior donde se va a realizar el mantenimiento con pintura liquida se identifica el sistema de protección a utilizar, se concluye utilizar como capa de acabado para el Colvox Pintura de resina poliuretano acrílico alifático, resistente a los rayos UV.

3) Para identificar la preparación de superficie idónea de acuerdo con las condiciones de operación dependerá de :

   a) Condiciones iniciales del sustrato (acero)

   b) El entorno ambiental al que estará expuesto

   c) Tipo de sistema de recubrimiento que se recomiende para el mantenimiento.

   Con una preparación de superficie por chorro abrasivo seco se puede eliminar los contaminantes visibles (como por ejemplo recubrimiento antiguo, mill scale, óxido) en su totalidad y a la vez crear un perfil de anclaje mayor que al usar herramientas motoras o manuales para el mismo fin.

IV. RECOMENDACIONES

1) Es necesario iniciar siempre con una pre-limpieza para eliminar todos los contaminantes visibles (grasa, aceite, suciedad) y no visibles (sales solubles) porque pueden causar fallas prematuras de corrosión.

2) Para evitar dañar el nuevo sistema de recubrimiento aplicado y a la vez asegurar un perfil de anclaje parecido al que se obtiene mediante una preparación de superficie por chorro abrasivo, una buena opción es la limpieza con herramientas motoras al metal desnudo.

3) Si bien es cierto que la aplicación del stripe coat ayuda evitar fallas prematuras de corrosión, la eliminación o corrección de las fallas de fabricación asegura que no se tendrá este tipo de inconvenientes

V. REFERENCIAS BIBLIOGRÁFICAS

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Norma ASTM D610: “Evaluating Degree of Rusting on Painted Steel Surfaces” (“Evaluación del grado de oxidación en superficies de acero pintadas”)

Norma ASTM D714: “Evaluating Degree of Blistering of Paints” (“Evaluación del grado de formación de ampollas en las pinturas”)

Norma ISO 4628–4: “Assessment of degree of cracking” (“Evaluación del grado de craqueo o agrietamiento”)

Norma ISO 4628–5: “Assessment of degree of flaking” (“Evaluación del grado de descascarado o desconchado”)

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Hoja Técnica – AMERLOCK 400 – CPPQ SA

Hoja Técnica – AMERCOAT 450 HS – CPPQ SA

ANEXOS

Anexo Nº 1 : Norma SSPC SP1, *“Solvent Cleaning”* (“Limpieza con solventes”)

Anexo Nº 2 : Norma SSPC SP2 : “Hand Tool Cleaning” (“Limpieza con herramientas manuales”)

Anexo Nº 3 : Norma SSPC SP3 : “Power Tool Cleaning” (“Limpieza con herramientas motorizadas”)

Anexo Nº 4 : Norma SSPC SP11 : “*Power Tool Cleaning to Bare Metal”* (“Limpieza con herramientas de motorizadas al metal desnudo”)

Anexo Nº 5 : Norma SSPC SP7 : *“Brush–off Blast Cleaning”* (“Limpieza por chorro abrasivo al grado ligero”), norma SSPC SP6 : *“Commercial Blast Cleaning”* (“Limpieza por chorro abrasivo al grado comercial”), norma SSPC SP10 : *“near–White Metal Blast Cleaning”* (“Limpieza por chorro abrasivo al grado cercano al metal blanco”), norma SSPC SP5 : *“White Metal Blast Cleaning”* (“Limpieza por chorro abrasivo al grado metal blanco”)

Anexo Nº 6 : Norma SSPC TR2 : *“Wet Abrasive Blast Cleaning”* (“Limpieza por chorro abrasivo húmedo”)

Anexo Nº 7 : Norma SSPC SP–WJ1 : *“Waterjet Cleaning of Metals – Clean to Bare Substrate”* (“Limpieza por chorro de agua al grado sustrato desnudo”), norma SSPC SP–WJ2 : *“Waterjet Cleaning of Metals – Very Thorough Cleaning”* (“Limpieza por chorro de agua al grado muy minucioso”), norma SSPC SP–WJ3 : *“Waterjet Cleaning of Metals – Thorough Cleaning”* (“Limpieza por chorro de agua al grado profunda”), norma SSPC SP–WJ4 : *“Waterjet Cleaning of Metals – Light Cleaning”* (“Limpieza de chorro de agua al grado ligero”)

Anexo Nº 8 : Norma ASTM D610 : *“Evaluating Degree of Rusting on Painted Steel Surfaces”* (“Evaluación del grado de oxidación en superficies de acero pintadas”)

Anexo Nº 9 : Norma ASTM D714 : *“Evaluating Degree of Blistering of Paints”* (“Evaluación del grado de formación de ampollas en las pinturas”)

Anexo Nº 10 : Norma ISO 4628–4: “ *Assessment of degree of cracking”* (“Evaluación del grado de craqueo o agrietamiento”)

Anexo Nº 11 : Norma ISO 4628–5 : *“Assessment of degree of flaking”* (“Evaluación del grado de descascarado o desconchado”)

Anexo Nº 12 : Norma ISO 4628–6 : *“Assessment of degree of chalking by tape method”* (“Evaluación del grado de tizamiento o caleo por el método de la cinta”)

Anexo Nº 13 : Norma ISO 12944–2 : “Classifications of environments” (“Clasificaciones de los entornos ambientales”)

ANEXO Nº 1

SSPC-SP 1
November 1, 1982
Editorial Revisions November 1, 2004

SSPC: The Society for Protective Coatings
SURFACE PREPARATION SPECIFICATION NO. 1
Solvent Cleaning

1. Scope

1.1 This specification covers the requirements for the solvent cleaning of steel surfaces.

2. Definition

2.1 Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces.

2.2 It is intended that solvent cleaning be used prior to the application of paint and in conjunction with surface preparation methods specified for the removal of rust, mill scale, or paint.

3. Surface Preparation Before and After Solvent Cleaning

3.1 Prior to solvent cleaning, remove foreign matter (other than grease and oil) by one or a combination of the following: brush with stiff fiber or wire brushes, abrade, scrape, or clean with solutions of appropriate cleaners, provided such cleaners are followed by a fresh water rinse.

3.2 After solvent cleaning, remove dirt, dust, and other contaminants from the surface prior to paint application. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

4. Methods of Solvent Cleaning

4.1 Remove heavy oil or grease first by scraper. Then remove the remaining oil or grease by any of the following methods:

4.1.1 Wipe or scrub the surface with rags or brushes wetted with solvent. Use clean solvent and clean rags or brushes for the final wiping.

4.1.2 Spray the surface with solvent. Use clean solvent for the final spraying.

4.1.3 Vapor degrease using stabilized chlorinated hydrocarbon solvents.

4.1.4 Immerse completely in a tank or tanks of solvent. For the last immersion, use solvent which does not contain detrimental amounts of contaminant.

4.1.5 Emulsion or alkaline cleaners may be used in place of the methods described. After treatment, wash the surface with fresh water or steam to remove detrimental residues.

4.1.6 Steam clean, using detergents or cleaners and follow by steam or fresh water wash to remove detrimental residues.

5. Inspection

5.1 All work and materials supplied under this standard shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this standard. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, then a procedure mutually agreeable to purchaser and contractor shall be used.

5.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the standard.

6. Disclaimer

6.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the specification or standard itself.

6.2 This specification does not attempt to address problems concerning safety associated with its use. The user of this specification, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.

7. Note

Notes are not requirements of this specification.

7.1 A Commentary Section is available and contains additional information and data relative to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to solvent cleaning and the appropriate Commentary section

7.2

Section Subject	SSPC-SP COM Section
Solvents and Cleaners	5.1.1 through 5.1.3
Steam Cleaning	5.1.4
Threshold Limit Values	5.1.5

ANEXO Nº 2

SSPC: The Society for Protective Coatings
SURFACE PREPARATION SPECIFICATION NO. 2
Hand Tool Cleaning

1. Scope

1.1 This standard covers the requirements for hand tool cleaning steel surfaces.

2. Definitions

2.1 Hand tool cleaning is a method of preparing steel surfaces by the use of non-power hand tools.

2.2 Hand tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 SSPC-VIS 3 or other visual standard of surface preparation agreed upon by the contracting parties may be used to further define the surface (see Note 8.1).

3. Referenced Standards

3.1 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern, unless otherwise specified. Standards marked with an asterisk (*) are referenced only in the Notes, which are not requirements of this standard.

3.2 If there is a conflict between the requirements of any of the cited reference standards and this standard, the requirements of this standard shall prevail.

3.3 *SSPC SPECIFICATIONS:*

SP 1	Solvent Cleaning
***SP 3**	Power Tool Cleaning
***SP 11**	Power Tool Cleaning to Bare Metal
***SP 15**	Commercial Grade Power Tool Cleaning
VIS 3	Guide and Reference Photographs for Steel Surfaces Prepared by for Power- and Hand-Tool Cleaning

INTERNATIONALORGANIZATION FOR STANDARDIZATION (ISO):

*** 8501-1**	Preparation of steel substrates before application of paints and related products: Visual assessment of surface cleanliness–Part I.

4. Surface Preparation Before and After Hand Tool Cleaning

4.1 Before hand tool cleaning, visible deposits of oil, grease, or other materials that may interfere with coating adhesion shall be removed in accordance with SSPC-SP 1 or other agreed- upon methods. Nonvisible surface contaminants such as soluble salts shall be treated to the extent specified by the procurement documents [project specifications] (see Note 8.2).

4.2 After hand tool cleaning and prior to painting, reclean the surface if it does not conform to this standard.

4.3 After hand tool cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

5. Methods of Hand Tool Cleaning

5.1 Use impact hand tools to remove stratified rust (rust scale).

5.2 Use impact hand tools to remove all weld slag.

5.3 Use hand wire brushing, hand abrading, hand scraping, or other similar non-impact methods to remove all loose mill scale, all loose or non-adherent rust, and all loose paint.

5.4 Regardless of the method used for cleaning, if specified in the procurement documents, feather the edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

5.5 If approved by the owner, use power tools or blast cleaning as a substitute cleaning method for this standard.

6. Inspection

6.1 Unless otherwise specified in the procurement documents, the contractor or material supplier is responsible for quality control to assure that the requirements of this document are met. Work and materials supplied under this standard are also subject to inspection by the purchaser or an authorized representative. Materials and work areas shall be accessible to the inspector.

6.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then a procedure mutually agreeable to purchaser and material supplier (or contractor) shall be used.

7. Disclaimer

7.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the specification or standard itself.

7.2 This standard does not attempt to address problems concerning safety associated with its use. The user of this standard, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.

8. Notes

Notes are not requirements of this standard.

8.1 Note that the use of visual standards in conjunction with this standard is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents.

SSPC-VIS 3 provides a suitable comparative visual standard for SSPC-SP 2, SSPC-SP 3, SSPC-SP 11, and SSPC-SP 15. ISO 8501-1 may also serve as a visual standard.

8.2 The SSPC Surface Preparation Commentary (SSPC-SP COM) contains additional information and data relevant to this specification. The Commentary is non-mandatory and is not part of this specification. The table below lists the subjects discussed relevant to hand tool cleaning and the appropriate Commentary Section.

Subject	**Commentary Section**
Film Thickness	10
Maintenance Painting	4.2
Rust, Stratified Rust, Pack Rust, and Rust Scale	4.3.1
Visual Standards	11
Weld Spatter	4.4.1

ANEXO Nº 3

SSPC: The Society for Protective Coatings
SURFACE PREPARATION SPECIFICATION NO. 3
Power Tool Cleaning

1. Scope

1.1 This standard covers the requirements for power tool cleaning of steel surfaces.

2. Definition

2.1 Power tool cleaning is a method of preparing steel surfaces by the use of power assisted hand tools.

2.2 Power tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 SSPC-VIS 3 or other visual standard of surface preparation agreed upon by the contracting parties may be used to further define the surface (see Note 8.1).

3. Referenced Standards

3.1 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern, unless otherwise specified. Standards marked with an asterisk (*) are referenced only in the Notes, which are not requirements of this standard.

3.2 If there is a conflict between the requirements of any of the cited reference standards and this standard, the requirements of this standard shall prevail.

3.3 SSPC STANDARDS:

SP 1	Solvent Cleaning
***SP 2**	Hand Tool Cleaning
***SP 11**	Power Tool Cleaning to Bare Metal
***SP 15**	Commercial Grade Power Tool Cleaning
VIS 3	Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning

3.4 INTERNATIONAL ORGANIZATION FOR STANDARD-IZATION (ISO):

***8501-1**	Preparation of steel substrates before application of paints and re- lated products: visual assessment of surface cleanliness, Part I

4. Surface Preparation Before and After power Tool Cleaning

4.1 Before power tool cleaning, visible deposits of oil, grease, or other materials that may interfere with coating adhesion shall be removed in accordance with SSPC-SP 1 or other agreed-upon methods. Nonvisible surface contaminants such as soluble salts shall be treated to the extent specified by the procurement documents [project specifications] (see Note 8.2).

4.2 After power tool cleaning and prior to painting, reclean the surface if it does not conform to this standard.

4.3 After power tool cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

5. Methods of Power Tool Cleaning

5.1 Use rotary or impact power tools to remove stratified rust (rust scale).

5.2 Use rotary or impact power tools to remove all weld slag.

5.3 Use power wire brushing, power abrading, power impact, or other power rotary tools to remove all loose mill scale, all loose or non-adherent rust, and all loose paint. Do not burnish the surface.

5.4 Operate power tools in a manner that prevents the formation of burrs, sharp ridges, and sharp cuts.

5.5 Regardless of the method used for cleaning, if specified in the procurement documents, feather the edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

5.6 If approved by the owner, use blast cleaning as a substitute cleaning method for this standard.

6. Inspection

6.1 Unless otherwise specified in the procurement documents, the contractor or material supplier is responsible for timely quality control to assure that the requirements of this document are met. Work and materials supplied under this standard are also subject to inspection by the purchaser or an authorized representative. Materials and work areas shall be accessible to the inspector.

6.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then a procedure mutually agreeable to purchaser and material supplier (or contractor) shall be used

7. Disclaimer

7.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the specification or standard itself.

7.2 This standard does not attempt to address problems concerning safety associated with its use. The user of this standard, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.

8. Notes

Notes are not requirements of this standard.

8.1 Note that the use of visual standards in conjunction with this standard is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents.

SSPC-VIS 3 provides a suitable comparative visual standard for SSPC-SP 2, SSPC-SP 3, SSPC-SP 11, and SSPC-SP 15. ISO 8501-1 may also serve as a visual standard.

8.2 The Surface Preparation Commentary, SSPC-SP COM, contains additional information and data relevant to this specification. The Commentary is non-mandatory and is not a part of this specification. The table below lists the subjects discussed relevant to power tool cleaning and the appropriate Commentary Section.

Subject	**Commentary Section**
Film Thickness	10
Rust Back	4.5
Rust, Stratified Rust, Pack Rust, and Rust Scale	4.3.1
Visual Standards	11
Weld Spatter	4.4.1

ANEXO Nº 4

SSPC: The Society for Protective Coatings

1. *Surface Preparation Standard No. 11*

Power-Tool Cleaning to Bare Metal

1. Scope

1.1 This standard contains the requirements for power- tool cleaning steel to produce a bare metal power tool cleaned surface having a minimum 25-micrometer (1.0-mil) surface profile.

1.2 This standard is suitable where a roughened, clean, bare metal surface free of all visible oil, grease, dirt, rust, coating, oxides, mill scale, corrosion products, and other foreign matter is required, but where abrasive blasting is not feasible or permissible (see Notes 8.1 and 8.2).

1.3 This standard differs from SSPC-SP 3, Power-Tool Cleaning, in that SSPC-SP 3 requires the removal of loosely adherent materials only, and contains no requirement to expose bare metal or to achieve a minimum surface profile.

1.4 This standard differs from SSPC-SP 15, Commercial Grade Power-Tool Cleaning, in that SSPC-SP 15 allows stains to remain on the surface.

2. Definition

2.1 A bare metal power-tool cleaned steel surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, rust, coating, oxides, mill scale, corrosion products, and other foreign matter. Slight residues of rust and coating are permitted to remain in the lower portions of pits if the original surface is pitted (see Notes 8.1 and 8.3).

2.2 Acceptable variations in appearance that do not affect surface cleanliness as defined in Section 2.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat-affected zones, or the texture/features associated with the use of a particular power tool.

2.3 The surface profile shall be a minimum of 25 micrometers (1.0 mil). The peaks and valleys on the prepared surface shall form a continuous pattern with no smooth, unprofiled areas.

2.4 The profile shall be measured in accordance with ASTM D 4417 Method B unless otherwise specified (see Notes 8.4, 8.5, and 8.6).[1]

2.5 Reference photographs of power-tool cleaned surfaces found in SSPC-VIS 3 are often used to supplement the written definition. In any dispute, the written definition set forth in this standard shall take precedence over reference photographs. Additional information on reference photographs is in Note 8.3

3. Referenced Standards

3.1 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern unless otherwise specified. Standards marked with an asterisk (*) are referenced only in the Notes, which are not requirements of this standard.

3.2 If there is a conflict between the requirements of any of the cited reference standards and this standard, the requirements of this standard shall prevail.

3.3 SSPC STANDARDS:

*	**PA 2**	Procedure for Determining Conformance to Dry Coating Thickness Requirements
	SP 1	Solvent Cleaning
	SP 3	Power-Tool Cleaning
*	**SP 5/NACE No. 1**	White Metal Blast Cleaning
	SP 15	Commercial Grade Power-Tool cleaning
	VIS 3	Guide and Reference Photographs for Steel Surfaces Prepared by Power- and Hand-Tool Cleaning

3.4 ASTM INTERNATIONAL STANDARDS[2]:

	D 4285	Method for Indicating the Presence of Oil or Water in Compressed Air
	D 4417	Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel
*	**D 7127**	Standard Test Method for Measurement of Surface Roughness of Abrasive Blast-Cleaned Metal Surfaces Using a Portable Stylus Instrument

4. Tools and Methods for Power-Tool Cleaning to Bare Metal

4.1 POWER TOOLS: Any hand-held motorized tool on which the media described in Sections 4.1.1 and 4.1.2 are capable of being mounted in accordance with manufacturer's instructions and that will produce a steel surface meeting the requirements of Sections 2.1 and 2.3 is acceptable (see Notes 8.7.1, 8.7.2, 8.8, and 8.9). Sections 4.1.1 and 4.1.2 describe the two main categories of power tools. It is possible for powertools to alter an existing surface profile.

4.1.1 Grinding Tools: Grinding tools use media containing bonded abrasive grains to cut through corroded surfaces and include, but are not limited to, discs or wheels as described in Note 8.6.1.

4.1.2 Impact Tools: Impact tools use media that repeatedly collide with the target surface and include, but are not limited to, various rotary and reciprocating devices as described in Note 8.6.2.

4.2. The use of several different power tools meeting the requirements of Sections 4.1, 4.1.1 and 4.1.2 is sometimes necessary to achieve a bare metal power-tool cleaned surface meeting the requirements of Sections 2.1 and 2.3 (see Note 8.7 and subsections).

4.3 If the procurement documents require power-tool cleaning to prepare surfaces for subsequent coating, the edges of remaining intact coatings shall, unless otherwise specified, be feathered to improve the appearance of the repaired coating (see Note 8.2).

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[1] Although ASTM D 4417 and ASTM D 7127 indicate in their titles that they describe methods intended for use on blast-cleaned steel, there is currently no method specifically designed for measurement of profile on steel surfaces prepared using power-tools. Visual comparators used for ASTM D 4417 Method A represent surfaces prepared by abrasive blast cleaning and are inappropriate for comparison with power-tool cleaned surfaces. The replica tape used for ASTM D 4417 Method C cannot accurately measure the profile produced by some types of power-tool cleaning media. A test area prepared at the job site can be used to assess the suitability of media and profile measure-ment method for a project prior to full-scale production.

5. Procedures Prior to Power-Tool Cleaning

5.1 Prior to power-tool cleaning, visible deposits of oil, grease, or other materials that interfere with coating adhesion shall be removed in accordance with SSPC-SP 1 or other specified methods.

5.2 Surface imperfections such as slivers and laminations, sharp edges, weld spatter, or burning slag shall be removed from the surface to the extent specified by the procurement documents [project specifications] (see Note 8.10).

5.3 When air-driven tools are used, cleanliness of the compressed air shall be verified in accordance with the procedure described in ASTM D 4285.

6. Procedures Following Power-Tool Cleaning and Immediately Prior to Coating

6.1 Visible deposits of oil, grease, or other contaminants shall be removed in accordance with SSPC-SP 1 or as specified.

6.2 Dust and loose residues shall be removed from power-tool cleaned (SSPC-SP 11) surfaces by brushing; blowing off with clean, dry air per Section 5.3; vacuum cleaning; or other methods established in the procurement documents (project specification).

6.3 After power-tool cleaning, any remaining surface imperfections as described in Section 5.2 (e.g., laminations, sharp edges, weld spatter, burning slag, scabs, slivers) shall be removed to the extent required by the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Section 2.3 (see Note 8.10).

6.4 Immediately prior to coating application, the entire surface to be coated shall comply with the requirements of Sections 2.1 and 2.3 (see Notes 8.11 and 8.12).

7. Disclaimer

7.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the specification or standard itself.

7.2 This standard does not attempt to address problems concerning safety associated with its use. The user of this standard, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all applicable governmental regulations.

8. Notes

Notes are not requirements of this standard.

8.1 FUNCTION: The type of power-tool surface preparation described in this standard removes tightly adherent material, producing a surface that is free from rust, mill scale, and old coatings. The surface must also have a minimum 25-micrometer (1.0 mil) surface profile. Power-Tool Cleaning to Bare Metal produces a greater degree of cleaning than SSPC-SP 3, which does not remove adherent material, and SSPC-SP 15, which allows visible stains on 33% of each unit area. Power-Tool Cleaning to Bare Metal may be considered for coatings that require a very clean surface.

This standard is suitable where a roughened, cleaned surface is required, but where abrasive blasting is not feasible or permissible. The surfaces prepared according to this standard should not be compared to surfaces cleaned by abrasive blast cleaning. Although this method produces surfaces that resemble SSPC-SP 5 (White Metal Blast Cleaning), with the exception of material allowed in pits, power-tool cleaned surfaces are not necessarily equivalent to surfaces produced by abrasive blast cleaning. The contracting parties should agree on the appropriateness of the finished surface to accept the specified coating system. Selection of power tools and cleaning media should be based on (1) the condition of the surface prior to surface preparation; (2) the extent of cleaning that is required; and (3) the surface profile required.

The SSPC Surface Preparation Commentary (SSPC-SP COM) provides additional information on subjects related to power-tool cleaning. The recommendations contained in SSPC-SP COM are believed to represent good practice, but are not to be considered requirements of this standard.

8.2 MAINTENANCE AND REPAIR PAINTING: When this standard is used in maintenance painting, specific instructions should be given on the extent of surface to be power-tool cleaned, including any additional requirements for retaining old paint, removing unsound paint, feathering and spot cleaning.

8.3 VISUAL GUIDES AND COMPARATORS: Note that the use of visual guides or comparators in conjunction with this standard is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual guides or comparators be made mandatory in the procurement documents.

SSPC-VIS 3 provides a suitable comparative visual guide for SSPC-SP 3, SSPC-SP 11, and SSPC-SP 15. However, visual comparators for blast-cleaned steel (e.g., SSPC-VIS 1) are not suitable for assessing power-tool cleaned surfaces. Because power-tool cleaning is time- and labor-intensive, it is advisable to prepare a test area of 1 x 1 sq meter (3 x 3 sq. ft.) for large areas or 30 x 30 cm (12 x 12 inch) for spot cleaning to an acceptable level agreed upon by the contracting parties, and cover it with a clear lacquer to save it as a standard during the power-tool cleaning operation. A 30 x 30 cm (12 x 12 inch) steel test plate can also be power-tool cleaned to an acceptable level and sealed to serve as a project standard. Alternatively, such a field standard could be protected with a volatile corrosion inhibitor, tablet, or impregnated paper, with or without a desiccant, and kept in a sealed plastic bag to permit examination of the surface profile.

8.4 PROFILE: The profile created by any cleaning media depends on many factors, including the composition and hardness of the steel, the presence and depth of any pre-existing profile, and the hardness and thickness of any existing coating materials.

The ability of various media to produce a profile or maintain an existing profile depends upon physical characteristics such as hardness, angularity or sharpness, size and mass; spacing; speed (velocity) of impact on the steel; and ability to fracture the coating material and alter the steel surface.

The media indicated in Section 4.1.1 are capable of producing a profile of 12.5 micrometers (0.5 mil) on mild (struc-

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[2] ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

tural) steel, while the media in Section 4.1.2 are capable of producing a profile of 25 micrometers (1.0 mil) and greater on mild steel. The same media may not be capable of producing the same profile depth on other steels, e.g., weathering steel, stainless steel, welds, et al. These capabilities are possible when the tools are used by an experienced operator

Power tools are also capable of reducing existing deeper profiles by partial removal of the tops of the existing profiles, especially by grinding, sanding, and the use of rotary flaps. In cases of excessive pressure or dwell period at a specific location, the power tools can cause sharp edges and cuts in the steel. Rotary power tools can cause a burnishing of profile previously imparted to steel or of the existing profile, thereby reducing that profile. Impact power tools can cause burrs and gouges

It is important to determine prior to the start of production

if the power tool[s] to be used can create a profile that meets the requirement of the project specification or the manufacturer's requirement for the specified coating. Concerns about the suitability of a tool to achieve these requirements should be discussed in advance with the tool manufacturer's technicalrepresentative.

8.5. FILM THICKNESS: It is essential that ample coatingbe applied after power-tool cleaning to adequately cover the peaks of the surface profile. The dry film thickness above the peaks of the profile should equal the thickness needed for the desired protection. If the dry film thickness over the peaks is inadequate according to contract documents or manufacturer's specifications, premature rust-through or failure will occur. The procedures in SSPC-PA 2 should be used to ensure that coating thickness is properly measured.

8.6. SUITABLE TOOLS AND MEDIA: The tools/media in the text of this standard are intended solely to guide the user to typical types of equipment and media that are available to meet the standard. The tools/media cited in this document do not include all of the tools, devices, or products available, nor does their mention constitute an endorsement by SSPC. The presence of hazardous material in the coatings, cleaning media, or in the work area itself, can place restrictions on the methods of cleaning permitted.

8.6.1 Grinding tools/media: Any rotary or reciprocating tool that uses bonded abrasives as the cutting media for generating surfaces meeting requirements of Sections 2.1, 2.2, and

2.3 These include, but are not limited to, reciprocating sanders, orbital sanders, or any grinding device, whether right angle or straight shaft, that utilizes abrasive cloths, discs, wheels, or flaps.

8.6.2 Impact tools/media: Any rotary or reciprocating tool that uses repetitious impact for generating surfaces meeting requirements of Sections 2.1, 2.2 and 2.3. This includes, but is not limited to: rotary flap, cutter bundle, needle gun, wire bristle impact, and hammer flail assemblies.

8.7 SELECTION OF TOOLS AND MEDIA

8.7.1 Selection of Tools: Power tools should be selected on the basis of the size and speed rating of the media. These requirements may differ from one type of medium to another and should be taken into consideration if more than one type of medium will be used in the surface preparation process. Power tools should be selected that will produce enough power to perform the cleaning operation efficiently. Operator fatigue should be considered in the selection of power tools.

8.7.2 Selection of Media: When power-tool cleaning rusted surfaces, it is important to avoid embedding rust into the substrate. Use of more than one type of medium may be required in order to obtain the desired end result.

Power wire brushes or sanding discs when used alone may not produce the required surface profile and may remove or degrade an existing profile to an unacceptable level. Exceedingly heavy deposits of corrosion products should be removed using hand or power tools prior to using surface profiling media. After removal of excessive corrosion, a structural inspection may be warranted to ascertain if the metal thickness remains in compliance with the governing requirements, including applicable codes (e.g. ASME codes for pressure vessels).

8.8 CAUTION: Improper use of power tools can result in damage to the surface being cleaned. Excessive pressure or an overly long dwell time on a surface being cleaned using impact tools can result in formation of burrs and gouges. Rotary or grinding tools that remain over a specific location too long can bend the peaks of an existing profile and damage the anchor pattern. In extreme cases, burnishing of the surface may result. Improper use of tools with embedded abrasive media, including, but not limited to discs, wheels, pads, and flappers, may result in partial melting and smearing of the matrix on the surface. A review of the manufacturer's literature or a discussion with the technical representative about the tool and its use on the intended substrate should be undertaken if the operator has little or no experience with the tool.

CLEANING LIMITED ACCESS AREAS: SSPC defines a "limited access area" as a location in which the configuration of a structure or surface or the characteristics of a tool restrict the use or performance of that tool at that location. Alternative methods should be considered for limitedaccess areas.

8.9 SURFACE IMPERFECTIONS: Surface imperfections can cause premature failure when the environment is severe. Generally, coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult for a coating to properly cover and protect include crevices, weld porosity, laminations, etc. Poorly adherent contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, should be removed during power-tool cleaning. Other surface defects may not be evident until the surface preparation has been completed. Therefore, proper planning for such repair work is essential, since the timing of the repairs may occur before, during, or after power-tool cleaning operations.

8.10 RUST-BACK: Rust-back (re-rusting) occurs when freshly cleaned steel is exposed to conditions of high humidity, moisture, contamination, or a corrosive atmosphere. The time interval between power-tool cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions, it is best to clean and coat a surface the same day. Severe conditions may require coating more quickly to avoid contamination. For exposure under controlled conditions, the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting, regardless of time elapsed.

8.11DEW POINT: Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is recommended that the temperature of the steel surface beat least 3 °C (5 °F) above the dew point during power-tool cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during cleaning. It is equally important to continue to monitor the surface temperature/dew-point relationship until the coating is applied in order to avoid painting over a damp surface, unless the selected coating is specifically intended for application on damp substrates.

ANEXO Nº 5

SSPC: The Society for Protective Coatings

JOINT SURFACE PREPARATION STANDARD
SSPC-SP 7/NACE NO. 4

Brush-Off Blast Cleaning

This The Society for Protective Coatings (SSPC)/NACE International (NACE) standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. It is intended to aid the manufacturer, the consumer, and the general public. Its acceptance does not in any respect preclude anyone, whether he has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not addressed in this standard. Nothing contained in this SSPC/NACE standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents current technology and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. SSPC and NACE assume no responsibility for the interpretation or use of this standard by other parties and accept responsibility for only those official interpretations issued by SSPC or NACE in accordance with their governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

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Pittsburgh, PA 15222
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©NACE International
1440 South Creek
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(telephone +1 281/228-6200)

2. Foreword

This joint standard covers the use of blast cleaning abrasives to achieve a defined degree of cleaning of steel surfaces prior to the application of a protective coating or lining system. This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who may be responsible for defining a standard degree of surface cleanliness.

The focus of this standard is brush-off blast cleaning. White metal blast cleaning, near-white metal blast cleaning, commercial blast cleaning, and industrial blast cleaning are addressed in separate standards.

Brush-off blast cleaning provides a lesser degree of cleaning than industrial blast cleaning (SSPC-SP 14/NACE No. 8[1]). The difference between an industrial blast cleaning and a brush-off blast cleaning is that the objective of a brush-off blast cleaning is to allow as much of an existing adherent coating to remain as possible and to roughen the surface prior to coating application, whereas the purpose of the industrial blast cleaning is to remove most of the coating, mill scale, and rust, while the extra effort required to remove every trace of these is determined to be unwarranted.

This joint standard was originally prepared in 1994 and revised in 2000 by the SSPC/NACE Task Group A on Surface Preparation by Abrasive Blast Cleaning. This joint task group includes members of both the SSPC Surface Preparation Committee and the NACE Unit Committee T-6G on Surface Preparation. It was reaffirmed in 2006 by the SSPC Surface Preparation Committee, and NACE Specific Technology Group (STG) 04, Protective Coatings and Linings: Surface Preparation

In SSPC/NACE standards, *shall* and *must* are used to state mandatory requirements. *Should* is used to state that which is considered good and is recommended but is not absolutely mandatory. *May* is used to state that which is considered optional.

1. *Section 1: General*

1.1 This joint standard covers the requirements for brush-off blast cleaning of uncoated or coated steel surfaces by the use of abrasives. These requirements include the end condi- tion of the surface and materials and procedures necessary to achieve and verify the end condition.

1.2 The mandatory requirements are described in Sections 1 to 9. Section 10, “Comments,” and Appendix A, “Explanatory Notes,” are not mandatory requirements of this standard.

1.3 Information about the function of brush-off blast cleaning is in Paragraph A1 of Appendix A.

1.4 Information about use of this standard in maintenance coating work is in Paragraph A2 of Appendix A.

2. Section 2: Definitions

2.1 Brush-Off Blast Cleaned Surface: A brush-off blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust, and loose coating. Tightly adherent mill scale, rust, and coating may remain on the surface. Mill scale, rust, and coating are considered tightly adherent if they cannot be removed by lifting with a dull putty knife after abrasive blast cleaning has been performed.

2.1.1 The entire surface shall be subjected to the abrasive blast. The remaining mill scale, rust, or coating shall be tight. Flecks of the underlying steel need not be exposed whenever the original substrate consists of intact coating.

2.1.2 SSPC-VIS 1[2] may be specified to supplement the written definition. In any dispute, the written definition set forth in this standard shall take precedence over reference photographs and comparators. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

3. Section 3: Associated Documents

3.1 The latest issue, revision, or amendment of the documents listed in paragraph 3.3 in effect on the date of invitation to bid shall govern unless otherwise specified.

3.2 If there is a conflict between the requirements of any of the documents listed in paragraph 3.3 and this standard, the requirements of this standard shall prevail.

3.3 Documents cited in the mandatory sections of this standard include:

Document	*Title*
SSPC-AB 1[3]	Mineral and Slag Abrasives SSPC-
AB 2[4]	Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 3[5]	Ferrous Metallic Abrasives
SSPC-SP 1[6]	Solvent Cleaning
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

4. Section 4: Procedures Before Cleaning

7

4.1 Before blast cleaning, visible deposits of oil, grease, or other contaminants shall be removed in accordance with SSPC-SP 1 or other agreed-upon methods.

4.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification). Additional information on surface imperfections is in Paragraph A4 of Appendix A.

4.3 If reference photographs or comparators are specified to supplement the written standard, the condition of the steel prior to blast cleaning should be determined before the blasting commences. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

5. Section 5: Blast Cleaning Methods andOperation

5.1 Clean, dry compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve this requirement.

5.2 Any of the following methods of surface preparation may be used to achieve a brush-off blast cleaned surface:

5.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

5.2.2 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

5.2.3 Dry abrasive blasting using a closed-cycle, recircu-lating abrasive system with centrifugal wheels and abrasive.

Other methods of surface preparation (such as wet abrasive blast cleaning) may be used to achieve a brush-off blast cleaned surface by mutual agreement between those responsible for establishing the requirements and those responsible for performing the work. Information on the use of inhibitors to prevent the formation of rust immediately after wet abrasive blast cleaning is in Paragraph A5 of Appendix

6. Section 6: Blast Cleaning Abrasives

6.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, the type of blast cleaning system used, the finished surface to be produced (cleanliness and surface profile [roughness]), and whether the abrasive will be recycled. A.

6.2 The cleanliness and size of recycled abrasives shall be maintained to ensure compliance with this standard.

6.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other contaminants as determined by the test methods found in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

6.4 Any limitations on the use of specific abrasives, the quantity of contaminants, or the degree of allowable embedment shall be included in the procurement documents (project specification) covering the work, because abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements. Additional information on abrasive selection is in Paragraph A6 of Appendix A.

6.5 When a coating is specified, the cleaned surface shall be roughened to a degree suitable for the specified coating system. Additional information on surface profile and the film thickness of coating applied over the surface profile is in Paragraphs A7 and A8 of Appendix A.

7. Section 7: Procedures Following Blast Cleaning and Immediately Prior to Coating

7.1 Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP 1 or another method agreed upon by those parties responsible for establishing the requirements and those responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other methods agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

7.2.1 The presence of toxic metals in the abrasives or coating being removed may place restrictions on the methods of cleaning permitted. The chosen method shall comply with all applicable regulations.

7.2.2 Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, any remaining surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers) shall be removed to the extent required by the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Paragraph 6.5. Additional information on surface imperfections is in Paragraph A4 of Appendix A.

7.4 Immediately prior to coating application, the entire surface shall comply with the degree of cleaning specified in this standard. Information on chemical contamination, rust-back (rerusting), and the effect of dew point (surface condensation)is in

8. Section 8: Inspection

8.1 Work performed and materials supplied under this standard are subject to inspection by a representative of those responsible for establishing the requirements. Materials and work areas shall be accessible to the inspector. The proce- dures and times of inspection shall be as agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

8.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, a procedure mutually agreeable to purchaser and supplier shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Section 9: Safety and Environmental equirements

9.1 Because abrasive blast cleaning is a hazardous opera-tion, all work shall be conducted in compliance with applicable occupational and environmental health and safety rules and regulations.

10. Section 10: Comments (Nonmandatory)

10.1 Additional information and data relative to this standard are in Appendix A. Detailed information and data are presented in SSPC-SP COM.[7] The recommendations in Appendix A and SSPC-SP COM are believed to represent good practice, but are not to be considered requirements of the standard. The sections of SSPC-SP COM that discuss subjects related to brush-off blast cleaning are listed below.

Subject	**Commentary Section**
Abrasive Selection	6
Film Thickness	10
Maintenance Repainting	4.2
Reference Photographs	11
Rust-Back (Rerusting)	4.5
Surface Profile	6.2
Weld Spatter	4.4.1
Wet Abrasive Blast Cleaning	8.2

References

1. SSPC-SP 14/NACE No. 8 (latest revision), "Industrial Blast Cleaning" (Pittsburgh, PA: SSPC, and Houston, TX: NACE).
2. SSPC-VIS 1 (latest revision), "Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning" (Pittsburgh, PA: SSPC).
3. SSPC-AB 1 (latest revision), "Mineral and Slag Abrasives" (Pittsburgh, PA: SSPC).
4. SSPC-AB 2 (latest revision), "Cleanliness of Recycled Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).
5. SSPC-AB 3 (latest revision), "Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).
6. SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pittsburgh, PA: SSPC).
7. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).
8. SSPC-PA Guide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems" (Pittsburgh, PA: SSPC).
9. NACE Standard SP0178 (formerly RP1078-2003) (latest revision), "Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service" (Houston, TX: NACE)
10. NACE Standard RP0287 (latest revision), "Field Measure-ment of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape" (Houston, TX: NACE).
11. ASTM(1) D 4417 (latest revision), "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel" (West Conshohocken, PA: ASTM).
12. SSPC-PA 2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).

A1 FUNCTION: Brush-off blast cleaning (SSPC-SP 7/ NACE No. 4) provides a lesser degree of cleaning than industrial blast cleaning (SSPC-SP 14/NACE No. 8). It should be used when the service environment is mild enough to permit tight mill scale, coating, rust, and other foreign matter to remain on the surface. The primary functions of blast cleaning before coating are (a) to remove material from the surface that can cause early failure of the coating and (b) to obtain a suitable surface profile (roughness) to enhance the adhesion of the new coating system. The hierarchy of blasting standards is as follows: white metal blast cleaning, near-white metal blast cleaning, commercial blast cleaning, industrial blast cleaning, and brush-off blast cleaning

A2 MAINTENANCE COATING WORK: When this stan-dard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. In these cases, this degree of cleaning applies to the entire specified area. For example, if all weld seams are to be cleaned in a maintenance operation, this degree of cleaning applies to 100 percent of all weld seams. If the entire structure is to be prepared, this degree of cleaning applies to 100 percent of the entire structure. SSPC-PA Guide 4[8] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 REFERENCE PHOTOGRAPHS AND COMPARATORS SSPC-VIS 1 provides color photographs for the various grades of surface cleaning as a function of the initial condition of the steel. The photographs A SP 7, B SP 7, C SP 7, D SP 7, G_1 SP 7, G_2 SP 7, and G_3 SP 7 depict surfaces cleaned to brush- off blast grade. Other available reference photographs and comparators are described in Section 11 of SSPC-SP COM.

A4 SURFACE IMPERFECTIONS: Surface imperfections can cause premature coating failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to cover and protect properly include crevices, weld porosities, laminations, etc. The high cost of the methods to remedy surface imperfections (such as edge rounding and weld spatter removal) should be weighed against the costs of a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface cleaning has been completed. Repair of such surface defects should be planned properly because the timing of the repairs may occur before, during, or after the blast cleaning operation. Section of SSPC-SP COM and NACE Standard SP0178[9] contain additional information on surface imperfections.

A5 WET ABRASIVE BLAST CLEANING: Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing. It may be necessary to add inhibitors to the water or apply them to the surface immediately after blast cleaning to temporarily prevent rust formation. The use of inhibitors or the application of coating over slight discoloration should be in accordance with the requirements of the coating manufacturer. **CAUTION:** Some inhibitive treatments may interfere with the performance of certain coating systems.

A6 ABRASIVE SELECTION: Types of metallic and nonmetallic abrasives are discussed in SSPC-SP COM. Blasting abrasives may become embedded in, or leave residues on, the surface of the steel during cleaning. While such embedment or residues are normally not detrimental, care should be taken to ensure that the abrasive is free from detrimental amounts of water-soluble, solvent-soluble, acid-soluble, or other soluble contaminants (particularly if the cleaned steel is to be used in an immersion environment). Criteria for selecting and evaluating abrasives are in SSPC-AB 1, SSPC-AB 2, and SSPC-AB .

A7 SURFACE PROFILE: Surface profile is the roughness of the surface that results from abrasive blast cleaning. The profile height is dependent on the size, shape, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of abrasive recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent on the thickness of the coating to be applied. Large particle-sized abrasives (particularly metallic) can produce a surface profile that may be too high to be adequately covered by a single thin-film coat. Accordingly, the use of larger abrasives should be avoided in these cases. However, larger abrasives may be needed for thick-film coatings or to facilitate removal of thick coatings, heavy mill scale, or rust. If control of surface profile (minimum/maximum) is deemed to be significant to coating performance, it should be addressed in the procurement documents (project specification). Typical surface profile heights achieved with commercial abrasive media are shown in Table 6 of SSPC-SP COM. Surface profile should be measured in accordance with NACE Standard RP0287[10] or ASTM D 4417.[11]

A8 FILM THICKNESS: It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry-film thickness of the coating above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry-film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[12] should be used.

A9 CHEMICAL CONTAMINATION: Steel contaminated with soluble salts (e.g., chlorides and sulfates) develops rust- back rapidly at intermediate and high levels of humidity. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning if the abrasive is contaminated. Therefore, rust- back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after blast cleaning. Wet methods of removal are described in SSPC-SP 12/NACE No. 5.[13] Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests as described in SSPC-Guide 15.[14]

A10 RUST-BACK: Rust-back (rerusting) occurs when freshly cleaned steel is exposed to moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back varies greatly from one environment to another. Under mild ambient conditions, if chemical contamination (see Paragraph A9) is not present, it is best to blast clean and coat a surface on the same day. Severe conditions may require a more expeditious coating application to avoid contamination from fallout. Chemical contamination should be removed prior to coating.

A11 DEW POINT: Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is therefore recommended that the temperature of the steel surface be at least 3°C (5 °F) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations and to avoid the application of coating over a damp surface.

SSPC: The Society for Protective Coatings
JOINT SURFACE PREPARATION STANDARD SSPC-SP 6/NACE NO. 3
Commercial Blast Cleaning

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Foreword

This joint standard covers the use of blast cleaning abrasives to achieve a defined degree of cleaning of steel surfaces prior to the application of a protective coating or lining system. This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who may be responsible for defining a standard degree of surface cleanliness.

The focus of this standard is commercial blast cleaning. White metal blast cleaning, near-white metal blast cleaning, industrial blast cleaning, and brush-off blast cleaning are addressed in separate standards.

Commercial blast cleaning provides a greater degree of cleaning than industrial blast cleaning (SSPC-SP 14/NACE No. 8[1]) but less than near-white metal blast cleaning (SSPC- SP 10/NACE No. 2[2]).

Commercial blast cleaning is used when the objective is to remove all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter, leaving staining or shadows on no more than 33 percent of each unit area of surface.

The difference between a commercial blast cleaning and a near-white metal blast cleaning is in the amount of staining permitted to remain on the surface. Commercial blast cleaning allows stains or shadows on 33 percent of each unit area of surface. Near-white metal blast cleaning allows staining or shadows on only 5 percent of each unit area of surface.

The difference between a commercial blast cleaning and an industrial blast cleaning is that a commercial blast cleaning removes all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter from all surfaces and allows stains to remain on 33 percent of each unit area of surface, while industrial blast cleaning allows defined mill scale, coating, and rust to remain on less than 10 percent of each unit area of surface and allows defined stains to remain on all surfaces.

SSPC-SP 6/NACE No. 3
January 1, 2007

This joint standard was originally prepared in 1994 and reaffirmed in 2000 by the SSPC/NACE Task Group A on Surface Preparation by Abrasive Blast Cleaning. This joint task group includes members of both the SSPC Surface Preparation Committee and the NACE Unit Committee T-6G on Surface Preparation. It was reaffirmed in 2006 by the SSPC Surface Preparation Committee and NACE Specific Technology Group (STG) 04, Protective Coatings and Linings: Surface Preparation.

In SSPC/NACE standards, *shall* and *must* are used to state mandatory requirements. *Should* is used to state that which is considered good and is recommended but is not absolutely mandatory. *May* is used to state that which is considered optional.

1. *Section 1: General*

1.1 This joint standard covers the requirements for commercial blast cleaning of uncoated or coated steel surfaces by the use of abrasives. These requirements include the end condition of the surface and materials and procedures necessary to achieve and verify the end condition.

1.2 The mandatory requirements are described in Sections 1 to 9. Section 10, “Comments,” and Appendix A, “Explanatory Notes,” are not mandatory requirements of this standard.

1.3 Information about the function of commercial blast cleaning is in Paragraph A1 of Appendix A.

1.4 Information about use of this standard in maintenance coating work is in Paragraph A2 of Appendix A.

2. Section 2: Definitions

2.1 Commercial Blast Cleaned Surface: A commercial blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter. Random staining shall be limited to no more than 33 percent of each unit area of surface (approximately 5,800 mm^2 [9.0 in.^{2}]) (i.e., a square 76 mm x 76 mm [3.0 in. x 3.0 in.]) and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coating.

2.1.1 Acceptable variations in appearance that do not affect surface cleanliness as defined in Paragraph 2.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat-affected zones, blasting abrasives, and differences because of blasting technique.

2.1.2 SSPC-VIS 1[3] may be specified to supplement the written definition. In any dispute, the written definition set forth in this standard shall take precedence over reference photographs and comparators. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

3. Section 3: Associated Documents

3.1 The latest issue, revision, or amendment of the documents listed in Paragraph 3.3 in effect on the date of invitation to bid shall govern unless otherwise specified.

3.2 If there is a conflict between the requirements of any of the documents listed in Paragraph 3.3 and this standard, the requirements of this standard shall prevail.

3.3 Documents cited in the mandatory sections of this standard include:

Document	*Title*
SSPC-AB 1[4]	Mineral and Slag Abrasives
SSPC-AB 2[5]	Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 3[6]	Ferrous Metallic Abrasives
SSPC-SP 1[7]	Solvent Cleaning
SSPC-VIS 1 Photographs	Guide and Reference for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

4. Section 4: Procedures Before Cleaning

4.1 Before blast cleaning, visible deposits of oil, grease, or other contaminants shall be removed in accordance with SSPC-SP 1 or other agreed-upon methods.

4.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification). Additional information on surface imperfections is in Paragraph A4 of Appendix A.

4.3 If reference photographs or comparators are specified to supplement the written standard, the condition of the steel prior to blast cleaning should be determined before the blasting commences. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

5. Section 5: Blast Cleaning Methods and Operation

5.1 Clean, dry compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve this requirement.

5.2 Any of the following methods of surface preparation may be used to achieve a commercial blast cleaned surface:

5.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

5.2.2 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

5.2.3 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with centrifugal wheels and abrasive.

5.3 Other methods of surface preparation (such as wet abrasive blast cleaning) may be used to achieve a commercial blast cleaned surface by mutual agreement between those responsible for establishing the requirements and those responsible for performing the work. Information on the use of inhibitors to prevent the formation of rust immediately after wet abrasive blast cleaning is in Paragraph A5 of Appendix A.

6. Section 6: Blast Cleaning Abrasives

6.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, the type of blast cleaning system used, the finished surface to be produced (cleanliness and surface profile [roughness]), and whether the abrasive will be recycled.

6.2 The cleanliness and size of recycled abrasives shall be maintained to ensure compliance with this standard.

6.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other contaminants as determined by the test methods found in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

6.4 Any limitations on the use of specific abrasives, the quantity of contaminants, or the degree of allowable embedment shall be included in the procurement documents (project specification) covering the work, because abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements. Additional information on abrasive selection is in Paragraph A6 of Appendix A.

6.5 When a coating is specified, the cleaned surface shall be roughened to a degree suitable for the specified coating system. Additional information on surface profile and the film thickness of coating applied over the surface profile is in Paragraphs A7 and A8 of Appendix A.

7. Section 7: Procedures Following Blast Cleaning and Immediately Prior To Coating

7.1 Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP 1 or another method agreed upon by those parties responsible for establishing the requirements and those responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing; blowing off with clean, dry air;

vacuum cleaning; or other methods agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

7.2.1 The presence of toxic metals in the abrasives or coating being removed may place restrictions on the methods of cleaning permitted. The chosen method shall comply with all applicable regulations.

7.2.2 Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, any remaining surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers) shall be removed to the extent required by the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Paragraph 6.5. Additional information on surface imperfections is in Paragraph A4 of Appendix A.

7.4 Immediately prior to coating application, the entire surface shall comply with the degree of cleaning specified in this standard. Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by recleaning the rusted areas before coating. Information on chemical contamination, rust-back (rerusting), and the effect of dew point (surface condensation) is in Paragraphs A9, A10, and A11 of Appendix A.

8. Section 8: Inspection

8.1 Work performed and materials supplied under this standard are subject to inspection by a representative of those responsible for establishing the requirements. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

8.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlemen procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, a procedure mutually agreeable to purchaser and supplier shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Section 9: Safety and EnvironmentalRequirements

9.1 Because abrasive blast cleaning is a hazardous operation, all work shall be conducted in compliance with applicable occupational and environmental health and safety rules and regulations.

10. Section 10: Comments (Nonmandatory)

10.1 Additional information and data relative to this standard are in Appendix A. Detailed information and data are presented in SSPC-SP COM.[8] The recommendations in Appendix A and SSPC-SP COM are believed to represent good practice, but are not to be considered requirements of the standard. The sections of SSPC-SP COM that discuss subjects related to commercial blast cleaning are listed below.

Subject	**Commentary Section**
Abrasive Selection	6
Film Thickness	10
Maintenance Repainting	4.2
Reference Photographs	11
Rust-Back (Rerusting)	4.5
Surface Profile	6.2
Weld Spatter	4.4.1
Wet Abrasive Blast Cleaning	8.2

References

1. SSPC-SP 14/NACE No. 8 (latest revision), “Industrial Blast Cleaning” (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

2. SSPC-SP 10/NACE No. 2 (latest revision), “Near-White Metal Blast Cleaning” (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

3. SSPC-VIS 1 (latest revision), “Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning” (Pittsburgh, PA: SSPC).

4. SSPC-AB 1 (latest revision), “Mineral and Slag Abrasives” (Pittsburgh, PA: SSPC).

5.

6. SSPC-AB 2 (latest revision), “Cleanliness of Recycled Ferrous Metallic Abrasives” (Pittsburgh, PA: SSPC).

7. SSPC-AB 3 (latest revision), “Ferrous Metallic Abrasives” (Pittsburgh, PA: SSPC).

8. SSPC-SP 1 (latest revision), “Solvent Cleaning” (Pittsburgh, PA: SSPC).

9. SSPC-SP COM (latest revision), “Surface Preparation Commentary for Steel and Concrete Substrates” (Pittsburgh,PA: SSPC).

10. SSPC-PAGuide 4 (latest revision), “Guide to Maintenance Repainting with Oil Base orAlkyd Painting Systems”(Pittsburgh,PA: SSPC).

11. NACE Standard SP0178 (formerly RP0178-2003) (latest revision), “Design, Fabrication, and Surface Finish Practicesfor Tanks and Vessels to Be Lined for Immersion Service” (Houston, TX: NACE).

12. NACE Standard RP0287 (latest revision), “Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape” (Houston, TX: NACE).

13. SSPC-Guide 15 (latest revision), “Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates” (Pittsburgh, PA: SSPC).

14. ASTM(1) D 4417 (latest revision), “Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel” (West Conshohocken, PA: ASTM).

15. SSPC-PA 2 (latest revision), “Measurement of Dry Coating Thickness with Magnetic Gages” (Pittsburgh, PA: SSPC).

16. SSPC-SP 12/NACE No. 5 (latest revision), “Surface Prepa-

ration and Cleaning of Metals by Waterjetting Prior to Recoating” (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

Appendix A: Explanatory Notes (Nonmandatory)

A1 FUNCTION: Commercial blast cleaning (SSPC- SP 6/NACE No. 3) provides a greater degree of cleaning than industrial blast cleaning (SSPC-SP 14/NACE No. 8) but less than near-white metal blast cleaning (SSPC-SP 10/NACE No. 2). It should be specified only when a compatible coating will be applied. The primary functions of blast cleaning before coating are (a) to remove material from the surface that can cause early failure of the coating and (b) to obtain a suitable surface profile (roughness) to enhance the adhesion of the

A2 MAINTENANCE COATING WORK: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. In these cases, this degree of cleaning applies to the entire specified area. For example, if all weld seams are to be cleaned in a maintenance operation, this degree of cleaning applies to 100 percent of all weld seams. If the entire structure is to be prepared, this degree of cleaning applies to 100 percent of the entire structure. SSPC-PA Guide 4[9] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 REFERENCE PHOTOGRAPHS AND COMPARATORS: SSPC-VIS 1 provides color photographs for the various grades of surface cleaning as a function of the initial condition of the steel. The photographs B SP 6, C SP 6, D SP 6, G_1 SP 6, G_2 SP 6, and G_3 SP 6 depict surfaces cleaned to commercial grade. Other available reference photographs and comparators are described in Section 11 of SSPC-SP COM.

A4 SURFACE IMPERFECTIONS: Surface imperfections can cause premature coating failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to cover and protect properly include crevices, weld porosities, laminations, etc. The high cost of the methods to remedy surface imperfections (such as edge rounding and weld spatter removal) should be weighed against the costs of a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface cleaning has been completed. Repair of such surface defects should be planned properly because the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4.4 of SSPC-SP COM and NACE Standard SP0178[10] contain additional information on surface imperfections.

A5 WET ABRASIVE BLAST CLEANING: Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing. It may be necessary to add inhibitors to the water or apply them to the surface immediately after blast cleaning to temporarily prevent rust formation. The use of inhibitors or the application of coating over slight discoloration should be in accordance with the requirements of the coating manufacturer. **CAUTION:** Some inhibitive treatments may interfere with the performance of certain coating systems.

A6 ABRASIVE SELECTION: Types of metallic and nonmetallic abrasives are discussed in SSPC-SP COM. Blasting abrasives may become embedded in, or leave residues on, the surface of the steel during cleaning. While such embedment or residues are normally not detrimental, care should be taken to ensure that the abrasive is free from detrimental amounts of water-soluble, solvent-soluble, acid-soluble, or other soluble contaminants (particularly if the cleaned steel is to be used in an immersion environment). Criteria for selecting and evaluating abrasives are in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

A7 SURFACE PROFILE: Surface profile is the roughness of the surface that results from abrasive blast cleaning. The profile height is dependent on the size, shape, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of abrasive recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent on the thickness of the coating to be applied. Large particle-sized abrasives (particularly metallic) can produce a surface profile that may be too high to be adequately covered by a single thin-film coat. Accordingly, the use of larger abrasives should be avoided in these cases. However, larger abrasives may be needed for thick-film coatings or to facilitate removal of thick coatings, heavy mill scale, or rust. If control of surface profile (minimum/maximum) is deemed to be significant to coating performance, it should be addressed in the procurement documents (project specification). Typical surface profile heights achieved with commercial abrasive media are shown in Table 6 of SSPC-SP COM. Surface profile should be measured in accordance with NACE Standard RP0287[11] or ASTM D 4417.[12]

A8 FILM THICKNESS: It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry-film thickness of the coating above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry-film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[13] should be used.

A9 CHEMICAL CONTAMINATION: Steel contaminated with soluble salts (e.g., chlorides and sulfates) develops rust-back rapidly at intermediate and high levels of humidity. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning if the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after blast cleaning. Wet methods of removal are described in SSPC-SP 12/NACE No. 5.[14] Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests as described in SSPC-Guide 15.[15]

A10 RUST-BACK: Rust-back (rerusting) occurs when freshly cleaned steel is exposed to moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back varies greatly from one environment to another. Under mild ambient conditions, if chemical contamination (see Paragraph A9) is not present, it is best to blast clean and coat a surface on the same day. Severe conditions may require a more expeditious coating application to avoid contamination from fallout. Chemical contamination should be removed prior to coating.

A11 DEW POINT: Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is therefore recommended that the temperature of the steel surface be at least 3 °C (5 °F) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations and to avoid t

SSPC: The Society for Protective Coatings

JOINT SURFACE PREPARATION STANDARDSSPC-SP 10/NACE NO. 2

Near-White Metal Blast Cleaning

This The Society for Protective Coatings (SSPC)/NACE International (NACE) standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. It is intended to aid the manufacturer, the consumer, and the general public. Its acceptance does not in any respect preclude anyone, whether he has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not addressed in this standard. Nothing contained in this SSPC/NACE standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents current technology and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. SSPC and NACE assume no responsibility for the interpretation or use of this standard by other parties and accept responsibility for only those official interpretations issued by SSPC or NACE in accordance with their governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

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CAUTIONARY NOTICE: SSPC/NACE standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with technical committee procedures. SSPC and NACE require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication. The user is cautioned to obtain the latest edition. Purchasers may receive current information on all standards and other publications by contacting the organizations at the addresses below:

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Foreword

This joint standard covers the use of blast cleaning abrasives to achieve a defined degree of cleaning of steel surfaces prior to the application of a protective coating or lining system. This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who may be responsible for defining a standard degree of surface cleanliness.

The focus of this standard is near-white metal blast cleaning. White metal blast cleaning, commercial blast cleaning, industrial blast cleaning, and brush-off blast cleaning are addressed in separate standards.

Near-white metal blast cleaning provides a greater degree of cleaning than commercial blast cleaning (SSPC-SP 6/NACE No. 3[1]) but less than white metal blast cleaning (SSPC-SP 5/NACE No. 1[2]).

Near-white metal blast cleaning is used when the objective is to remove all rust, coating, and mill scale, but when the extra effort required to remove all stains of these materials is determined to be unwarranted. Staining shall be limited to no more than 5 percent of each unit area of surface.

Near-white metal blast cleaning allows staining on only 5 percent of each unit area of surface, while commercial blast cleaning allows staining on 33 percent of each unit area of surface. White metal blast cleaning does not permit any staining to remain on the surface.

This joint standard was originally prepared in 1994 and reaffirmed in 2000 by the SSPC/NACE Task Group A on Surface Preparation by Abrasive Blast Cleaning, and NACE Unit Committee T-6G on Surface Preparation. This joint task

1. Section 1: General

1.1 This joint standard covers the requirements for near-white metal blast cleaning of uncoated or coated steel surfaces by the use of abrasives. These requirements include the endcondition of the surface and materials and procedures neces-sary to achieve and verify the end condition.

1.2 The mandatory requirements are described in Sections 1 to 9. Section 10, "Comments," and Appendix A, "Explanatory Notes," are not mandatory requirements of thisstandard.

1.3 Information about the function of near-white metal blast cleaning is in Paragraph A1 of Appendix A.

1.4 Information about use of this standard in maintenance coating work is in Paragraph A2 of Appendix A.

2. Section 2: Definitions

2.1 Near-White Metal Blast Cleaned Surface: A near-white metal blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and otherforeign matter. Random staining shall be limited to no more than 5 percent of each unit area of surface (approximately 5,800 mm^2 [9.0 $in.^2$] (i.e., a square 76 mm x 76 mm [3.0 in. x 3.0 in.]), and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coating.

Preparation.

In SSPC/NACE standards, *shall* and *must* are used to state mandatory requirements. *Should* is used to state that which is considered good and is recommended but is not absolutely mandatory. *May* is used to state that which is considered optional.

Preparation. It was reaffirmed in 2006 by the SSPC Surface Preparation Committee and NACE Specific Technology Group (STG) 04, Protective Coatings and Linings: Surface group includes members of both the SSPC Surface Preparation Committee and the NACE Unit Committee T-6G on Surface

2.1.1 Acceptable variations in appearance that do not affect surface cleanliness as defined in Paragraph 2.1 include variations caused by the type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat-affected zones, blasting abrasives, and differences because of blasting technique.

2.1.2 SSPC-VIS 1[3] may be specified to supplement the written definition. In any dispute, the written definition set forth in this standard shall take precedence over reference photographs and comparators. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

3. *Section 3: Associated Documents*

3.1 The latest issue, revision, or amendment of the documents listed in Paragraph 3.3 in effect on the date of invitation to bid shall govern unless otherwise specified.

3.2 If there is a conflict between the requirements of any of the documents listed in Paragraph 3.3 and this standard, the requirements of this standard shall prevail.

3.3 Documents cited in the mandatory sections of this standard include:

Document	*Title*
SSPC-AB 1[4]	Mineral and Slag Abrasives SSPC-
AB 2[5]	Cleanliness of Recycled Ferrous
Metallic Abrasives	
SSPC-AB 3[6]	Ferrous Metallic Abrasives
SSPC-SP 1[7]	Solvent Cleaning
SSPC-VIS 1	Guide and Reference Photographs
for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning	

4. *Section 4: Procedures Before Cleaning*

4.1 Before blast cleaning, visible deposits of oil, grease, or other contaminants shall be removed in accordance with SSPC-SP 1 or other agreed-upon methods.

4.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification). Additional information on surface imperfections is in Paragraph A4 of Appendix A.

4.3 If reference photographs or comparators are specified to supplement the written standard, the condition of the steel prior to blast cleaning should be determined before the blasting commences. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

5. *Section 5: Blast Cleaning Methods andOperation*

5.1 Clean, dry compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve this requirement.

5.2 Any of the following methods of surface preparation may be used to achieve a near-white metal blast cleaned surface:

5.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

5.2.2 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

5.2.3 Dry abrasive blasting using a closed-cycle, recircu-lating abrasive system with centrifugal wheels and abrasive.

5.3 Other methods of surface preparation (such as wet abrasive blast cleaning) may be used to achieve a near-white metal blast cleaned surface by mutual agreement between those responsible for establishing the requirements and those responsible for performing the work. Information on the use of inhibitors to prevent the formation of rust immediately after wet abrasive blast cleaning is in Paragraph A5 of Appendix A.

6. *Section 6: Blast Cleaning Abrasives*

6.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, the type of blast cleaning system used, the finished surface to be produced (cleanliness and surface profile [roughness]), and whether the abrasive will be recycled.

6.2 The cleanliness and size of recycled abrasives shall be maintained to ensure compliance with this standard.

6.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other contaminants as determined by the test methods found in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

6.4 Any limitations on the use of specific abrasives, the quantity of contaminants, or the degree of allowable embedment shall be included in the procurement documents (project specification) covering the work, because abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements. Additional information on abrasive selection is in Paragraph A6 of Appendix A.

6.5 When a coating is specified, the cleaned surface shall be roughened to a degree suitable for the specified coating system. Additional information on surface profile and the film thickness of coating applied over the surface profile is in Paragraphs A7 and A8 of Appendix A.

7. *Section 7: Procedures Following Blast Cleaningand Immediately Prior to Coating*

7.1 Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP 1 or another method agreed upon by those parties responsible for establishing the requirements and those responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other methods agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

7.2.1 The presence of toxic metals in the abrasives or coating being removed may place restrictions on the methods of cleaning permitted. The chosen method shall comply with all applicable regulations.

7.2.2 Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

After blast cleaning, any remaining surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers) shall be removed to the extent required by the procurement documents (project specification). Any damage to the surface

7.3. Immediately prior to coating application, the entire surface shall comply with the degree of cleaning specified in this standard. Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by recleaning the rusted areas before coating. Information on chemical contamination, rust-back (rerusting), and the effect of dew point (surface condensation) is in Paragraphs A9, A10, and A11 of Appendix A.

8. Section 8: Inspection

8.1 Work performed and materials supplied under this standard are subject to inspection by a representative of those responsible for establishing the requirements. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

8.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, a procedure mutually agreeable to purchaser and supplier shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Section 9: Safety and Environmental Requirements

9.1 Because abrasive blast cleaning is a hazardous operation, all work shall be conducted in compliance with applicable occupational and environmental health and safety rules and regulations.

10. Section 10: Comments (Nonmandatory)

10.1 Additional information and data relative to this standard are in Appendix A. Detailed information and data are presented in SSPC-SP COM.[8] The recommendations in Appendix A and SSPC-SP COM are believed to represent good practice, but are not to be considered requirements of the standard. The sections of SSPC-SP COM that discuss subjects related to near-white metal blast cleaning are listed below.

Subject	**Commentary Section**
Abrasive Selection	6
Film Thickness	10
Maintenance Repainting	4.2
Reference Photographs	11
Rust-Back (Rerusting)	4.5
Surface Profile	6.2
Weld Spatter	4.4.1
Wet Abrasive Blast Cleaning	8.2

References

1. SSPC-SP 6/NACE No. 3 (latest revision), "Commercial Blast Cleaning" (Houston, TX: NACE, and Pittsburgh, PA: SSPC).
2. SSPC-SP 5/NACE No. 1 (latest revision), "White Metal Blast Cleaning" (Pittsburgh, PA: SSPC, and Houston, TX: NACE).
3. SSPC-VIS 1 (latest revision), "Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning" (Pittsburgh, PA: SSPC).
4. SSPC-AB 1 (latest revision), "Mineral and Slag Abrasives" (Pittsburgh, PA: SSPC).
5. SSPC-AB 2 (latest revision), "Cleanliness of Recycled Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).
6. SSPC-AB 3 (latest revision), "Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).
7. SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pitts- burgh, PA: SSPC).
8. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).
9. SSPC-PAGuide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems" (Pittsburgh, PA: SSPC).
10. NACE Standard SP0178 (formerly RP0178-2003) (latest revision), "Fabrication Details, Surface Finish Requirements, and Proper Design Considerations for Tanks and Vessels to Be Lined for Immersion Service" (Houston, TX: NACE).
11. NACE Standard RP0287 (latest revision), "Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape" (Houston, TX: NACE).
12. ASTM(1) D 4417 (latest revision), "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel" (West Conshohocken, PA: ASTM)
13. SSPC-PA 2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).
14. SSPC-Guide 15 (latest revision), "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates" (Pittsburgh, PA: SSPC).

Appendix A: Explanatory Notes (Nonmandatory)

A1 FUNCTION: Near-white metal blast cleaning (SSPC- SP 10/NACE No. 2) provides a greater degree of cleaning than commercial blast cleaning (SSPC-SP 6/NACE No. 3) but less than white metal blast cleaning (SSPC-SP 5/NACE No. 1). It should be used when a high degree of blast cleaning is required. The primary functions of blast cleaning before coating are (a) to remove material from the surface that can cause early failure of the coating and (b) to obtain a suitable surface profile (roughness) to enhance the adhesion of the new coating system. The hierarchy of blasting standards is as follows: white metal blast cleaning, near-white metal blast cleaning, commercial blast cleaning, industrial blast cleaning, and brush-off blast cleaning.

A2 MAINTENANCE COATING WORK: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. In these cases, this degree of cleaning applies to the entire specified area. For example, if all weld seams are to be cleaned in a maintenance operation, this degree of cleaning applies to 100 percent of all weld seams. If the entire structure is to beprepared, this degree of cleaning applies to 100 percent of the entire structure. SSPC-PA Guide 4[9] provides a description ofaccepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 REFERENCE PHOTOGRAPHS AND COMPARATORS: **SSPC-VIS** 1 provides color photographs for the variousgrades of surface cleaning as a function of the initial condition ofthe steel. The photographs ASP 10, B SP 10, C SP 10, D SP 10, G_1 SP 10, G_2 SP 10, and G_3 SP 10 depict surfaces cleaned to near-white metal. Other available reference photographs and comparators are described in Section 11 of SSPC-SP COM.

A4 SURFACE IMPERFECTIONS: Surface imperfections can cause premature coating failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to cover and protect properly include crevices, weld porosities, laminations, etc. The high cost of the methods to remedy surface imperfections (such as edge rounding and weld spatter removal) should be weighed against the costs of a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface cleaning has been completed. Repair of such surface defects should be plannedproperly because the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4.4 of SSPC-SP COM and NACE Standard SP0178[10] contain addi-tional information on surface imperfections.

A5 WET ABRASIVE BLAST CLEANING: Steel that is wet abrasive blast cleaned may rust rapidly. Clean water shouldbe used for rinsing. It may be necessary to add inhibitors to the water or apply them to the surface immediately after blast cleaning to temporarily prevent rust formation. The use of inhibitors or the application of coating over slight discoloration should be in accordance with the requirements of the coating manufacturer. **CAUTION:** Some inhibitive treatments may interfere with the performance of certain coating systems.

A6 ABRASIVE SELECTION: Types of metallic and nonmetallic abrasives are discussed in SSPC-SP COM. Blastingabrasives may become embedded in, or leave residues on, thesurface of the steel during cleaning. While such embedment orresidues are normally not detrimental, care should be taken to ensure that the abrasive is free from detrimental amounts of water-soluble, solvent-soluble, acid-soluble, or other soluble contaminants (particularly if the cleaned steel is to be used in an immersion environment). Criteria for selecting and evaluating abrasives are in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

A7 SURFACE PROFILE: Surface profile is the roughness of the surface that results from abrasive blast cleaning. The profile height is dependent on the size, shape, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of abrasive recycling, and theproper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent on the thickness of the coating to be applied. Large particle-sized abrasives (particularly metallic) can produce a surface profile that may be too high to be adequately covered by a single thin-film coat. Accordingly, the use of larger abrasives should be avoided in these cases. However, larger abrasives may be needed for thick-film coatings or to facilitate removal of thick coatings, heavy mill scale, or rust. If control of surface profile (minimum/maximum) is deemed to be significant to coating performance, it should be addressed in the procurement documents (project specification). Typical surface profile heights achieved with commercial abrasive media areshown in Table 6 of SSPC-SP COM. Surface profile should be measured in accordance with NACE Standard RP0287[11] or ASTM D 4417.[12]

A8 FILM THICKNESS: It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry-film thickness of the coating above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry-film thickness over the peaks is inadequate, premature rust-throughor coating failure will occur. To ensure that coating thicknessesare properly measured, the procedures in SSPC-PA 2[13] should be used.

A9 CHEMICAL CONTAMINATION: Steel contaminated with soluble salts (e.g., chlorides and sulfates) develops rust-back rapidly at intermediate and high levels of humidity. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning if the abrasive is contaminated. Therefore, rust- back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after blast cleaning. Wet methods of removal are described in SSPC-SP 12/NACE No. 5.[14] Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests as described in SSPC-Guide 15.[15]

A10 RUST-BACK: Rust-back (rerusting) occurs when freshly cleaned steel is exposed to moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back varies greatly from one environment to another. Under mild ambient conditions, if chemical contami-nation (see Paragraph A9) is not present, it is best to blast clean and coat a surface on the same day. Severe conditions may require a more expeditious coating application to avoid contamination from fallout. Chemical contamination should beremoved prior to coating.

SSPC: The Society for Protective Coatings
JOINT SURFACE PREPARATION STANDARDSSPC-SP 5/NACE NO. 1
White Metal Blast Cleaning

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CAUTIONARY NOTICE: SSPC/NACE standards are subject to periodic review, and may be revised or withdrawn atany time in accordance with technical committee procedures. SSPC and NACE require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication. The user is cautioned to obtain the latest edition. Purchasers may receive current information on all standards and other publications by contacting the organizations at the addresses below:

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Foreword

This joint standard covers the use of blast cleaning abrasives to achieve a defined degree of cleaning of steel surfaces prior to the application of a protective coating or lining system. This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who may be responsible for defining a standard degree of surface cleanliness.

The focus of this standard is white metal blast cleaning. Near-white metal blast cleaning, commercial blast cleaning, industrial blast cleaning, and brush-off blast cleaning are addressed in separate standards.

White metal blast cleaning provides a greater degree of cleaning than near-white metal blast cleaning (SSPC-SP 10/NACE No. 2[1]).

The difference between a white metal blast and a near-white metal blast is that a white metal blast removes all of the coating, mill scale, rust, oxides, corrosion products, and other foreign matter from the surface. Near-white metal blasting allowslight shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coating to remain on no more than 5 percent of each unit area of surface as defined in SSPC-SP 10/NACE No. 2.

This joint standard was originally prepared in 1994 and reaffirmed in 2000 by the SSPC/NACE Task Group Aon Surface Preparation by Abrasive Blast Cleaning. This joint task group includes members of both the SSPC Surface Preparation Committee and the NACE Unit Committee T-6G on Surface Preparation. It was reaffirmed in 2006 by the SSPC Surface Preparation Committee and NACE Specific Technology Group (STG) 04, Protective Coatings and Linings: Surface Preparation.

In SSPC/NACE standards *shall* and *must* are used to state mandatory requirements. *Should* is used to state that which is considered good and is recommended but is not absolutely mandatory. *May* is used to state that which is considered optional.

1. *Section 1: General*

1.1 This joint standard covers the requirements for white metal blast cleaning of uncoated or coated steel surfaces by the use of abrasives. These requirements include the end condi- tion of the surface and materials and procedures necessary to achieve and verify the end condition.

1.2 The mandatory requirements are described in Sections 1 to 9. Section 10, "Comments," and Appendix A, "Explanatory Notes," are not mandatory requirements of thisstandard.

1.3 Information about the function of white metal blast cleaning is in Paragraph A1 of Appendix A.

1.4 Information about use of this standard in maintenance coating work is in Paragraph A2 of Appendix A.

2. *Section 2: Definitions*

2.1 White Metal Blast Cleaned Surface: A white metal blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter.

2.1.1 Acceptable variations in appearance that do not affect surface cleanliness as defined in Paragraph 2.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat-affected zones, blasting abrasives, and differences because of blasting technique.

2.1.2 SSPC-VIS 1[2] may be specified to supplement the written definition. In any dispute, the written definition set forth in this standard shall take precedence over reference photographs and comparators. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

3. Section 3: Associated Documents

3.1 The latest issue, revision, or amendment of the documents listed in Paragraph 3.3 in effect on the date of invitation to bid shall govern unless otherwise specified.

3.2 If there is a conflict between the requirements of any of the documents listed in Paragraph 3.3 and this standard, the requirements of this standard shall prevail.

3.3 Documents cited in the mandatory sections of this standard include:

Document	*Title*
SSPC-AB 1[3]	Mineral and Slag Abrasives
SSPC-AB 2[4]	Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 3[5]	Ferrous Metallic Abrasives
SSPC-SP 1[6]	Solvent Cleaning
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

4. Section 4: Procedures Before Cleaning

4.1 Before blast cleaning, visible deposits of oil, grease, or other contaminants shall be removed in accordance with SSPC-SP 1 or other agreed-upon methods.

4.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification). Additional information on surface imperfections is in Paragraph A4 of Appendix A.

4.3 If reference photographs or comparators are specified to supplement the written standard, the condition of the steel prior to blast cleaning should be determined before the blasting commences. Additional information on reference photographs and comparators is in Paragraph A3 of Appendix A.

5. Section 5: Blast Cleaning Methods and Operation

5.1 Clean, dry compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve this requirement.

5.2 Any of the following methods of surface preparation may be used to achieve a white metal blast cleaned surface:

5.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

5.2.2 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

5.2.3 Dry abrasive blasting using a closed-cycle, recirculating abrasive system with centrifugal wheels and abrasive.

5.3 Other methods of surface preparation (such as wet abrasive blast cleaning) may be used to achieve a white metal blast cleaned surface by mutual agreement between those responsible for establishing the requirements and those responsible for performing the work. Information on the use of inhibitors to prevent the formation of rust immediately after wet abrasive blast cleaning is in Paragraph A5 of Appendix A.

6. Section 6: Blast Cleaning Abrasives

6.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, the type of blast cleaning system used, the finished surface to be produced (cleanliness and surface profile [roughness]), and whether the abrasive will be recycled.

6.2 The cleanliness and size of recycled abrasives shall be maintained to ensure compliance with this standard.

6.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other contaminants as determined by the test methods found in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

6.4 Any limitations on the use of specific abrasives, the quantity of contaminants, or the degree of allowable embedment shall be included in the procurement documents (project specification) covering the work, because abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements. Additional information on abrasive selection is in Paragraph A6 of Appendix A.

6.5 When a coating is specified, the cleaned surface shall be roughened to a degree suitable for the specified coating system. Additional information on surface profile and the film thickness of coating applied over the surface profile is in Paragraphs A7 and A8 of Appendix A.

7. Section 7: Procedures Following Blast Cleaning and Immediately Prior to Coating

7.1 Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP 1 or another method agreed upon by those parties responsible for establishing the requirements and those responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other methods agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

7.2.1 The presence of toxic metals in the abrasives or coating being removed may place restrictions on the methods of cleaning permitted. The chosen method shall comply with all applicable regulations.

7.3 Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air. After blast cleaning, any remaining surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers) shall be removed to the extent required by the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Paragraph 6.5. Additional information on surface imperfections is in Paragraph A4 of Appendix A.

7.4 Immediately prior to coating application, the entire surface shall comply with the degree of cleaning specified in this standard. Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by recleaning the rusted areas before coating. Information on chemical contamination, rust-back (rerusting), and the effect of dew point (surface condensation) is in Paragraphs A9, A10, and A11 of Appendix A.

8. Section 8: Inspection

8.1 Work performed and materials supplied under this standard are subject to inspection by a representative of those responsible for establishing the requirements. Materials and work areas shall be accessible to the inspector. The proce- dures and times of inspection shall be as agreed upon by those responsible for establishing the requirements and those responsible for performing the work.

8.2 Conditions not complying with this standard shall be corrected. In the case of a dispute, an arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, a procedure mutually agreeable to purchaser and supplier shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Section 9: Safety and EnvironmentalRequirements

9.1 Because abrasive blast cleaning is a hazardous opera- tion, all work shall be conducted in compliance with applicable occupational and environmental health and safety rules and regulations

10. Section 10: Comments (Nonmandatory)

10.1 Additional information and data relative to this standard are in Appendix A. Detailed information and data are presented in SSPC-SP COM.[7] The recommendations in Appendix A and SSPC-SP COM are believed to represent good practice, but are not to be considered requirements of the standard. The sections of SSPC-SP COM that discuss subjects related to white metal blast cleaning are listed below.

Subject	Commentary Section
Abrasive Selection	6
Film Thickness	10
Maintenance Repainting	4.2
Reference Photographs	11
Rust-Back (Rerusting)	4.5
Surface Profile	6.2
Weld Spatter	4.4.1
Wet Abrasive Blast Cleaning	8.2

References

1. SSPC-SP 10/NACE No. 2 (latest revision), "Near-White Metal Blast Cleaning" (Houston, TX: NACE, and Pittsburgh, PA: SSPC).

2. SSPC-VIS 1 (latest revision), "Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning" (Pittsburgh, PA: SSPC).

3. SSPC-AB 1 (latest revision), "Mineral and Slag Abrasives" (Pittsburgh, PA: SSPC).

4. SSPC-AB 2 (latest revision), "Cleanliness of Recycled Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).

5. SSPC-AB 3 (latest revision), "Ferrous Metallic Abrasives" (Pittsburgh, PA: SSPC).

6. SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pittsburgh, PA: SSPC).

7. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).

8. SSPC-PAGuide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base orAlkyd Painting Systems"(Pittsburgh,PA: SSPC).

9. "Visual Comparator for Surface Finishing of Welds Priorto Coating," Visual Aid for Use with NACE Standard SP0178 (latest revision), (Houston, TX: NACE).

10. NACE Standard SP0178 (formerly RP0178-2003) (latest revision), "Design, Fabrication, and Surface Finish Practices for for Tanks and Vessels to Be Lined for Immersion Service"(Houston, TX: NACE).

11. NACE Standard RP0287 (latest revision), "Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape" (Houston, TX: NACE).

12. ASTM[(1)] D 4417 (latest revision), "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel" (West Conshohocken, PA: ASTM).

13. SSPC-PA2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).

14. SSPC-SP 12/NACE No. 5 (latest revision), "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating" (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

15. SSPC-Guide 15 (latest revision), "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates" (Pittsburgh, PA: SSPC).

Appendix A: Explanatory Notes (Nonmandatory)

A1 FUNCTION: White metal blast cleaning (SSPC-SP 5/NACE No. 1) provides the greatest degree of cleaning. It should be used when the highest degree of blast cleaning is required. The primary functions of blast cleaning before coating are (a) to remove material from the surface that can cause early failure of the coating and (b) to obtain a suitable surface profile (roughness) to enhance the adhesion of the new coating system. The hierarchy of blasting standards is as follows: white metal blast cleaning, near-white metal blast cleaning, commercial blast cleaning, industrial blast cleaning, and brush-off blast cleaning.

A2 MAINTENANCE COATING WORK: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. In these cases, this degree of cleaning applies to the entire specified area. For example, if all weld seams are to be cleaned in a maintenance operation, this degree of cleaning applies to 100 percent of all weld seams. If the entire structure is to be prepared, this degree of cleaning applies to 100 percent of the entire structure. SSPC-PA Guide 4[8] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 REFERENCE PHOTOGRAPHS AND COMPARA-TORS: SSPC-VIS 1 provides color photographs for the various grades of surface cleaning as a function of the initial condition of the steel. The photographs A SP 5, B SP 5, C SP 5, D SP 5, G_1 SP 5, G_2 SP 5, and G_3 SP 5 depict surfaces cleaned to white metal. In addition, the photograph series A SP 5M and A SP 5N depict surfaces cleaned by various metallic and nonmetallic abrasives to SP 5 condition. The NACE “Visual Comparator for Surface Finishing of Welds Prior to Coating”[9] is a plastic weld replica that complements NACE Standard SP0178.[10] Other available reference photographs and comparators are described in Section 11 of SSPC-SP COM.

A4 SURFACE IMPERFECTIONS: Surface imperfections can cause premature coating failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to cover and protect properly include crevices, weld porosities, laminations, etc. The high cost of the methods to remedy surface imperfections (such as edge rounding and weld spatter removal) should be weighed against the costs of a potential coating failure. Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface cleaning has been completed. Repair of such surface defects should be planned properly because the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4.4 of SSPC-SP COM and NACE Standard SP0178 contain additional information on surface imperfections.

A5 WET ABRASIVE BLAST CLEANING: Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing. It may be necessary to add inhibitors to the water or apply them to the surface immediately after blast cleaning to temporarily prevent rust formation. The use of inhibitors or the application of coating over slight discoloration should be in accordance with the requirements of the coating manufacturer. **CAUTION:** Some inhibitive treatments may interfere with the performance of certain coating systems.

A6 ABRASIVE SELECTION: Types of metallic and nonmetallic abrasives are discussed in SSPC-SP COM. Blasting abrasives may become embedded in, or leave residues on, the surface of the steel during cleaning. While such embedment or residues are normally not detrimental, care should be taken to ensure that the abrasive is free from detrimental amounts of water-soluble, solvent-soluble, acid-soluble, or other soluble contaminants (particularly if the cleaned steel is to be used in an immersion environment). Criteria for selecting and evaluating abrasives are in SSPC-AB 1, SSPC-AB 2, and SSPC-AB 3.

A7 SURFACE PROFILE: Surface profile is the roughness of the surface that results from abrasive blast cleaning. The profile height is dependent on the size, shape, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of abrasive recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent on the thickness of the coating to be applied. Large particle sized abrasives (particularly metallic) can produce a surface profile that may be too high to be adequately covered by a single thin-film coat. Accordingly, the use of larger abrasives should be avoided in these cases. However, larger abrasives may be needed for thick-film coatings or to facilitate removal of thick coatings, heavy mill scale, or rust. If control of surface profile (minimum/maximum) is deemed to be significant to coating performance, it should be addressed in the procurement documents (project specification). Typical surface profile heights achieved with commercial abrasive media are shown in Table 6 of SSPC-SP COM. Surface profile should be measured in accordance with NACE Standard RP0287[11] or ASTM D 4417.[12]

A8 FILM THICKNESS: It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry-film thickness of the coating above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry-film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[13] should be used.

A9 CHEMICAL CONTAMINATION: Steel contaminated with soluble salts (e.g., chlorides and sulfates) develops rust-back rapidly at intermediate and high levels of humidity. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning if the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after blast cleaning. Wet methods of removal are described in SSPC-SP 12/NACE No. 5.[14] Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests as described in SSPC-Guide 15.[15]

A10 RUST-BACK: Rust-back (rerusting) occurs when freshly cleaned steel is exposed to moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back varies greatly from one environment to another. Under mild ambient conditions, if chemical contami- nation (see Paragraph A9) is not present, it is best to blast clean and coat a surface on the same day. Severe conditions may require a more expeditious coating application to avoid contamination from fallout. Chemical contamination should be removed prior to coating.

A11 DEW POINT: Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is therefore recommended that the temperature of the steel surface be at least 3 °C (5 °F) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations and to avoid the application of coating over a damp surface.

ANEXO Nº 6

SSPC-TR 2/NACE 6G198

JOINT TECHNICAL REPORT

Wet Abrasive Blast Cleaning

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Foreword

This joint report was prepared by the SSPC/NACE Joint Task Group C on Wet Abrasive Blast Cleaning, which is comprised of members of both the SSPC Surface Preparation Committee and the NACE Unit Committee T6G on Surface Preparation (now STG 04). It is intended to be used primarily by specifiers, owners, painting contractors, inspectors, and others involved in surface preparation of industrial structures.

1. Scope

This document covers procedures, equipment, and materials involved in a variety of air/water/abrasive, water/abrasive, and water-pressurized abrasive blast cleaning systems. Equipment usage and safety are also discussed

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2. Description and Use

2.1 Air/water/abrasive blasting is a cleaning method in which water is injected into the air/abrasive stream generated by conventional air-pressurized abrasive blasting equipment.

2.1.1 Water helps to remove contaminants from the substrate, to wet the abrasive, and to substantially reduce dispersion of fine particulates (dust). Particulates are often caused by the breakup of the abrasives, surface corrosion products, and paint if the surface has been previously painted. Dust suppression is achieved by thoroughly wetting the abrasive and other particles to encapsulate them with a thin film of moisture. The objective is to remove contaminants and suppress the dusting effect caused by the impact of the abrasive on the substrate, while retaining the blasting characteristics of dry abrasive, including creation of anchor profile.

2.1.2 Air/water/abrasive blasting is an alternative to waterjetting, dry blasting, and water blasting with abrasive injection.

2.1.3 Air/water/abrasive blasting is referred to hereafter as "wet blasting."

2.2 Water/abrasive blasting is a cleaning method in which abrasive is injected into the water stream generated by conventional fluid pumps.

2.2.1 Water is the primary agent to remove the contaminants from the substrate. The abrasive is injected to help remove brittle contaminants and create a profile where necessary. Compared to wet blasting methods, water/abrasive blasting has a higher water to abrasive ratio. Dust suppression is achieved by the wetting of the abrasive and other particles. The objective is to remove contaminants with water and impact the abrasive on the substrate to retain the blasting characteristic of dry abrasive, including creation of anchor profile.

2.2.2 Water/abrasive blasting is an alternative to dry blasting, wet blasting, or waterjetting.(1)

3. Procedures and Parameters

3.1 Wet blasting is generally considered suitable for use on any substrate for which the use of abrasive is appropriate. Wet blasting can often be adjusted to clean delicate substrates.

3.2 Some wet blasting systems can utilize the same wide variety of available abrasives as conventional dry abrasive blast systems. Wet abrasive is more difficult to recycle than dry abrasive. In some cases, recycling of wet abrasive may not be possible. In some cases, the water may be recycled.

3.3 The water flow rate and the ratio of water to abrasive are usually adjustable so that a wide range of applications, from washing of surface contaminants to white metal blast, can be accomplished.

3.4 After wet blasting, all traces of abrasive and other loose particles are brushed, blown off with clean dry air, vacuumed, washed, or otherwise removed from the surface. Cleanliness of the surface cannot be overemphasized.

3.5 The injection of water to the air/abrasive stream helps to remove contaminants such as dirt and water-soluble salts, including ferrous, chloride, or sulfate salts.(2)

3.6 Inhibitors can be used to control flash rusting during wet or water/abrasive blasting. Many coating manufacturers prefer that inhibitors not be used in wet or water/abrasive blasting. (See Section 6.)

3.7 Production rates vary due to variations in surfaces being blasted, the type of abrasive used, and the level of fine particulate dust suppression desired. Systems introduced since 1985 claim production rates equal to or higher than conventional dry blasting, but independent studies have not been published as of this publication date.

3.8 Wet blasting is a process that can produce surface cleanliness and anchor profiles (surface roughness) similar to those obtained with dry blasting. The level of surface preparation specified is the same as that specified if dry blasting was the process being used. However, because the visual appearance of wet blasted surfaces is not necessarily the same as the visual appearance of dry blasted surfaces, care and judgment should be exercised by inspectors. It is common to encounter difficulty when visual inspection standards or aids prepared for dry blasting are used as inspection or judgment criteria for wet blasted surfaces. This visual difficulty can be lessened by preparation of a test patch which is agreed upon by the concerned parties during a pre-job conference.

4. Wet Blasting Equipment

4.1 The equipment used for wet blasting generally consists of conventional dry abrasive blasting equipment supplemented with modules to inject water into the abrasive stream. Ideally, the water encapsulates the abrasive particles with a thin film of moisture to suppress and contain the dust generated by the impact of the abrasive with the substrate. Abrasive injection into water blast equipment will also be discussed.

Systems are available that allow the operator to select adjustable rates of air, water, or abrasive as necessary to achieve optimum results. Some systems allow independent adjustment of each of these parameters while the system is in operation. Some systems also allow independent adjustment for each nozzle for multi-nozzle setups.

4.2 TYPES OF WET BLASTING SYSTEMS

4.2.1 General Requirements of Wet Blast Units: Most systems under the general classification of wet blast units contain a conventional dry abrasive blast pot with OSHA/NIOSH required deadman and other safety features, plus the normal complements of abrasive metering valve(s), compressed air inlet valve(s), blast hose, dry abrasive blast nozzle, etc. With these systems, the compressed air volumes and pressures are the same as for conventional dry abrasive blasting. Each of these systems can clean to SSPC-SP 5/NACE No. 1 (White Metal) and create a suitable anchor pattern for paint adhesion.

4.2.2 Radial Water Injectors: Some of these are commonly referred to as "water rings," and are available in three basic configurations. In the first configuration, water is injected at an angle toward the center of the blast stream as the air/abrasive stream enters the blast nozzle. The water is normally injected at or just above the pressure of the compressed air (see Figure 1). The second configuration is a "donut" that fits over the outside of the dry blast nozzle. Water is injected from around the outside of the blast stream radially inward at an angle toward the center of the blast stream as the air/abrasive stream exits the nozzle. The third configuration utilizes a wet blast venturi nozzle which allows water and atmospheric air to be inducted at midpoint in the nozzle behind the bore restriction.

4.2.3 Coaxial Water Injectors: In these systems the water is injected directly into the throat of the blast nozzle. The direction of water injection is parallel to the flow of the air/abrasive stream. The air/abrasive stream and the water stream have the same axis or center line (see Figure 2).

4.2.4 Slurry Blasters: The term "slurry blasting" is commonly used for the systems described in Sections 4.2.4 and 4.2.5. In these devices, the water is injected into the air/abrasive stream at some point substantially upstream from the blast nozzle. This allows the air/abrasive/water mixture to tumble for some distance in the blast hose to mix with and wet the abrasive. Typically, the water is injected at the blast pot abrasive metering valve or at a blast hose connection. Sometimes the water is injected at the connection point of the whip hose to the main blast hose (see Figure 3, Configuration 1).

In Figure 3, Configuration 2, the abrasive is loaded into a pressure vessel and simultaneously mixed with water. The vessel, loaded with the abrasive/water combination, is then pressurized using an integrated pump and the mixture is injected into the air stream. The unencumbered air flow reduces overall water consumption rates and provides good dust suppression. Wet abrasive can be reused in the configuration 2 system as long as the abrasive has not been crushed during the cleaning process and the material being removed in the blasting process is non-hazardous.

4.2.5 Water Blast with Abrasive Injection: These devices differ from the units described in Sections 4.2.2 through 4.2.4 in that the propelling force is the water stream, not compressed air. This method is commonly referred to as "abrasive wet jet" or "AWJ", or "slurry blasting." The typical devices consist of a fluid pump with a venturi nozzle of some type in which the water flow draws the abrasive into the water stream or the abrasive media is injected into the water stream under pressure. Because the fluid stream is well defined, these devices usually cut a narrow blast pattern (see Figure 4).

4.3 WATER DELIVERY SYSTEM

4.3.1 Purity of Water: The purity of the water used for wet abrasive blasting (or any wet cleaning method) can affect the quality of the cleaned substrate. To achieve a clean substrate, demineralized, potable, or other water that will not impose additional contaminants on the surface being cleaned is acceptable. There is no current definitive number for acceptable levels of water purity. The quality contamination of the substrate may be tested and confirmed. Recycled water may contain a buildup of contaminants.

4.3.2 Water Flow Rates Requirements: The system has sufficient water inlets with filters at the suction side of the pump to provide an adequate supply of water to the pump . The pump is capable of providing the water pressure at the required flow rates of the type of wet blast injector being used. Typical water flow rates and water pressures are:

a. Radial Water Injectors: 0.5 to 31 L/min (0.2 to 8 gpm) at 0.2 to 21 MPa (25 to 3,000 psi)
b. Coaxial Water Injectors: 2 to 4 L/min (0.5 to 1 gpm) at 0.7 to 21 MPa (100 to 3,000 psi)
c. Slurry Blasters (Figure 3, Configuration 1): 2 to 4 L/min (0.5 to 3 gpm) at 0.7 MPa (150 psi); Figure 3, Configuration 2, 0.02 to 1.6 L/min (0.0005 to 0.4 gpm) at 0.2 MPa (25 psi)
d. Water Blast with Abrasive Injection: 10 to 38 L/min (2.5 to 10 gpm) at 34 to 280 MPa (5,000 to 40,000 psi)

4.3.3 Inhibitors: Where inhibitors are used, typical inhibitor/ water ratios range from 1:1 to 1:1000. The inhibitor injector can be positively interlocked to the water pump to provide a uniform metered supply and constant concentration of inhibitor in the blasting water or mixed in a reservoir water supply. Other techniques, such as addition of inhibitor to a reservoir, can be equally efficient. The inhibitor or wet blast equipment supplier or manufacturer sometimes sets forth special recommenda- tions (see Section 6).

5. Selection of Abrasives

5.1. GENERAL: Virtually any type of abrasive commonly used with conventional dry blasting can be utilized with the radial and coaxial injection type wet blasting devices (Sections 4.2.2 and 4.2.3), because they are supplemental to conventional blast equipment and the abrasive is not wetted in the blast hoses (see SSPC-AB 1, "Mineral and Slag Abrasives").

5.2. The following are some considerations when selecting an abrasive:

5.5.1 Salt Content: The salt content of abrasives can contaminate a blast cleaned surface.

5.5.2 Hardness and Sharpness: The harder and sharper the abrasive particles, the higher the productivity of the opera-tors.

5.5.3 Particle Size: Utilizing a larger particle size decreases the tendency to create mud in corners and tight spots.

5.5.4 Mud Caking in Slurry Blasters: Development of "mud caking" in the blast hose in Figure 3 Configuration 1 (Section 4.2.4) causes frequent clogging of slurry blasters with many types of abrasives. Therefore, only abrasives which contain low levels of water soluble materials and which are not easily crushed are used with this type of slurry blasting equipment.

6. Inhibitors

6.1 PREVENTING FLASH RUSTING: Surfaces cleaned by water tend to flash rust. The rate of flash rusting depends upon how long the surface stays wet, ambient conditions such as temperature and relative humidity, purity of the water, contaminants remaining on the surface, and contaminants in the abrasive. Inhibitors retard the rate of flash rusting. CAUTION: Inhibitors may mask contaminants on the surface or introduce residues that interfere with coating performance.

6.2 REGULATIONS: Inhibitors complying with relevant federal, state, and local regulations are used.

6.3 COMPATIBILITY WITH COATING: Consult the coating supplier to make sure the inhibitors used do not inter- fere with the cure or the coating performance. Consult ASTM D 5367, "Standard Practice for Evaluating Coatings Applied over Surfaces Treated with Inhibitors Used to Prevent Flash Rusting of Steel When Water or Water/Abrasive Blasted" for information on compatibility of inhibitors with coatings.

6.4 USAGE: Inhibitors can be used in either the blast water or rinse water. The inhibitor manufacturer is consulted for specific usage recommendations.

7. Operation of Equipment

7.1 GENERAL: The equipment start-up sequence, opera- tion, and preventative maintenance are followed in accordance with the manufacturer's instructions and the procedures listed in Section 7.2. The safety guidelines listed in Section 8 of this document and the safety requirements of 29 CFR 1910.94 and 1910.1000 are also observed.

7.2 EQUIPMENT START-UP SEQUENCE, OPERATION, AND MAINTENANCE:

7.2.1 All equipment (including gauges and controls) is checked to verify that it is clean and is operating properly before work is started. The system is tested to the maximum working pressure to ensure integrity of the connections.

7.2.2 The air, water, and abrasive blast hoses are checked to ensure that they are not frayed, kinked, or worn. This is essential for operator safety, because a blow-out could be very hazardous.

7.2.3 The water supply is filtered or otherwise treated to remove contaminants that could damage pumps and valves or leave corrosive deposits on the surface being cleaned.

7.2.4 As in conventional dry abrasive blasting, the hose size is as large as practical for the operator to handle, and as short as feasible to reduce the pressure drop from the pressure source to the nozzle.

7.2.5 Clean and dry abrasive is used.

7.2.6 Water pressure and flow rate are set to maximize production while suppressing the excessive generation of fine particulates. Increasing the water flow rate above the optimum often has a negative effect on productivity by cushioning the impact of the abrasive particles, rather than increasing cleaning rates significantly (see Section 4.3.2 for water flow rates).

7.2.7 The nozzle distance to the work piece and the angle of incidence are adjusted to optimize cleaning rates. Heavier rust and tightly adherent materials are often more effectively removed by holding the nozzle closer to the work piece. An 80°-90° angle of attack has also been found to enhance the removal of this type of material.

7.2.8 Some specialized procedures for using the wet blast equipment consist of utilizing a relatively short sandblast whipline (with a diameter slightly larger than normal) and a blast nozzle that is one size larger than is used with conventional dry blasting. The water injector is kept as close to the blast nozzle as possible to minimize mud caking in the blast hose.

8. Safety Guidelines

8.1 The fine particulates and mist from the impact of the abrasive upon the substrate contain dust particles similar to those found in dry abrasive blasting. The concentration of particulates is, however, lower in wet blasting. Nonetheless, take precautions to avoid inhalation of particulates from blasting that may remain in the air for a considerable amount of time.

8.2 The wet blast procedures follow all the safety guidelines for conventional dry abrasive blast equipment. (See 29 CRF 1910.93 and 29 CFR 1910.1000.)

8.3 Only trained operators should be permitted to utilize the equipment. They are equipped with suitable protection such as blast gloves, air-fed blast hoods, rain suits, foot protection, and hearing protection.

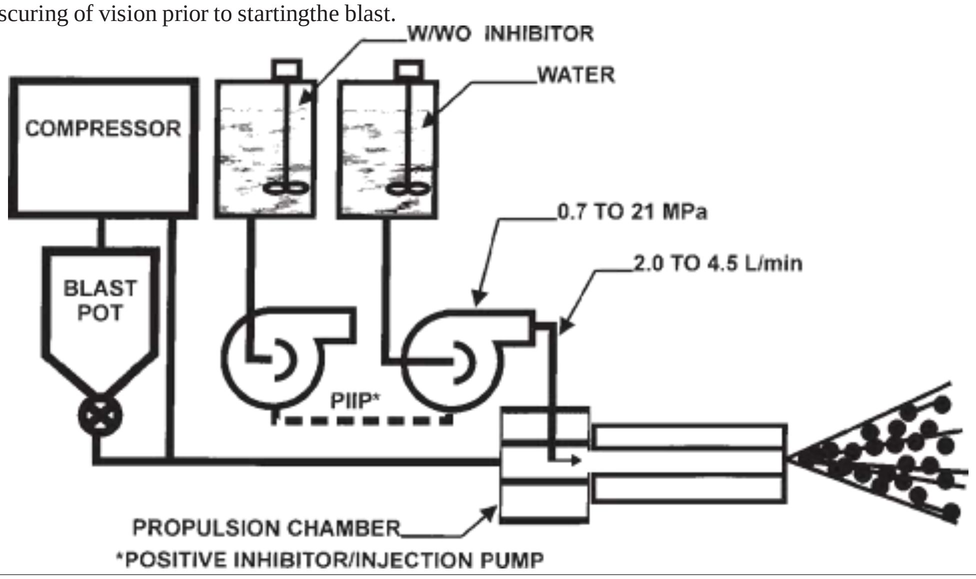
8.4 The nozzle should be pointed at the work surface only—never at personnel or other objects.

8.5 Water conducts electricity. Exercise caution around electrical equipment, wiring, or conduit. A safety professional should be consulted before beginning blast procedures.

8.6 All operation controls should be checked prior to work initiation.

8.7 Operators should wear required personal safety gear. They should establish a stable footing base and anticipate blastnozzle thrust and possible obscuring of vision prior to startingthe blast.

FIGURE 2



1. FIGURE 1

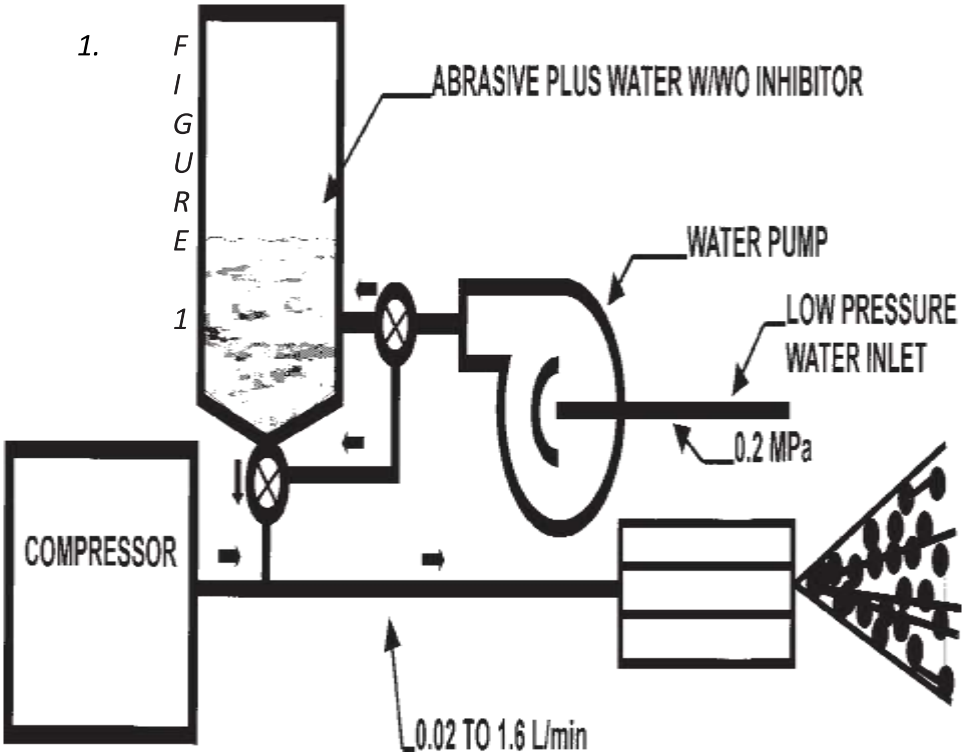
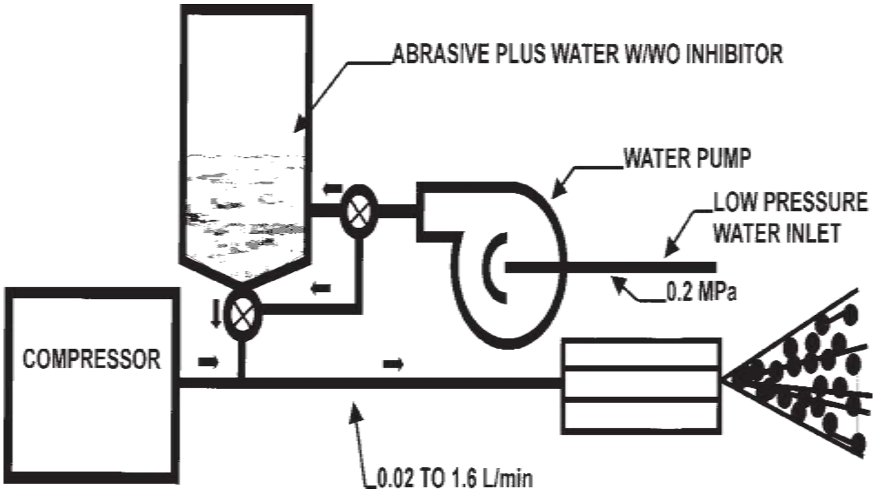


FIGURE 3, Configuration 1



2. **FIGURE 3, Configuration 2**

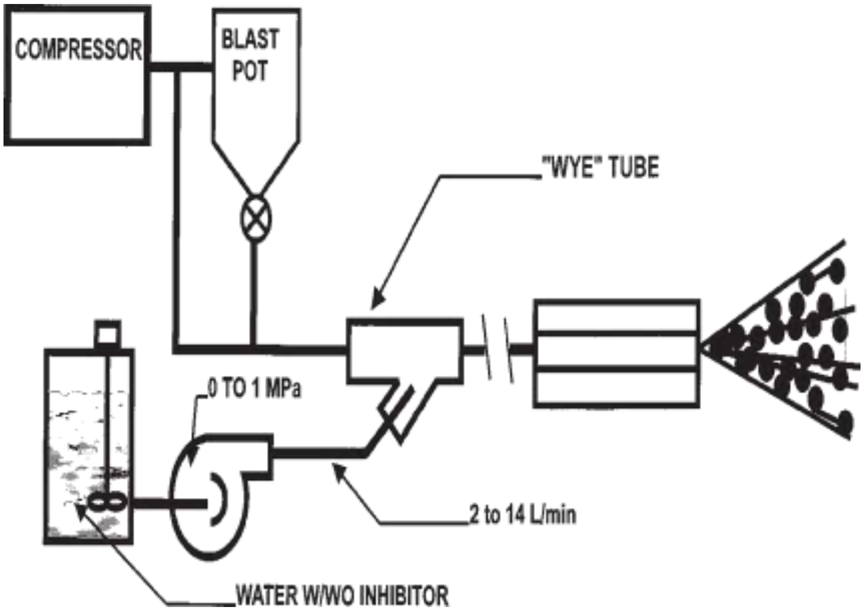
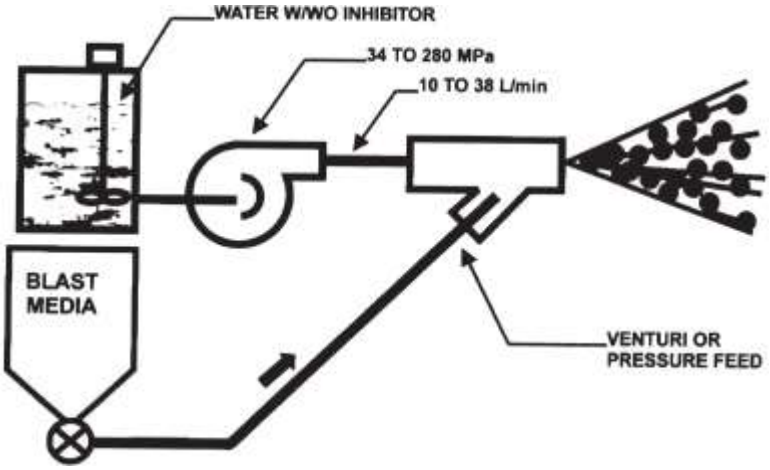


FIGURE 3, Configuration 3



8.8 Water runoff and blast debris should be handled in compliance with applicable safety and environmental regula-tions.

9. Bibliography

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ANEXO Nº 7

SSPC: The Society for Protective Coatings/NACE International

Joint Surface Preparation Standard

Waterjet Cleaning of Metals

SSPC-SP WJ-1/NACE WJ-1 – Clean To Bare Substrate

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Foreword

This SSPC/NACE joint standard defines the Clean to Bare Substrate (WJ-1) degree of surface cleanliness of coated or uncoated metallic substrates achieved by the use of waterjet cleaning prior to the application of a protective coating or lining. Waterjet cleaning is the use of pressurized surface preparation water for removing coatings and other materials, including hazardous materials, from a substrate to achieve a defined degree of surface cleanliness. Waterjet cleaning includes various methods such as low-pressure water cleaning (LP WC), high-pressure water cleaning (HP WC), high-pressure waterjetting (HP WJ), and ultrahigh-pressure waterjetting (UHP WJ).

The four degrees of surface cleanliness achieved by waterjet cleaning, which are addressed in separate standards, are as follows:

Degree of Surface Cleanliness	Designation
Clean to Bare Substrate	WJ-1
Very Thorough Cleaning	WJ-2
Thorough Cleaning	WJ-3
Light Cleaning	WJ-4

Clean to Bare Substrate (WJ-1) provides a greater degree of surface cleanliness than Very Thorough Cleaning (WJ-2).

Waterjet cleaning to achieve the Clean to Bare Substrate (WJ-1) degree of surface cleanliness is used when the objective is to remove every trace of rust and other corrosion products, coating, and mill scale. Discoloration of the surface may be present.

Waterjet cleaning does not provide the primary anchor pattern on the metallic substrate known as “surface profile.” The coatings industry uses waterjet cleaning primarily for recoating or relining projects in which there is an adequate pre-existing surface profile. The degrees of surface cleanliness cited above to be achieved by waterjet cleaning methods are not intended to require that a surface profile be present or defined prior to coating application.

Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates. Waterjet cleaning also helps remove oil, grease, rust and other corrosion products, and other foreign matter (for example, shotcrete spatter) from the surface, and is used when it is a more feasible method of surface preparation than, for example, abrasive blast cleaning, power or hand tool cleaning, or chemical stripping. Waterjet cleaning may be used when the application of high-performance coatings requires extensive surface preparation, surface decontamination, or both.

This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who have responsibility to define a standard degree of surface cleanliness to be achieved by waterjet cleaning methods.

This standard was prepared by SSPC/NACE Joint Task Group (TG) 275, "Surface Preparation of Metals to WJ-1 (Clean to Bare Substrate) by High-Pressure Waterjetting." TG 275 is administered by Specific Technology Group (STG) 04, "Coatings and Linings, Protective—Surface Preparation," and is sponsored by STG 02, "Coatings and Linings, Protective—Atmospheric," and STG 03, "Coatings and Linings, Protective–Immersion and Buried Service." This standard is issued by SSPC Group Committee C.2 on Surface Preparation, and by NACE under the auspices of STG 04. This standard is one of a set of four standards on degrees of surface cleanliness to be achieved by waterjet cleaning that are intended to replace SSPC-SP 12/NACE No. 5,[1] which includes all four degrees of surface cleanliness.

> In SSPC/NACE standards, the terms *shall, must, should,* and *may* are used in accordance with Paragraph 2.2.1.8 of the Agreement between SSPC: The Society for Protective Coatings and NACE International. The terms *shall* and *must* are used to state mandatory requirements. The term *should* is used to state something considered good and is recommended, but is not mandatory. The term *may* is used to state something considered optional.

1. Section 1: General

1.1 This standard defines the Clean to Bare Substrate (WJ-1) degree of surface cleanliness of uncoated or coated metallic substrates by use of waterjet cleaning. The defined degree of cleanliness shall be achieved prior to the application of a specified protective coating or lining system. These requirements include the end condition of the surface and materials and procedures necessary to achieve and verify the end condition, as determined by visual inspection. This standard also 2 may be used in situations in which the degree of cleanliness is required, but protective coatings or linings are not immediately applied. (Paragraphs A1 and A2 of Appendix A provide additional information.) Waterjet cleaning does not establish but may reveal an existing surface profile on a metallic substrate. If the existing surface profile is not acceptable for subsequent coating application, alternative surface preparation methods to create the required surface profile must be considered. (Paragraph A3 of Appendix A provides additional information.)

1.1.1 Clean to Bare Substrate (WJ-1) is the waterjet cleaning equivalent to the International Organization for Standardization (ISO)(1) 8501-1[2] degree of cleanliness Sa 3, cleaning to bare metal. ISO 8501-4[3] notes the use of various common terms for methods of waterjet cleaning: water jetting, water blast cleaning, hydrojetting, aquajetting, hydroblasting, aquablasting, and "cleaning by directing a jet of pressurized water onto the surface to be cleaned."

1.1.2 Within the hierarchy of degrees of surface cleanliness achieved by waterjet cleaning, Clean to Bare Substrate (WJ-1) is intended to be similar to the degree of surface cleanliness of SSPC-SP 5/NACE No. 1,[4] except that stains are permitted to remain on the surface.

1.2 Although carbon steel is the metallic substrate most frequently cleaned in the field using waterjetting technology, waterjet cleaning may be used on metallic substrates other than carbon steel, including other ferrous substrates such as alloy steels, stainless steels, ductile iron and cast irons, nonferrous substrates such as aluminum, and copper alloys such as bronze. For convenience, the written definitions of the degrees of surface cleanliness of the metallic substrate use the general term "rust and other corrosion products." The term "rust" is intended to apply to carbon steel substrates and the term "other corrosion products" (such as surface oxides) is intended to apply to metallic substrates other than carbon steel that are being waterjet cleaned. "Flash rust" is an oxidation product that forms as a wetted carbon steel substrate dries. The visual guides and comparators referenced for cleanliness and flash rust only illustrate carbon steel substrates.

1.3 This standard does not address surface preparation of concrete. Information on surface preparation of concrete can be found in SSPC-SP 13/ NACE No. 6.[5]

1.4 This standard is limited to requirements for visible surface contaminants. Information on nonvisible contamination can be found in Paragraph A8 of Appendix A.

2. Section 2: Definitions

2.1 Clean to Bare Substrate (WJ-1): A metal surface after Clean to Bare Substrate, when viewed without magnification, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust and other corrosion products, previous coatings, mill scale, and foreign matter.

2.1.1 Thin films of mill scale, rust and other corrosion products, and coating are not allowed. (Paragraphs A4 and A5 provide additional information).

2.1.2 The gray to brown-black discoloration remaining on corroded and pitted carbon steel that cannot be removed by further waterjet cleaning is allowed.

2.1.3 SSPC-VIS 4/NACE VIS 7[6] or other visual guide or comparator may be specified to supplement the written definition. In any dispute, the written standard shall take precedence over the visual guide or comparator. (Paragraph A6 of Appendix A provides additional information.)

3. Section 3: Additional Technical Considerations

3.1 Flash Rust

Flash rust is an additional consideration when a carbon steel substrate is subjected to waterjet cleaning. Gray or brown-black discoloration remaining in the pits of waterjet cleaned carbon steel is not the same as flash rust. Metals other than carbon steel can manifest discoloration as well. Degrees of flash rust may be qualitatively described as follows:

3.1.1 No flash rust: A carbon steel surface that, when viewed without magnification, exhibits no visible flash rust.

3.1.2 Light (L) flash rusted surface: A carbon Steel include variations caused by composition of the metallic substrate, original surface condition, thickness of the metal, weld metal, mill or fabrication marks, heat treating, heat-affected zones, and differences resulting from the initial abrasive blast cleaning abrasives or the abrasive blast pattern if previously blast cleaned, or waterjet cleaning pattern.

3.2. Carbon steel surfaces cleaned by waterjet cleaning initially exhibit a matte finish with a color that can range from light gray to dark brown-black but immediately acquires a golden hue unless a corrosion inhibitor or environmental controls are used. The matte finish on older carbon steel surfaces that have areas from which coating was removed and areas that were coating-free at the time of cleaning varies even when all visible surface material has been removed.

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(1) International Organization for Standardization (ISO), 1 ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

3.2.1 Metallic substrates show variations in texture, shade, color, tone, pitting, flaking, and mill scale that should be considered during the waterjet cleaning process. (Paragraph A6 of Appendix A provides additional information.)

Document	Title
SSPC-SP 5/NACE No. 1	"White Metal Blast Cleaning"
SSPC-SP 13/NACE No. 6	"Surface Preparationof Concrete"
SSPC-VIS 4/NACE VIS 7	"Guide and Visual Reference Photographs for Steel Cleanedby Waterjetting"
SSPC-SP 1[7]	"Solvent Cleaning"

3.2.1 Moderate (M) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of rust that obscures the original carbon steel surface. The rust layer may be evenly distributed or present in patches,but it is reasonably well adherent and leaves light marks on a cloth that is lightly wiped over the surface.

3.2.2 Heavy (H) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of heavy rust that hides original carbon steel surface completely. The rust may be evenly distributed or presentin patches, but it is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface.

3.3 Appearance Variations

3.3.1 Acceptable variations in appearance that do not affect the degree of surface cleanliness defined in Paragraph

3.3.2 Section 4: Associated Documents

3.3.3 Direct correlation to existing dry abrasive blasting standards and visual comparators is inaccurate or inappropriate

3.4 Documents associated with this standard and cited inits mandatory sections include:

4. *Section 5: Procedures Before Waterjet Cleaning*

4.1 Precleaning: Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, and A10 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

4.2 Prior to beginning waterjet cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag shall be addressed to the extent required by the procurement documents (project specifications). (Paragraph A12 of Appendix A provides additional information.)

4.3 CAUTION: Waterjet cleaning can be destructive to nonmetallic surfaces. Wood, rubber, insulation, electric instal- lations, instrumentation, etc., must be protected from direct and indirect impingement of water streams.

4.4 If a visual guide or comparator is specified to supplement the written standard, the condition of the substrate prior to waterjet cleaning should be determined before the waterjet cleaning commences. (Paragraph A6 of Appendix A provides additional information.)

4.5 If there is a conflict between the requirements of any of the documents listed in Paragraph 4.1 and this standard, therequirements of this standard shall govern.

5. *Section 6: Waterjet Cleaning Methods*

5.1 Any of the following waterjet cleaning methods may be used to achieve the Clean to Bare Substrate (WJ-1) degree of surface cleanliness. These waterjet cleaning methods all require the use of surface preparation water (hereinafter referred to as "SP water") in accordance with Paragraph 6.2. The presence of toxic metals in a coating being removed can place restrictions on the methods of cleaning permitted. The chosen method shall comply with applicable regulations. (Para- graph A13 of Appendix A and Paragraph C2.3 of Appendix C provide additional information.)

5.1.1 Water cleaning (WC): Use of pressurized SP water discharged from a nozzle to remove unwanted matter from a surface.

5.1.1.1 Low-pressure water cleaning (LP WC): Water cleaning performed at pressures less than 34 MPa (5,000 psig). This is also called "power washing" or "pressure washing."

5.1.1.2 High-pressure water cleaning (HP WC): Water cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig).

5.1.2 Waterjetting (WJ): Use of SP water discharged from a nozzle at pressures of 70 MPa (10,000 psig) or greater to prepare a surface for coating or inspection. The velocity of the SP water exiting the orifice is greater than 340 m/s (1,100 ft/s).

5.1.2.1 High-pressure waterjetting (HP WJ): Waterjet- ting performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig).

5.1.2.2 Ultrahigh-pressure waterjetting (UHP WJ): Waterjetting performed at pressures greater than 210 MPa (30,000 psig).

5.2 Surface preparation water (SP water): Water of sufficient purity and quality that it does not prevent the surface being cleaned from achieving the WJ-1 degree of surface cleanliness or nonvisible contamination criteria when contained in the procurement documents. SP water should not contain sediments or other impurities that are destructive to the proper functioning of the cleaning equipment. (Paragraph A7 of Appendix A provides additional information.)

5 Section 7: Procedures Following Waterjet Cleaningand Immediately Prior to Coating

7.1 Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, A10, and A11 of Appendix A and Para- graph C2.6 of Appendix C provide additional information.)

7.2 The existing surface profile shall be assessed to determine conformance with the requirements of the procure- ment documents. (Paragraphs A3 and A14 of Appendix A provide additional information.)

7.3 Immediately prior to coating application, the entire surface shall comply with the degree of surface cleanliness specified herein, and to the extent established, the procure- ment document (project specification) requirements, and degree of flash rust.

7.4 Flash rust shall be mitigated in accordance with the requirements of the procurement documents. An example of a specification statement is provided in Paragraph A10 of Appendix A. It is common practice to remove heavy flash rust by LP WC, HP WC, or dry abrasive sweep blasting.

7.5 Dust and loose residues shall be removed from cleaned surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other specified methods. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air. (Paragraph A13 of Appendix A provides additional information.)

References

1. SSPC-SP 12/NACE No. 5 (latest revision), "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating" (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

2. ISO 8501-1 (latest revision), "Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings" (Geneva, Switzerland: ISO).

3. ISO 8501-4 (latest revision), "Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 4: "Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting" (Geneva, Switzerland: ISO).

4. SSPC-SP 5/NACE No. 1 (latest revision), "White Metal Blast Cleaning" (Pittsburgh, PA: SSPC, and Houston, TX:NACE).

5. SSPC-PA Guide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems" (Pittsburgh, PA: SSPC).

6. SSPC-Guide 15 (latest revision), "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates" (Pittsburgh, PA: SSPC).

7. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).

8. NACE SP0178 (formerly RP0178) (latest revision), "Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service" (Houston, TX: NACE).

9. SSPC-PA 2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).

10. "Recommended Guidelines for Evaluating Flash Rust" (Charleston, SC: National Shipbuilding Research Program [NSRP],(2) 2009). (Available from SSPC and NACE.)

11. ISO 8502-3 (latest revision), "Preparation of steel substrates before application of paints and related products—Tests for the assessment of surface cleanliness—Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)" (Geneva, Switzerland: ISO).

12. ASTM(3) D 3359 (latest revision), "Standard Test Methods for Measuring Adhesion by Tape Test" (West Conshohocken, PA: ASTM).

13. "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment" (latest revision) (St. Louis, MO: WaterJet Technology Association [WJTA]).(4)

14. D.A. Summers, WaterJetting Technology (London, UK: Chapman and Hall, 1995).

1. Appendix A: Explanatory Notes(Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

A1 Function: Clean to Bare Substrate (WJ-1) provides a greater degree of surface cleanliness than Very Thorough Cleaning (WJ-2). The hierarchy of waterjet cleaning standards is as follows: WJ-1, WJ-2, WJ-3, and WJ-4. Clean to Bare Substrate (WJ-1) should be used when the highest degree of cleaning is required. The primary functions of waterjet cleaning before coating are:

(a) To remove material from the surface that can cause early failure of the coating system;
(b) To enhance the adhesion of the new coating system;
(c) To expose the surface profile of the substrate that is underneath the existing coating or rust and other corrosion products. (Paragraph A3 provides additional information.); and
(d) To reduce or remove nonvisible contamination.

Clean to Bare Substrate (WJ-1) is used when the objective is to remove every trace of the coating, mill scale, and rust and other corrosion products, and when the extra effort required to remove all of these materials is determined to be warranted. Discoloration of the metal substrate surface may be present. Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates.

A2 Maintenance Coating Work: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be waterjet cleaned or spot-waterjet cleaned to this degree of surface cleanliness. In these cases, the surface cleanliness should be achieved across the entire area specified. For example, if all weld seams are to be cleaned in a maintenance operation, the degree of surface cleanliness applies to 100 percent of all weld seams. If the entire structure is to be cleaned, this degree of surface cleanliness applies to 100 percent of the entire structure. SSPC-PA Guide 4[8] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 Surface Profile: Waterjet cleaning reveals the surface profile (roughness) of the substrate that exists under the original coatings or rust and other corrosion products. When a coating is specified, another surface preparation method may be needed in addition to the waterjet cleaning to achieve the surface profile suitable for the specified coating system.

A4 Rust Scale: If rust scale is present, it must be removed. Rust scale is not a suitable substrate over which to apply coatings, and, if not removed, may also prevent removal of water-soluble salts that may accelerate corrosion. Methods other than waterjet cleaning may be used.

A5 Mill Scale: Mill scale is not allowed in this degree of surface cleanliness. Mill scale is that dark blue-black layer of iron oxide on the surface of hot-rolled steel. Over time, the adherence of the mill scale can change. Older mill scale might be removed easily in the field with waterjetting at 100 MPa (15,000 psi) and above. Waterjetting at pressures greater than 240 MPa (35,000 psig) is capable of removing tightly adherent mill scale, but production rates are not always cost effective. When the mill scale comes off, the steel surface under the millscale has whatever surface profile is under the mill scale.

A6 Reference Photographs: Photographs may be specified to supplement the written definition. SSPC VIS 4/NACE VIS 7 depicts various precleaning conditions and the appearance of a carbon steel surface that is consistent with the Cleanto Bare Substrate (WJ-1) degree of surface cleanliness defined in this standard. In any dispute, the written standard shall takeprecedence over the visual guide. The visual appearance of carbon steel that has heavily flash rusted after initial waterjet cleaning and is then recleaned by LP WC has a different appearance from the original light flash-rusted steel depicted in SSPC VIS 4/NACE VIS 7.

A7 Quality of Water: SP water used by waterjet cleaning equipment should be clean and free of erosive silts or other contaminants that damage pump valves and/or prevent the surface from achieving the specified degree of surface cleanliness. A general rule is that the cleaner the water, the longer the service life of the waterjet cleaning equipment. The use of deionized water may be detrimental to some water pumps and care should be taken to ensure compatibility.

1. *A8 Nonvisible Contamination (NV)*

A8.1 Nonvisible contamination (NV): Nonvisible contamination is the presence of organic matter, such as thin films of oil and grease, and inorganic and/or soluble ionic materials such as chlorides, ferrous salts, nitrates, and sulfatesthat may be present on the substrate. (Paragraphs A6, A7, andA8 provide additional information.)

A8.2 Steel contaminated with water-soluble salts (e.g., sodium chloride and potassium sulfate) rapidly develops rust- back. Rust back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after cleaning. These contaminants, along with their concentrations, may be identified using laboratory and field tests as described in SSPC Guide 15.[9] Conductivity measurement is another method for testing for water-soluble salts.

A8.3 Other nonvisible contaminants (e.g., oil, acid, base, silicone, wax) may have an effect on coating performance. Coatings manufacturers should be consulted for recommendations of maximum surface contamination allowed. The specifier should determine what level of nonvisible contaminants may remain.

A8.4 The test method or procedure to be used for determining the level of remaining nonvisible contaminants should be addressed in the procurement documents (project specification).

A8.5 The level of nonvisible contaminants found in an extraction from the surface that may remain on the surface is usually expressed as mass per unit area; for example, µg/cm^2 or mg/m^2 (1 µg/cm^2 = 10 mg/m^2).

A8.6 The following is an example specification for salt contamination based on concentration measurements:

"Immediately prior to the application of the coating, the surface extract shall not contain more than xx µg/cm^2 of the specific contaminant (e.g., chloride) when tested with a specified method."

A8.7 The following is an example specification for salt contamination based on conductivity measurements:

"Immediately prior to the application of the coating, the conductivity of the surface extract shall not exceed xx µS/cm when tested with a specified method."

A9 Use of Corrosion Inhibitors: It may be advantageous to add corrosion inhibitors to the SP water or apply them to the surface immediately after waterjet cleaning to temporarily prevent rust formation. Some corrosion inhibitor treatments may interfere with the performance of certain coatings systems. The coatings manufacturer should be consulted to ensure the compatibility of corrosion inhibitors with the coatings.

2. A10 Specification Statement:

A10.1 The specifier should use the degree of surface cleanliness and one of the degrees of flash rust to specify the required end condition. The following are examples of a specification statement:

"All surfaces to be recoated shall be waterjet cleaned to SSPC-SP WJ-1 L/NACE WJ-1/L, Clean to Bare Substrate, Light Flash Rust."

"At the time of the recoating, the degree of flash rust shallbe no greater than moderate (M)."

A10.2 In addition, the specifier should consider whether a surface should be cleaned as required to achieve a particular, not to exceed maximum, level of nonvisible contamination (NV) prior to recoating. A suggested specification statement for nonvisible contamination (NV) is given in Paragraph A8.

A11 Flash Rust: An oxidation product that forms as a wetted carbon steel substrate dries. With the exception of stainless steel surfaces, any steel surface may show flash rust within 30 minutes or longer while the substrate is drying (water evaporation) after waterjet cleaning, depending on environmental conditions. Flash rust has the appearance of rust bloom. Flash rust quickly changes the appearance of the waterjet cleaned surface and may be reduced or eliminated by physical or chemical methods. The color of the flash rust may vary depending on the age and composition of the steel and

3. A12 Surface Imperfections:

A12.1 Surface imperfections that can cause premature failure are often present. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to properly cover and protect include crevices, weld porosities, and laminations.

A12.2 Poorly adhering fabrication defects, such as weld slag residues, loose weld spatter, and surface laminations may be removed during the waterjet cleaning operation. Other surface defects, such as steel laminations, weld porosities, or deep corrosion pits may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work should be given prior consideration because the timing of the repairs may occur before, during,or after the waterjet cleaning operation. The SSPC-SP COM[10]and NACE SP0178[11] contain additional information on surfaceimperfections.

A12.3 The high cost of the methods to remedy surface imperfections (e.g., edge rounding and weld spatter removal) should be compared with the benefits of preventing premature coating failure.

Therefore, those responsible for establishing the requirements and those responsible for performing the work should agree on the procedures to be used to repair surface imperfections to the extent required in the procurement documents (project specification).

A13 Removal of Coatings with Hazardous Components—Hygiene: Waterjet cleaning is often used to remove coatings with hazardous components. Because the particles are wetted, respiratory protection requirements for waterjet cleaning may be less stringent than for other methods of surface preparation. However, the wetted particles tend to stay on the skin. Applicable industrial hygiene tests should be performed to determine the destination of the wetted particles. Good industrial hygiene should be followed.

A14 Film Thickness: It is essential that ample coating be applied after waterjet cleaning to adequately cover the peaks of the surface profile. The dry film thickness of the coating above the peaks of the surface profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[12] for verification of accuracy of Type 1 and Type 2 gauges should be used.

2. Appendix B

Methods of Assessing the Degree of Flash Rust (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

The degree of flash rust is related to the quantity of loose, clean rust dust that is present on the surface. One of the following alternative methods may be used to assess the degree of flash rust, or other methods may be used if specified.

1. B1 Wipe Test

The following procedure is suggested to standardize the amount of pressure used to perform a wipe test on a flash-rusted surface:

(a) Neatly wrap a white, lint-free, woven cloth around a standard 100 mm (4 in) nylon paint brush, and hold it in place in a manner that prevents the cloth from slipping.
(b) Swipe the cloth-wrapped paint brush across the flash-rusted surface in one motion, using pressure equivalent to that used to apply house paint to a door. The length of the swipe should be consistent (e.g., one pass covering 1,500 mm [6 in] in length).
(c) Remove the white cloth from the paint brush and evaluate the color and amount of rust on the cloth. "Recommended Guidelines for Evaluating Flash Rust,"[13] issued by the NSRP, provides guidance to perform this evaluation of flash rust.

2.

2. B2 Tape Pull Test

The tape pull test is a modification of the pressure-sensitive tape method in ISO 8502-3.[14] The procedure is as follows:

(a) Select a test area on the flash-rusted surface to perform the test.
(b) Place a 50 mm (2 in) long piece of tape (as specified in ASTM D 3359[15]) on the selected test area and rub it thoroughly with a fingertip (not a fingernail) to ensure that the tape adheres firmly. Then peel the tape off the surface and place it on a piece of white paper for reference.
(c) Repeat the procedure in (b) nine times (for a total of 10 times) using a fresh piece of tape applied to the same spot on the surface (selected test area) each time.
(d) Assess the appearance of the 10th tape and the appearance of the test area on the flash-rusted surface after the 10th tape is pulled off in accordance with Table B1.

3. Appendix C:

Waterjet Cleaning Equipment and Operating Parameters (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

1. C1 Waterjet Cleaning Equipment

Multiple configurations of pumps, heads, and containment systems are suitable for waterjet cleaning operations. The equipment systems may include manual lances, fixed lances on platforms, or robot-driven systems. Additional descriptions relevant to waterjet cleaning systems are in the WaterJet Technology Association's "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment,"[16] which also addresses concerns relevant to waterjet cleaning operations. The commercial waterjet cleaning unit can be mounted on a skid, trailer, or truck; can be equipped with various prime movers (diesel, electric motor, etc.); and usually consists of a pump, hoses, and various tools. The tools can be hand-held or mounted on a robot or controlled by a traversing mechanism. Water is propelled through a single jet, fan jet, pulse generator, or multiple rotating jets. Rotation of the nozzle head is provided by small electric, air, or hydraulic motors, or by slightly inclined orifices in a multiple-orifice nozzle.

C1.1 All waterjet cleaning units normally use a hydraulic hose with a minimum bursting strength of 2.5 times the capability of its maximum-rated operating strength.

C1.2 Waterjet streams are produced by orifices, or tips, that can have different forms–the higher the pressure, the more limited is the choice of forms. Round jets are most commonly used, but orifices of other shapes are available. Tips can be designed to produce multiple jets of water that are normally rotated to achieve higher material-removal rates. Interchangeable nozzle tips should be used to produce the desired streams. The manufacturer should be consulted for specific recommendations.

C1.3 Effect of Corrosion Inhibitors and Detergents on Equipment: If corrosion inhibitors are to be used with the SP water, the manufacturer of the waterjet cleaning equipment should be consulted to ensure compatibility of corrosion inhibitors with the equipment. Compatibility of detergents with the special seals and high-alloy metals of the waterjet cleaning equipment should be carefully investigated to ensure that the cleaning equipment is not damaged.

2. C2 Operating Parameters

C2.1 Waterjet Cleaning Method Selection: The person performing the work should have sufficient experience to select the waterjet cleaning method and the specific combination of water pressure and flow (velocity and volume) to achieve the specified degree of surface cleanliness. A water flow rate of 4 to 53 L/min (1 to 14 gal/min) is typical.

(a) LP WC or HP WC (the flow rate of the water is thedominant energy characteristic);
(b HP WJ (pressure or water velocity and flow rate areequally important); or
(c) UHP WJ (pressure or water velocity is the dominantenergy characteristic).

C2.2 Stand-off Distance: The distance from the nozzle tothe work piece surface (stand-off distance) is critical for effective cleaning with any of the waterjet cleaning methods. Typical stand-off distances for HP WJ and UHP WJ range from 25 to 150 mm (1.0 to 6.0 in) for coatings removal. Typical stand-off distances range up to 600 mm (24 in) to remove foreign matter that is not tightly adherent. Excessive stand-off distance does not produce the desired cleaning.

C2.3 Threshold Pressure: The threshold pressure of a coating can be determined. In general, the tougher, more resilient, or harder the coating (i.e., the more resistant to probing or cutting by a pocket knife), the higher the threshold pressure; thesofter and more jelly-like the coating, the lower the threshold pressure. Threshold pressure is defined by Summers[17] as theminimum required pressure to penetrate the material. Once the threshold pressure is achieved or exceeded, the production rate increases dramatically. Therefore, waterjet cleaning production rates can be classified according to two conditions:

(a) Relatively Slow—Erosion at pressures lower than thethreshold pressure; and
(b) Relatively Fast—Waterjet cutting and erosion at pressures greater than the threshold pressure.

Pressure loss is a function of the flow rate of the water through the hose and the inside diameter of the hose. The manufacturer should be consulted for specific information on potential pressure loss for each type of equipment.

C2.4 Depending on the initial condition of the area and the materials to be removed, the choice of waterjet cleaning method to achieve Clean to Bare Substrate (WJ-1) is ultimately based on the capabilities of the equipment and its components. Dwell time, traverse rate, pressure, flow, stand-off distances, the number of nozzles, and rotation speed allinteract in determining materials that remain and those thatare removed.

C2.5 Reuse of Effluent Water: If effluent water is captured for reuse by the waterjet cleaning equipment, caution should be used to avoid introducing any removed contaminants back onto the cleaned substrate. The effluent watermay be placed in a clean holding tank and tested to determinethe contaminant content prior to reintroduction into the water supply stream to the waterjet cleaning equipment. The effluent water should be monitored for suspended particulates, hydrocarbons, salts, hazardous materials, or other by-products of the surface preparation procedures.

C2.6 Additives: Any detergents, degreasers, or other types of cleaners used in conjunction with the waterjet cleaning method should be removed prior to applying a coating. If corrosion inhibitors are to be used with the SP water, the coating manufacturer should be consulted to ensure compatibility of corrosion inhibitors with the coating.

C2.7 Containment Systems: Containment systems may consist of water-impermeable membranes or vacuum collection heads or the systems described in SSPC-Guide 6.[18] The containment design should consider the pressures used and water volumes produced and if the process may be open or closed loop (with a single pass or multiple passes of the waterthrough the system).

TABLE B1
ASSESSMENT OF DEGREE OF FLASH RUST—TAPE PULL TEST

	Degree of Flash Rust Appearance of 10th Tape **(after final pull from test area)**	*3. Appearance of Test Area(after 10th tape pull)*
Light	No rust on tape	No change, or only slight change in test area appearance
Moderate	Slight, localized red-brown rust on tape	Significant change of test area appearance, showing localized areas of black rust
Heavy	Significant, uniform red-brown rust on tape, also showing grains of black rust	Significant change of test area appearance, showing localized areas of black rust

SSPC: The Society for Protective Coatings/NACE International

Joint Surface Preparation Standard

Waterjet Cleaning of Metals

SSPC-SP WJ-2/NACE WJ-2 – Very Thorough Cleaning

This SSPC: The Society for Protective Coatings/NACE International joint surface preparation standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard practice. Nothing contained in this SSPC/NACE standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by letters patent, or as indemnifying or protecting anyone against liability for infringement of letters patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials not discussed herein. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. SSPC and NACE assume no responsibility for the interpretation or use of this standard by other parties, and accept responsibility for only those official SSPC or NACE interpretations issued by SSPC or NACE in accordance with their governing procedures and policies, which preclude the issuance of interpretations by individual volunteers.

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CAUTIONARY NOTICE: SSPC/NACE joint surface preparation standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with SSPC/ NACE technical committee procedures. SSPC and NACE require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of SSPC/NACE standards may receive current information on all standards and other SSPC/NACE joint publications by contacting the organizations at the addresses below:

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Foreword

This SSPC/NACE joint standard defines the Very Thorough Cleaning (WJ-2) degree of surface cleanliness of coated or uncoated metallic substrates achieved by the use of waterjet cleaning prior to the application of a protective coating or lining. Waterjet cleaning is the use of pressurized surface preparation water for removing coatings and other materials, including hazardous materials, from a substrate to achieve a defined degree of surface cleanliness. Waterjet cleaning includes various methods such as low-pressure water cleaning (LP WC), high-pressure water cleaning (HP WC), high-pressure waterjetting (HP WJ), and ultrahigh-pressure waterjetting (UHP WJ).

The four degrees of surface cleanliness achieved by waterjet cleaning, which are addressed in separate standards, are as follows:

Degree of Surface Cleanliness	Designation
Clean to Bare Substrate	WJ-1
Very Thorough Cleaning	WJ-2
Thorough Cleaning	WJ-3
Light Cleaning	WJ-4

Very Thorough Cleaning (WJ-2) provides a greater degree of surface cleanliness than Thorough Cleaning (WJ-3), but a lesser degree of surface cleanliness than Cleaning to Bare Substrate (WJ-1).

Waterjet cleaning to achieve the Very Thorough Cleaning (WJ-2) degree of surface cleanliness is used when the objective is to remove almost all rust and other corrosion products, coating, and mill scale, but when the extra effort required to remove all of these materials is determined to be unwarranted. Discoloration of the surface may be present.

Waterjet cleaning does not provide the primary anchor pattern on the metallic substrate known as “surface profile.” The coatings industry uses waterjet cleaning primarily for recoating or relining projects in which there is an adequate pre-existing surface profile. The degrees of surface cleanliness cited above to be achieved by waterjet cleaning methods are not intended to require that a surface profile be present or defined prior to coating application.

Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates. Waterjet cleaning also helps remove oil, grease, rust and other corrosion products, and other foreign matter (for example, shotcrete spatter) from the surface, and is used when it is a more feasible method of surface preparation than, for example, abrasive blast cleaning, power or hand tool cleaning, or chemical stripping. Waterjet cleaning may be used when the application of high-performance coatings requires extensive surface preparation, surface decontamination, or both.

This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who have responsibility to define a standard degree of surface cleanliness to be achieved by waterjet cleaning methods.

This standard was prepared by SSPC/NACE Joint Task Group (TG) 276, “Surface Preparation of Metals to WJ-2 (Very Thorough Cleaning) by High-Pressure Waterjetting.” TG276 is administered by Specific Technology Group (STG) 04, and is sponsored by STG 02, “Coatings and Linings, Protec- tive–Atmospheric,” and STG 03, “Coatings and Linings, Protective–Immersion and Buried Service.” This standard is issued by SSPC Group Committee C.2 on Surface Prepara- tion, and by NACE under the auspices of STG 04, “Coatings and Linings, Protective–Surface Preparation”. This standard is one of a set of four standards on degrees of surface clean- liness to be achieved by waterjet cleaning that are intended to replace SSPC-SP 12/NACE No. 5,[1] which includes all four degrees of surface cleanliness.

> In SSPC/NACE standards, the terms *shall, must, should*, and *may* are used in accordance with Paragraph 2.2.1.8 ofthe Agreement between SSPC: The Society for Protective Coatings and NACE International. The terms *shall* and *must* are used to state mandatory requirements. The term *should* is used to state something considered good and is recom- mended, but is not mandatory. The term *may* is used to state something considered optional.

6. *Section 1: General*

1.1 This standard defines the Very Thorough Cleaning (WJ-2) degree of surface cleanliness of uncoated or coated metallic substrates by use of waterjet cleaning. The defined of a specified protective coating or lining system. These require- ments include the end condition of the surface and materials and procedures necessary to achieve and verify the end condi- tion, as determined by visual inspection. This standard also may be used in situations in which the degree of cleanliness is required, but protective coatings or linings are not immediately applied. (Paragraphs A1 and A2 of Appendix A provide addi- tional information.) Waterjet cleaning does not establish but may reveal an existing surface profile on a metallic substrate. If the existing surface profile is not acceptable for subsequent coating application, alternative surface preparation methods to create the required surface profile must be considered. (Para- graph A3 of Appendix A provides additional information.)

1.1.1 Very Thorough Cleaning (WJ-2) is essentially equiv- alent to the International Organization for Standardization (ISO)(1) 8501-4[2] degree of cleanliness Wa 2.5, very thorough cleaning. ISO 8501-4 notes the use of various common terms for methods of waterjet cleaning: water jetting, water blast cleaning, hydrojetting, aquajetting, hydroblasting, aqua- blasting, and “cleaning by directing a jet of pressurized water onto the surface to be cleaned.”

1.1.2 Within the hierarchy of degrees of surface cleanliness achieved by waterjet cleaning, Very Thorough Cleaning (WJ-2) is intended to be similar to the degree of surface cleanli-ness of SSPC-SP 10/NACE No. 2,[3] except that tightly adherent material, rather than only stains, is permitted to remain on thesurface.

1.2 Although carbon steel is the metallic substrate most frequently cleaned in the field using waterjetting technology, waterjet cleaning may be used on metallic substrates other than carbon steel, including other ferrous substrates such as alloy steels, stainless steels, ductile iron and cast irons, nonferrous substrates such as aluminum, and copper alloys such as bronze. For convenience, the written definitions of the degrees of surface cleanliness of the metallic substrate use the general term “rust and other corrosion products.” The term “rust” is intended to apply to carbon steel substrates and the term “other corrosion products” (such as surface oxides) is intended to apply to metallic substrates other than carbon steel that are being waterjet cleaned. “Flash rust” is an oxidation product that forms as a wetted carbon steel substrate dries. The visual guides and comparators referenced for cleanliness and flash rust only illustrate carbon steel substrates.

1.3 This standard does not address surface preparation of concrete. Information on surface preparation of concrete can be found in SSPC-SP 13/NACE No. 6.[4]

1.4 This standard is limited to requirements for visible surface contaminants. Information on nonvisible contamina- tion can be found in Paragraph A8 of Appendix A.

7. *Section 2: Definitions*

2.1 Very Thorough Cleaning (WJ-2): A metal surface after Very Thorough Cleaning, when viewed without magnifica- tion, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corro- sion products, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter shall be limited to no more than 5 percent of each unit area of surface and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.

2.1.1 A unit area of surface is an area approximately 5,800 mm^2 [9.0 in^2] (i.e., a square 76 mm x 76 mm [3.0 in x 3.0 in].

2.1.2 Coatings, mill scale, and foreign matter are consid- ered tightly adherent if they cannot be removed by lifting with a dull putty knife. (Paragraphs A4 and A5 of Appendix A provide additional information.)

2.1.3 The gray to brown-black discoloration remaining on corroded and pitted carbon steel that cannot be removed by further waterjet cleaning is not considered part of the percentage staining.

2.1.4 SSPC-VIS 4/NACE VIS 7[5] or other visual guide or comparator may be specified to supplement the written defini-tion. In any dispute, the written standard shall take precedence over the visual guide or comparator. (Paragraph A6 of Appendix A provides additional information.)

8. *Section 3: Additional Technical Considerations*

3.1 *Flash Rust*

Flash rust is an additional consideration when a carbon steel substrate is subjected to waterjet cleaning. Gray or brown- black discoloration remaining in the pits of waterjet cleaned carbon steel is not the same as flash rust. Metals other than carbon steel can manifest discoloration as well. Degrees of flash rust may be qualitatively described as follows:

3.1.1 No flash rust: A carbon steel surface that, when viewed without magnification, exhibits no visible flash rust.

3.1.2 Light (L) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits small quantities of a rust layer through which the carbon 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 lightly wiping with a cloth.

3.1.3 Moderate (M) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of rust that obscures the original carbon steel surface. The rust layer may be evenly distributed or present in patches, but it is reasonably well adherent and leaves light marks on a cloth that is lightly wiped over the surface.

3.1.4 Heavy (H) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of heavy rust that hides original carbon steel surface completely. The rust may be evenly distributed or present in patches, but it is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface.

(Paragraphs A6, A9, and A10 of Appendix A provide addi-tional information. Appendix B provides additional information on methods of assessing the degree of flash rust.)

3.2 *Appearance Variations*

3.2.1 Acceptable variations in appearance that do not affect the degree of surface cleanliness defined in Paragraph, include variations caused by composition of the metallic substrate, original surface condition, thickness of the metal, weld metal, mill or fabrication marks, heat treating, heat-affected zones, and differences resulting from the initial abrasive blast cleaning abrasives or the abrasive blast pattern if previously blast cleaned, or waterjet cleaning pattern.

3.2.1.1 Carbon steel surfaces cleaned by waterjet cleaning initially exhibit a matte finish with a color that can range from light gray to dark brown-black but immediately acquires a golden hue unless a corrosion inhibitor or environmental controls are used. The matte finish on older carbon steel surfaces that have areas from which coating was removed and areas that were coating-free at the time of cleaning varies even when all visible surface material has been removed.

Document	Title
SSPC-VIS 4/NACE VIS 7	"Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting"
SSPC-SP 1[6]	"Solvent Cleaning"

3.3 If there is a conflict between the requirements of any of the documents listed in Paragraph 4.1 and this standard, the requirements of this standard shall govern.

4. *Section 5: Procedures Before Waterjet Cleaning*

4.1 Precleaning: Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, and A10 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

4.2 Prior to beginning waterjet cleaning, surface imperfec-tions such as sharp fins, sharp edges, weld spatter, or burning slag shall be addressed to the extent required by the procure-ment documents (project specifications). (Paragraph A12 of Appendix A provides additional information.)

4.3 CAUTION: Waterjet cleaning can be destructive to nonmetallic surfaces. Wood, rubber, insulation, electric instal- lations, instrumentation, etc., must be protected from direct and indirect impingement of water streams.

4.4 If a visual guide or comparator is specified to supple-ment the written standard, the condition of the substrate prior to waterjet cleaning should be determined before the waterjet cleaning commences. (Paragraph A6 of Appendix A provides additional information.)

4.4.1 Metallic substrates show variations in texture, shade, color, tone, pitting, flaking, and mill scale that should be considered during the waterjet cleaning process. (Paragraph A6 of Appendix A provides additional information.)

4.4.2 Direct correlation to existing dry abrasive blasting standards and visual comparators is inaccurate or inappropriate.

3. *Section 4: Associated Documents*

5.1 Documents associated with this standard and cited in its mandatory sections include:

Document	Title
SSPC-SP 5/NACE No. 10	"Near-White Metal Blast Cleaning"
SSPC-SP 13/NACE No. 6	"Surface Preparation of Concrete"

5. *Section 6: Waterjet Cleaning Methods*

6.1 Any of the following waterjet cleaning methods may be used to achieve the Very Thorough Cleaning (WJ-2) degree of surface cleanliness. These waterjet cleaning methods all require the use of surface preparation water (hereinafter referred to as "SP water") in accordance with Paragraph 6.2. The presence of toxic metals in a coating being removed can place restrictions on the methods of cleaning permitted. The chosen method shall comply with applicable regulations. (Para- graph A13 of Appendix A and Paragraph C2.3 of Appendix C provide additional information.)

6.1.1 Water cleaning (WC): Use of pressurized SP water discharged from a nozzle to remove unwanted matter from a surface.

6.1.1.1 Low-pressure water cleaning (LP WC): Water cleaning performed at pressures less than 34 MPa (5,000 psig). This is also called "power washing" or "pressure washing.

6.1.1.2 High-pressure water cleaning (HP WC): Water cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig).

6.1.2 Waterjetting (WJ): Use of SP water discharged from a nozzle at pressures of 70 MPa (10,000 psig) or greater to prepare a surface for coating or inspection. The velocity of the SP water exiting the orifice is greater than 340 m/s (1,100 ft/s).

6.1.2.1 High-pressure waterjetting (HP WJ): Waterjet-ting performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig).

6.1.2.2 Ultrahigh-pressure waterjetting (UHP WJ): Waterjetting performed at pressures greater than 210 MPa (30,000 psig).

6.2 Surface preparation water (SP water): Water of sufficient purity and quality that it does not prevent the surface being cleaned from achieving the WJ-2 degree of surface cleanliness or nonvisible contamination criteria when contained in the procurement documents. SP water should not contain sediments or other impurities that are destructive to the proper functioning of the cleaning equipment. (Paragraph A7 of Appendix A provides additional information.)

6. Section 7: Procedures Following Waterjet Cleaning and Immediately Prior to Coating

7.1 Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, A10, and A11 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

7.2 The existing surface profile shall be assessed to determine conformance with the requirements of the procurement documents. (Paragraphs A3 and A14 of Appendix A provide additional information.)

7.3 Immediately prior to coating application, the entire surface shall comply with the degree of surface cleanliness specified herein, and to the extent established, the procurement document (project specification) requirements, and degree of flash rust.

7.4 Flash rust shall be mitigated in accordance with the requirements of the procurement documents. An example of a specification statement is provided in Paragraph A10 of Appendix A. It is common practice to remove heavy flash rust by LP WC, HP WC, or dry abrasive sweep blasting.

7.5 Dust and loose residues shall be removed from cleaned surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other specified methods. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air. (Paragraph A13 of Appendix A provides additional information.)

”

1. References

1. SSPC-SP 12/NACE No. 5 (latest revision), “Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating” (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

2. ISO 8501-4 (latest revision), “Preparation of steel substrates before application of paints and related products–Visual assessment of surface cleanliness–Part 4: “Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting”(Geneva, Switzerland: ISO).

3. SSPC-SP 10/NACE No. 2 (latest revision), “Near-White Metal Blast Cleaning” (Pittsburgh, PA: SSPC, and Houston, TX: NACE).

4. SSPC-SP 13/NACE No. 6 (latest revision), “Surface Preparation of Concrete” (Pittsburgh, PA: SSPC, and Houston,TX: NACE.)

5. SSPC-VIS 4/NACE VIS 7 (latest revision), “Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting” (Pittsburgh, PA: SSPC, and Houston, TX: NACE)

6. SSPC-SP 1 (latest revision), “Solvent Cleaning” (Pittsburgh, PA: SSPC).

7. SSPC PA Guide 4, (latest revision), “Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems” (Pittsburgh, PA: SSPC).

8. SSPC-Guide 15 (latest revision), “Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates” (Pittsburgh, PA: SSPC).

9. SSPC-SP COM (latest revision), “Surface PreparationCommentary for Steel and Concrete Substrates” (Pittsburgh, PA: SSPC).

10. NACE SP0178 (formerly RP0178) (latest revision), “Design, Fabrication, and Surface Finish Practices forTanks and Vessels to Be Lined for Immersion Service” (Houston, TX: NACE).

11. SSPC-PA 2 (latest revision), “Measurement of Dry Coating Thickness with Magnetic Gages” (Pittsburgh, PA: SSPC).

12. “Recommended Guidelines for Evaluating Flash Rust” (Charleston, SC: National Shipbuilding Research Program [NSRP],[2] 2009). (Available from SSPC and NACE.)

13. ISO 8502-3 (latest revision), “Preparation of steel substrates before application of paints and related products—Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)” (Geneva, Switzerland: ISO).

14. ASTM[3] D3359 (latest revision), “Standard Test Methods for Measuring Adhesion by Tape Test” (West Conshohocken, PA: ASTM).

15. “Recommended Practices for the Use of Manually Opeated High-Pressure Waterjetting Equipment” (latest revision) (St. Louis, MO: WaterJet Technology Association [WJTA])[4]

16. D.A. Summers, WaterJetting Technology (London, UK: Chapman and Hall, 1995).

17. SSPC-Guide 6 (latest revision), “Guide for Containing Debris Generated During Paint Removal Operations”

2. Appendix A: Explanatory Notes(Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any orall of the the provisions herein.

A1 Function: Very Thorough Cleaning (WJ-2) provides a greater degree of surface cleanliness than Thorough Cleaning(WJ-3) but less than Clean to Bare Substrate (WJ-1). The hierarchy of waterjet cleaning standards is as follows: WJ-1, WJ-2,WJ-3, and WJ-4. Very Thorough Cleaning (WJ-2) should be used when a high degree of cleaning is required. The primaryfunctions of waterjet cleaning before coating are:

(a) To remove material from the surface that can cause early failure of the coating system;
(b) To enhance the adhesion of the new coating system;
(c) To expose the surface profile of the substrate that is underneath the existing coating or rust and other corrosion products (Paragraph A3 provides additionalinformation.); and
(d) To reduce or remove nonvisible contamination

.

Very Thorough Cleaning (WJ-2) is used when the objective is to remove every trace of the coating, mill scale, andrust and other corrosion products but when the extra effort required to remove all of these materials is determined to be unwarranted. Discoloration of the metal substrate surface may be present. Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter is limited to a maximum of 5 percent of each unit area of the surface. Thorough Cleaning (WJ-3) allows staining or tightly adherent matter to a maximum of 33 percent of each unit area of the surface, and a Clean to Bare Substrate (WJ-1) surface is free of all visible rust and other corrosion products, dirt, previous coatings, mill scale, and foreign matter dispersed stains of rust and other corrosion products, tightly

A2 Maintenance Coating Work: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be waterjet cleaned or spot-waterjet cleaned to this degree of surface cleanliness.In these cases, the surface cleanliness should be achieved across the entire area specified. For example, if all weld seams are to be cleaned in a maintenance operation, the degree of surface cleanliness applies to 100 percent of all weld seams. If the entire structure is to be cleaned, this degree of surface cleanliness applies to 100 percent of the entire structure. SSPC-PA Guide 4[7] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 Surface Profile: Waterjet cleaning reveals the surface profile (roughness) of the substrate that exists under the original coatings or rust and other corrosion products. When a coating is specified, another surface preparation method may be needed in addition to the waterjet cleaning to achieve the surface profile suitable for the specified coating system.

A4 Rust Scale: If rust scale is present, it must be removed. Rust scale is not a suitable substrate over which to apply coatings, and, if not removed, may also prevent removal of water-soluble salts that may accelerate corrosion. Methods other than waterjet cleaning may be used.

A5 Mill Scale: Mill scale is not allowed in this degree of surface cleanliness. Mill scale is that dark blue-black layer of iron oxide on the surface of hot-rolled steel. Over time, the adherence of the mill scale can change. Older mill scale might be removed easily in the field with waterjetting at 100 MPa (15,000 psi) and above. Waterjetting at pressures greater than 240 MPa (35,000 psig) is capable of removing tightly adherent mill scale, but production rates are not always cost effective. When the mill scale comes off, the steel surface under the millscale has whatever surface profile is under the mill scale.

A6 Reference Photographs: Photographs may be specified to supplement the written definition. SSPC-VIS 4/NACE VIS 7 depicts various precleaning conditions and the appearance of a carbon steel surface that is consistent with the Very Thorough Cleaning (WJ-2) degree of surface cleanliness defined in this standard. In any dispute, the written standard shall take precedence over the visual guide. The visual appearance of carbon steel that has heavily flash rusted after initial waterjet cleaning and is then recleaned by LP WC has a different appearance from the original light flash-rusted steeldepicted in SSPC-VIS 4/NACE VIS 7.

A7 Quality of Water: SP water used by waterjet cleaning equipment should be clean and free of erosive silts or other contaminants that damage pump valves and/or prevent the surface from achieving the specified degree of surface cleanliness. A general rule is that the cleaner the water, the longer the service life of the waterjet cleaning equipment. The use of deionized water may be detrimental to some water pumps and care should be taken to ensure compatibility.

A8 Nonvisible Contamination (NV)

A8.1 Nonvisible contamination (NV): Nonvisible contamination is the presence of organic matter, such as thin films of oil and grease, and inorganic and/or soluble ionic materials such as chlorides, ferrous salts, nitrates, and sulfates thatmay be present on the substrate. (Paragraphs A6, A7, and A8provide additional information.)

A8.2 Steel contaminated with water-soluble salts (e.g., sodium chloride and potassium sulfate) rapidly develops rust-back. Rust-back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after cleaning. These contaminants, along with their concentrations, may be identified using laboratory and field tests as described in SSPC Guide 15[8] Conductivity measurement is another method for testing for water-soluble salts.

A8.3 Other nonvisible contaminants (e.g., oil, acid, base, silicone, wax) may have an effect on coating performance. Coatings manufacturers should be consulted for recommendations of maximum surface contamination allowed. The specifier should determine what level of nonvisible contaminants may remain.

A8.4 The test method or procedure to be used for determining the level of remaining nonvisible contaminants should be addressed in the procurement documents (project specification).

A8.5 The level of nonvisible contaminants found in an extraction from the surface that may remain on the surface is usually expressed as mass per unit area; for example, $\mu g/cm^2$ or mg/m^2 ($1\ \mu g/cm^2 = 10\ mg/m^2$).

A8.6 The following is an example specification for salt contamination based on concentration measurements:

"Immediately prior to the application of the coating, the surface extract shall not contain more than xx $\mu g/cm^2$ of the specific contaminant (e.g., chloride) when tested with a specified method."

A8.7 The following is an example specification for salt contamination based on conductivity measurements: "Immediately prior to the application of the coating, the conductivity of the surface extract shall not exceed xx µS/cm when tested with a specified method."

A9 Use of Corrosion Inhibitors: It may be advantageousto add corrosion inhibitors to the SP water or apply them to the surface immediately after waterjet cleaning to temporarily prevent rust formation. Some corrosion inhibitor treatments may interfere with the performance of certain coatings systems. The coatings manufacturer should be consulted to ensure the compatibility of corrosion inhibitors with the coatings.

1. A10 Specification Statement:

A10.1 The specifier should use the degree of surface cleanliness and one of the degrees of flash rust to specify the required end condition. The following are examples of a specification statement:

"All surfaces to be recoated shall be waterjet cleaned to SSPC-SP WJ-2 L /NACE WJ-2/L, Very Thorough Cleaning, Light Flash Rust."

"At the time of the recoating, the degree of flash rust shall be no greater than moderate (M)."

A10.2 In addition, the specifier should consider whether a surface should be cleaned as required to achieve a particular, not to exceed maximum, level of nonvisible contamination (NV) prior to recoating. A suggested specification statement for nonvisible contamination (NV) is given in Paragraph A8.

A11 Flash Rust: An oxidation product that forms as a wetted carbon steel substrate dries. With the exception of stainless steel surfaces, any steel surface may show flash rust within 30 minutes or longer while the substrate is drying (water evaporation) after waterjet cleaning, depending on environmental conditions. Flash rust has the appearance of rust bloom. Flash rust quickly changes the appearance of the waterjet cleaned surface and may be reduced or eliminated by physical or chemical methods. 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. With time, the flash rust changes from a yellow-brown, well adherent, light rust to a red-brown, loosely adherent, heavy rust. Appendix B contains additional information on methods of assessing the degree of flash rust.

A12 Surface Imperfections:

A12.1 Surface imperfections that can cause premature failure are often present. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to properly cover and protect include crevices, weld porosities, and laminations.

A12.2 Poorly adhering fabrication defects, such as weld slag residues, loose weld spatter, and surface laminations may be removed during the waterjet cleaning operation. Other surface defects, such as steel laminations, weld porosities, or deep corrosion pits may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work should be given prior consideration because the timing of the repairs may occur before, during, or after the waterjet cleaning operation. The SSPC-SP COM[9] and NACE SP0178[10] contain additional information on surface imperfections.

A12.3 The high cost of the methods to remedy surface imperfections (e.g., edge rounding and weld spatter removal) should be compared with the benefits of preventing premature coating failure. Therefore, those responsible for establishing the requirements and those responsible for performing the work should agree on the procedures to be used to repair surface imperfections to the extent required in the procurement documents (project specification).

A13 Removal of Coatings with Hazardous Components—Hygiene: Waterjet cleaning is often used to remove coatings with hazardous components. Because the particles are wetted, respiratory protection requirements for waterjet cleaning may be less stringent than for other methods of surface preparation. However, the wetted particles tend to stay on the skin. Applicable industrial hygiene tests should be performed to determine the destination of the wetted particles. Good industrial hygiene should be followed.

A14 Film Thickness: It is essential that ample coating be applied after waterjet cleaning to adequately cover the peaks of the surface profile. The dry film thickness of the coating above the peaks of the surface profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[11] for verification of accuracy of Type 1 and Type 2 gauges should be used.

Appendix B

Methods of Assessing the Degree of Flash Rust (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

The degree of flash rust is related to the quantity of loose, clean rust dust that is present on the surface. One of the following alternative methods may be used to assess the degree of flash rust, or other methods may be used if specified.

2. B1 Wipe Test

The following procedure is suggested to standardize the amount of pressure used to perform a wipe test on a flash-rusted surface:

(a) Neatly wrap a white, lint-free, woven cloth around a standard 100 mm (4 in) nylon paint brush, and hold it in place in a manner that prevents the cloth from slipping.

(b) Swipe the cloth-wrapped paint brush across the flash-rusted surface in one motion, using pressure equivalent to that used to apply house paint to a door. The length of the swipe should be consistent (e.g., one pass covering 1,500 mm [6 in] in length).

(c) Remove the white cloth from the paint brush and evaluate the color and amount of rust on the cloth. "Recommended Guidelines for Evaluating Flash Rust,"[12] issued by the NSRP, provides guidance to perform this evaluation of flash rust.

If lint deposition is a concern, the project specification may require use of an alternate technique to determine the degree of flash rust.

1. B2 Tape Pull Test

The tape pull test is a modification of the pressure-sensitive tape method in ISO 8502-3.[13] The procedure is as follows:

(a) Select a test area on the flash-rusted surface to perform the test.

(b) Place a 50 mm (2 in) long piece of tape (as specified in ASTM D 3359[14]) on the selected test area and rub it thoroughly with a fingertip (not a fingernail) to ensure that the tape adheres firmly. Then peel the tape off the surface and place it on a piece of white paper for reference.

(c) Repeat the procedure in (b) nine times (for a total of 10 times) using a fresh piece of tape applied to the same spot on the surface (selected test area) each time. Assess the appearance of the 10th tape and the appearance of the test area on the flash-rusted surface after the 10th tape is pulled off in accordance with Table B1.

Appendix C:

Waterjet Cleaning Equipment and Operating Parameters (Nonmandatory)

tips,that can have different forms–the higher the pressure, the more limited is the choice of forms. Round jets are most commonly used, but orifices of other shapes are available. Tips can be designed to produce multiple jets of water that are normally rotated to achieve higher material-removal rates. Interchangeable nozzle tips should be used to produce the desired streams. The manufacturer should be consulted for specific recommendations.

C1.2 Waterjet streams are produced by orifices, o

C1.3 Effect of Corrosion Inhibitors and Detergents on Equipment: If corrosion inhibitors are to be used with the SP water, the manufacturer of the waterjet cleaning equipment should be consulted to ensure compatibility of corrosion inhibi- tors with the equipment. Compatibility of detergents with the special seals and high-alloy metals of the waterjet cleaning equipment should be carefully investigated to ensure that the cleaning equipment is not damaged.

C1.4 All waterjet cleaning units normally use a hydraulic hose with a minimum bursting strength of 2.5 times the capa- bility of its maximum-rated operating strength.

1. C2 Operating Parameters

C2.1 Waterjet Cleaning Method Selection: The person performing the work should have sufficient experience to selectthe waterjet cleaning method and the specific combination of water pressure and flow (velocity and volume) to achieve the specified degree of surface cleanliness. A water flow rate of 4 to 53 L/min (1 to 14 gal/min) is typical.

(a) LP WC or HP WC (the flow rate of the water is the dominant energy characteristic);
(b) HP WJ (pressure or water velocity and flow rate are equally important); or
(c) UHP WJ (pressure or water velocity is the dominant energy characteristic).

equipped with various prime movers (diesel, electric motor, etc.); and usuallyconsists of a pump, hoses, and various tools. The tools can behand-held or mounted on a robot or controlled by a traversing mechanism. Water is propelled through a single jet, fan jet, pulse generator, or multiple rotating jets. Rotation of the nozzlehead is provided by small electric, air, or hydraulic motors, or by slightly inclined orifices in a multiple-orifice nozzle. relevant to waterjet cleaning operations. The commercial waterjet cleaning unit can be mounted on a skid, trailer, or truck; can be

C2.2 Stand-off Distance: The distance from the nozzle to the work piece surface (stand-off distance) is critical for effec-tive cleaning with any of the waterjet cleaning methods. Typical stand-off distances for HP WJ and UHP WJ range from 25 to 150 mm (1.0 to 6.0 in) for coatings removal. Typical stand-off distances range up to 600 mm (24 in) to remove foreign matter that is not tightly adherent. Excessive stand-off distance does not produce the desired cleaning.

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this stan-dard is not required to follow, but may choose to follow, any orall of the the provisions herein.

2. C1 Waterjet Cleaning Equipment

Multiple configurations of pumps, heads, and containment systems are suitable for waterjet cleaning operations. The equipment systems may include manual lances, fixed lances on platforms, or robot-driven systems. Additional descriptions relevant to waterjet cleaning systems are in the WaterJet Tech- nology Association's "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment,"[15] which also addresses concerns

C2.3 Threshold Pressure: The threshold pressure of a coating can be determined. In general, the tougher, more resilient, or harder the coating (i.e., the more resistant to probing or cutting by a pocket knife), the higher the threshold pressure; the softer and more jelly-like the coating, the lower the threshold pressure. Threshold pressure is defined by Summers[16] as the minimum required pressure to penetrate thematerial. Once the threshold pressure is achieved or exceeded, the production rate increases dramatically. Therefore, waterjet cleaning production rates can be classified according to two conditions:

(a) Relatively Slow–Erosion at pressures lower than the threshold pressure; and
(b) Relatively Fast–Waterjet cutting and erosion at pres-sures greater than the threshold pressure

Pressure loss is a function of the flow rate of the water through the hose and the inside diameter of the hose. The manufacturer should be consulted for specific information on potential pressure loss for each type of equipment.

C2.4 Depending on the initial condition of the area and the materials to be removed, the choice of waterjet cleaning method to achieve Very Thorough Cleaning (WJ-2) is ulti- mately based on the capabilities of the equipment and its components. Dwell time, traverse rate, pressure, flow, stand- off distances, the number of nozzles, and rotation speed all interact in determining materials that remain and those that are removed.

C2.5 Reuse of Effluent Water: If effluent water is captured for reuse by the waterjet cleaning equipment, cautionshould be used to avoid introducing any removed contami- nants back onto the cleaned substrate. The effluent water may be placed in a clean holding tank and tested to determine the contaminant content prior to reintroduction into the water supply stream to the waterjet cleaning equipment. The effluent water should be monitored for suspended particulates, hydro- carbons, salts, hazardous materials, or other by-products of the surface preparation procedures.

C2.6 Additives: Any detergents, degreasers, or other types of cleaners used in conjunction with the waterjet cleaningmethod should be removed prior to applying a coating. If corro- sion inhibitors are to be used with the SP water, the coating manufacturer should be consulted to ensure compatibility of corrosion inhibitors with the coating.

C2.7 Containment Systems: Containment systems may consist of water-impermeable membranes or vacuum collec- tion heads or the systems described in SSPC-Guide 6.[17] The containment design should consider the pressures used and water volumes produced and if the process may be open or closed loop (with a single pass or multiple passes of the waterthrough the system).

SSPC: The Society for Protective Coatings/NACE International
Joint Surface Preparation Standard
Waterjet Cleaning of Metals
SSPC-SP WJ-3/NACE WJ-3 – Thorough Cleaning

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Foreword

This SSPC/NACE joint standard defines the Thorough Cleaning degree of surface cleanliness of coated or uncoated metallic substrates achieved by the use of waterjet cleaning prior to the application of a protective coating or lining. Waterjet cleaning is the use of pressurized surface preparation water for removing coatings and other materials, including hazardous materials, from a substrate to achieve a defined degree of surface cleanliness. Waterjet cleaning includes various methods such as low-pressure water cleaning (LP WC), high- pressure water cleaning (HP WC), high-pressure waterjetting (HP WJ), and ultrahigh-pressure waterjetting (UHP WJ).

The four degrees of surface cleanliness achieved by waterjet cleaning, which are addressed in separate standards, are as follows:

Degree of Surface Cleanliness	Designation
Clean to Bare Substrate	WJ-1
Very Thorough Cleaning	WJ-2
Thorough Cleaning	WJ-3
Light Cleaning	WJ-4

Thorough Cleaning (WJ-3) provides a greater degree of surface cleanliness than Light Cleaning (WJ-4), but a lesser degree of cleaning than Very Thorough Cleaning (WJ-2).

Waterjet cleaning to achieve the Thorough Cleaning (WJ-3) degree of surface cleanliness is used when the objective is to remove much of the rust and other corrosion products, coating, and mill scale, and leave tightly adherent thin films, but when the extra effort required to remove almost all of these materials is determined to be unwarranted. Discoloration of the surface may be present.

Waterjet cleaning does not provide the primary anchor pattern on the metallic substrate known as "surface profile." The coatings industry uses waterjet cleaning primarily for recoating or relining projects in which there is an adequate pre-existing surface profile. The degrees of surface cleanliness cited above to be achieved by waterjet cleaning methods are not intended to require that a surface profile be present or defined prior to coating application.

Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates. Waterjet cleaning also helps remove oil, grease, rust and other corrosion products, and other foreign matter (for example, shotcrete spatter) from the surface, and is used when it is a more feasible method of surface preparation than, for example, abrasive blast cleaning, power or hand tool cleaning, or chemical stripping. Waterjet cleaning may be used when the application of high-performance coatings requires extensive surface preparation, surface decontamination, or both.

This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who have responsibility to define a standard degree of surface cleanliness to be achieved by waterjet cleaning methods.

This standard was prepared by SSPC/NACE Joint Task Group (TG) 277, "Surface Preparation of Metals to WJ-3 (Thorough Cleaning) by High-Pressure Waterjetting." TG 275 is administered by Specific Technology Group (STG) 04, "Coatings and Linings, Protective–Surface Preparation," and is sponsored by STG 02, "Coatings and Linings, Protective–Atmospheric," and STG 03, "Coatings and Linings, Protective–

Immersion and Buried Service." This standard is issued by SSPC Group Committee C.2 on Surface Preparation, and by NACE under the auspices of STG 04. This standard is one of a set of four standards on degrees of surface cleanliness to be achieved by waterjet cleaning that are intended to replace SSPC-SP 12/NACE No. 5,[1] which includes all four degrees of surface cleanliness.

In SSPC/NACE standards, the terms *shall, must, should*, and *may* are used in accordance with Paragraph 2.2.1.8 of the Agreement between SSPC: The Society for Protective Coatings and NACE International. The terms *shall* and *must* are used to state mandatory requirements. The term *should* is used to state something considered good and is recommended, but is not mandatory. The term *may* is used to state something considered optional.

1. Section 1: General

1.1 This standard defines the Thorough Cleaning (WJ-3) degree of surface cleanliness of uncoated or coated metallic substrates by use of waterjet cleaning. The defined degree of cleanliness shall be achieved prior to the application of a specified protective coating or lining system. These requirements include the end condition of the surface and materials and procedures necessary to achieve and verify the end condition, as determined by visual inspection. This standard also may be used in situations in which the degree of cleanliness is required, but protective coatings or linings are not immediately applied. (Paragraphs A1 and A2 of Appendix A provide additional information.) Waterjet cleaning does not establish but may reveal an existing surface profile on a metallic substrate. If the existing surface profile is not acceptable for subsequent coating application, alternative surface preparation methods to create the required surface profile must be considered. (Paragraph A3 of Appendix A provides additional information.)

1.1.1 Thorough Cleaning (WJ-3) is essentially equivalent to the International Organization for Standardization (ISO)(1) 8501-4[2] degree of cleanliness Wa 2, thorough cleaning ISO 8501-4 notes the use of various common terms for methods of waterjet cleaning: water jetting, water blast cleaning, hydrojetting, aquajetting, hydroblasting, aquablasting, and "cleaning by directing a jet of pressurized water onto the surface to be cleaned."

1.1.2 Within the hierarchy of degrees of surface cleanliness achieved by waterjet cleaning, Thorough Cleaning (WJ 3) is intended to be similar to the degree of surface cleanliness of SSPC-SP 6/NACE No. 3,[3] except that tightly adherent material, rather than only stains, is permitted to remain on the surface, and to the degree of surface cleanliness of SSPC-SP 14/NACE No. 8[4], Industrial Blast Cleaning, which allows tightly adherent material to remain on the surface.

1.1.3

1.2 Although carbon steel is the metallic substrate most frequently cleaned in the field using waterjetting technology, waterjet cleaning may be used on metallic substrates other than carbon steel, including other ferrous substrates such as alloy steels, stainless steels, ductile iron and cast irons, nonferrous substrates such as aluminum, and copper alloys such as bronze. For convenience, the written definitions of the degrees of surface cleanliness of the metallic substrate use the general term "rust and other corrosion products." The term "rust" is intended to apply to carbon steel substrates and the term "other corrosion products" (such as surface oxides) is intended to apply to metallic substrates other than carbon steel that are being waterjet cleaned. "Flash rust" is an oxidation product that forms as a wetted carbon steel substrate dries. The visual guides and comparators referenced for cleanliness and flash rust only illustrate carbon steel substrates.

1.3 This standard does not address surface preparation of concrete. Information on surface preparation of concrete can be found in SSPC-SP 13/NACE No. 6.[5]

1.4 This standard is limited to requirements for visible surface contaminants. Information on nonvisible contamination can be found in Paragraph A8 of Appendix A.

2. Section 2: Definitions

2.1 Thorough Cleaning (WJ-3): A metal surface after Thorough Cleaning, when viewed without magnification, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corrosion products, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter shall be limited to no more than 33 percent of each unit area of surface and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.

2.1.1 A unit area of surface is an area approximately 5,800 mm^2 [9.0 in^2] (i.e., a square 76 mm x 76 mm [3.0 in x 3.0 in].

2.1.2 Coatings, mill scale, and foreign matter are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. (Paragraphs A4 and A5 of Appendix A provide additional information.

2.1.3 The gray to brown-black discoloration remaining on corroded and pitted carbon steel that cannot be removed by further waterjet cleaning is allowed.

2.1.4 SSPC-VIS 4/NACE VIS 7[6] or other visual guide or comparator may be specified to supplement the written definition. In any dispute, the written standard shall take precedence over the visual guide or comparator. (Paragraph A6 of Appendix A provides additional information.)

3. Section 3: Additional Technical Considerations

3.1 Flash Rust

Flash rust is an additional consideration when a carbon steel substrate is subjected to waterjet cleaning. Gray or brown-black discoloration remaining in the pits of waterjet cleaned carbon steel is not the same as flash rust. Metals other than carbon steel can manifest discoloration as well. Degrees of flash rust may be qualitatively described as follows:

3.1.1 No flash rust: A carbon steel surface that, when viewed without magnification, exhibits no visible flash rust.

3.1.2 Light (L) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits small quantities of a rust layer through which the carbon steel substrate may be observed. The rust or discoloration maybe evenly distributed or present in patches, but it is tightly adherent and not easily removed by lightly wiping with a cloth.

3.1.3 Moderate (M) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of rust that obscures the original carbon steel surface. The rust layer may be evenly distributed or present in patches, but it is reasonably well adherent and leaves light marks on a cloth that is lightly wiped over the surface.

3.1.4 Heavy (H) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of heavy rust that hides original carbon steel surface completely. The rust may be evenly distributed or present in patches, but it is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface. (Paragraphs A6, A9, and A10 of Appendix A provide addi- tional information. Appendix B provides additional information on methods of assessing the degree of flash rust.)

3.2 Appearance Variations

3.2.1 Acceptable variations in appearance that do not affect the degree of surface cleanliness defined in Paragraph 2.1 include variations caused by composition of the metallic substrate, original surface condition, thickness of the metal, weld metal, mill or fabrication marks, heat treating, heat- affected zones, and differences resulting from the initial abrasive blast cleaning abrasives or the abrasive blast pattern if previously blast cleaned, or waterjet cleaning pattern.

3.2.1.1 Carbon steel surfaces cleaned by waterjet cleaninginitially exhibit a matte finish with a color that can range from light gray to dark brown-black but immediately acquires a golden hue unless a corrosion inhibitor or environmental controls are used. The matte finish on older carbon steel surfaces that have areas from which coating was removed and areas that were coating-free at the time of cleaning varies even when all visible surface material has been removed.

3.2.2 Metallic substrates show variations in texture, shade, color, tone, pitting, flaking, and mill scale that should be considered during the waterjet cleaning process. (Paragraph A6 of Appendix A provides additional information.)

3.2.3 Direct correlation to existing dry abrasive blasting standards and visual comparators is inaccurate or inappropriate.

4. *Section 4: Associated Documents*

Documents associated with this standard and cited inits

4.1 If there is a conflict between the requirements of any of the documents listed in Paragraph 4.1 and this standard, therequirements of this standard shall govern.

5. *Section 5: Procedures Before Waterjet Cleaning*

5.1 Precleaning: Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, and A10 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

5.2 Prior to beginning waterjet cleaning, surface imper- fections such as sharp fins, sharp edges, weld spatter, or burning slag shall be addressed to the extent required by the procurement documents (project specifications). (Paragraph A12 of Appendix A provides additional information.)

5.3 CAUTION: Waterjet cleaning can be destructive to nonmetallic surfaces. Wood, rubber, insulation, electric instal- lations, instrumentation, etc., must be protected from direct and indirect impingement of water streams.

5.4 If a visual guide or comparator is specified to supplement the written standard, the condition of the substrate prior to waterjet cleaning should be determined before the waterjet cleaning commences. (Paragraph A6 of Appendix A provides additional information.)

6. *Section 6: Waterjet Cleaning Methods*

6.1 Any of the following waterjet cleaning methods may be used to achieve the Thorough Cleaning (WJ-3) degree of surface cleanliness. These waterjet cleaning methods all require the use of surface preparation water (hereinafter referred to as "SP water") in accordance with Paragraph 6.2. The presence of toxic metals in a coating being removed can place restrictions on the methods of cleaning permitted. The chosen method shall comply with applicable regulations. (Para- graph A13 of Appendix A and Paragraph C2.3 of Appendix C provide additional information.)

Document	Title
SSPC-SP 6/NACE No. 3	"Commercial Blast Cleaning"
SSPC-SP 13/NACE No. 6	"Surface Preparationof Concrete"
SSPC-VIS 4/NACE VIS 7	"Guide and Visual Reference Photographs for Steel Cleanedby Waterjetting"

6.1.1 Water cleaning (WC): Use of pressurized SP water discharged from a nozzle to remove unwanted matter from a surface.

6.1.1.1 Low-pressure water cleaning (LP WC): Water cleaning performed at pressures less than 34 MPa (5,000 psig).This is also called "power washing" or "pressure washing."

6.1.1.2 High-pressure water cleaning (HP WC): Water cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig).

6.1.2 Waterjetting (WJ): Use of SP water discharged from a nozzle at pressures of 70 MPa (10,000 psig) or greater to prepare a surface for coating or inspection. The velocity of theSP water exiting the orifice is greater than 340 m/s (1,100 ft/s).

6.1.2.1 High-pressure waterjetting (HP WJ): Waterjetting performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig).

6.1.2.2 Ultrahigh-pressure waterjetting (UHP WJ): Waterjetting performed at pressures greater than 210 MPa (30,000 psig).

6.2 Surface preparation water (SP water): Water of sufficient purity and quality that it does not prevent the surface being cleaned from achieving the WJ-3 degree of surface cleanliness or nonvisible contamination criteria when contained in the procurement documents. SP water should not contain sediments or other impurities that are destructive to the proper functioning of the cleaning equipment. (Paragraph A7 of Appendix A provides additional information.)

7. Section 7: Procedures Following Waterjet Cleaning and Immediately Prior to Coating

7.1 Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, A10, and A11 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

7.2 The existing surface profile shall be assessed to determine conformance with the requirements of the procurement documents. (Paragraphs A3 and A14 of Appendix A provide additional information.)

7.3 mmediately prior to coating application, the entire surface shall comply with the degree of surface cleanliness specified herein, and to the extent established, the procurement document (project specification) requirements, and degree of flash rust.

7.4 Flash rust shall be mitigated in accordance with the requirements of the procurement documents. An example of a specification statement is provided in Paragraph A10 of Appendix A. It is common practice to remove heavy flash rust by LP WC, HP WC, or dry abrasive sweep blasting.

7.5 Dust and loose residues shall be removed from cleaned surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other specified methods. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air. (Paragraph A13 of Appendix A provides additional information.)

Document	Title
SSPC-SP 14/NACE No. 8	Industrial Blast Cleaning
SSPC-SP 1[7]	"Solvent Cleaning"

1. References

1. SSPC-SP 12/NACE No. 5 (latest revision), "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
2. ISO 8501-4 (latest revision), "Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 4: "Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting" (Geneva, Switzerland: ISO).
3. SSPC-SP 6/NACE No. 3 (latest revision), "Commercial Blast Cleaning" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
4. SSPC-SP 14/NACE No. 8 (latest revision), "Industrial Blast Cleaning" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
5. SSPC-SP 13/ NACE No. 6 (latest revision), "Surface Preparation of Concrete" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
6. SSPC-VIS 4/NACE VIS 7 (latest revision), "Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting" (Pittsburgh, PA: SSPC and Houston, TX: NACE).
7. SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pittsburgh, PA: SSPC).
8. SSPC-PA Guide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base or Alkyd Systems" (Pittsburgh, PA: SSPC).
9. SSPC-Guide 15 (latest revision), "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates" (Pittsburgh, PA: SSPC).
10. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).
11. NACE SP0178 (formerly RP0178) (latest revision), "Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service" (Houston, TX: NACE).
12. SSPC-PA 2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).
13. "Recommended Guidelines for Evaluating Flash Rust" (Charleston, SC: National Shipbuilding Research Program [NSRP],(2) 2009). (Available from SSPC and NACE.)
14. ISO 8502-3 (latest revision), "Preparation of steel substrates before application of paints and related products—Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)" (Geneva, Switzerland: ISO).
15. ASTM(3) D 3359 (latest revision), "Standard Test Methods for Measuring Adhesion by Tape Test" (West Conshohocken, PA: ASTM).
16. "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment" (latest revision) (St. Louis, MO: WaterJet Technology Association [WJTA]).(4)

17. D.A. Summers, WaterJetting Technology (London, UK: Chapman and Hall, 1995).

18. SSPC-Guide 6 (latest revision), "Guide for Containing Debris Generated During Paint Removal Operations" (Pittsburgh, PA: SSPC).

1. Appendix A: Explanatory Notes (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any orall of the the provisions herein.

A1 Function: Thorough Cleaning (WJ-3) provides a greater degree of surface cleanliness than Light Cleaning(WJ-4) but less than Very Thorough Cleaning (WJ-2). The hierarchy of waterjet cleaning standards is as follows: WJ-1, WJ-2, WJ-3, and WJ-4. Thorough Cleaning (WJ-3) should be used when a moderate degree of cleaning is required. The primary functions of waterjet cleaning before coating are:

(a) To remove material from the surface that can cause early failure of the coating system;
(b) To enhance the adhesion of the new coating system;
(c) To expose the surface profile of the substrate that is underneath the existing coating or rust and other corrosion products. (Paragraph A3 provides additional information.); and
(d) To reduce or remove nonvisible contamination.

Thorough Cleaning (WJ-3) is used when the objective is to remove much of the rust and other corrosion products, coating, and mill scale, and leave tightly adherent thin films, but when the extra effort required to remove almost all of these materials is determined to be unwarranted. Discoloration of the metal substrate surface may be present. Waterjet cleaningreduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates.

Thorough Cleaning (WJ-3) allows staining or tightly adherent foreign matter to a maximum of 33 percent of each unit area of the surface, and a Light Cleaning (WJ-4) allows as much of the tightly adherent existing coating or tightly adherentforeign matter to remain as possible. Very Thorough Cleaning (WJ-2) allows staining or tightly adherent matter to a maximum of 5 percent of each unit area of the surface, and a Clean to Bare Substrate (WJ-1) surface is free of all visible rust and other corrosion products, dirt, previous coatings, mill scale, and foreign matter.

A2 Maintenance Coating Work: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be waterjet cleaned or spot-waterjet cleaned to this degree of surface cleanliness. In these cases, the surface cleanliness should beachieved across the entire area specified. For example, if all weld seams are to be cleaned in a maintenance operation,the degree of surface cleanliness applies to 100 percent of all weld seams. If the entire structure is to be cleaned, this degree of surface cleanliness applies to 100 percent of the entire structure. SSPC-PA Guide 4[8] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 Surface Profile: Waterjet cleaning reveals the surface profile (roughness) of the substrate that exists under the original coatings or rust and other corrosion products. When a coating is specified, another surface preparation method may be needed in addition to the waterjet cleaning to achieve the surface profile suitable for the specified coating system.

A4 Rust Scale: If rust scale is present, it must be removed. Rust scale is not a suitable substrate over which to apply coatings, and, if not removed, may also prevent removal of water-soluble salts that may accelerate corrosion. Methodsother than waterjet cleaning may be used.

A5 Mill Scale: Mill scale is not allowed in this degree of surface cleanliness. Mill scale is that dark blue-black layer of iron oxide on the surface of hot-rolled steel. Over time, the adherence of the mill scale can change. Older mill scale might be removed easily in the field with waterjetting at 100 MPa (15,000 psi) and above. Waterjetting at pressures greater than 240 MPa (35,000 psig) is capable of removing tightly adherent mill scale, but production rates are not always cost effective. When the mill scale comes off, the steel surface under the mill scale has whatever surface profile is under the mill scale.

A6 Reference Photographs: Photographs may be specified to supplement the written definition. SSPC-VIS 4/ NACE VIS 7 depicts various precleaning conditions and the appearance of a carbon steel surface that is consistent with the Thorough Cleaning (WJ-3) degree of surface cleanliness defined in this standard. In any dispute, the written standard shall take precedence over the visual guide. The visual appearance of carbon steel that has heavily flash rusted after initial waterjet cleaning and is then recleaned by LP WC has a different appearance from the original light flash-rusted steeldepicted in SSPC-VIS 4/ NACE VIS 7.

A7 Quality of Water: SP water used by waterjet cleaning equipment should be clean and free of erosive silts or other contaminants that damage pump valves and/or prevent the surface from achieving the specified degree of surface cleanliness. A general rule is that the cleaner the water, the longer the service life of the waterjet cleaning equipment. The use of deionized water may be detrimental to some water pumps and care should be taken to ensure compatibility.

A8 Nonvisible Contamination (NV)

A8.1 Nonvisible contamination (NV): Nonvisible contamination is the presence of organic matter, such as thin films of oil and grease, and inorganic and/or soluble ionic materials such as chlorides, ferrous salts, nitrates, and sulfates thatmay be present on the substrate. (Paragraphs A6, A7, and A8provide additional information.)

A8.2 Steel contaminated with water-soluble salts (e.g., sodium chloride and potassium sulfate) rapidly develops rust-back. Rust-back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after cleaning. These contaminants, along with their concentrations, may be identified using laboratory and field tests as described in SSPC Guide 15.[9] Conductivity measurement is another method for testing for water-soluble salts.

A8.3 Other nonvisible contaminants (e.g., oil, acid, base, silicone, wax) may have an effect on coating performance. Coatings manufacturers should be consulted for recommendations of maximum surface contamination allowed. The specifier should determine what level of nonvisible contaminants may remain.

A8.4 The test method or procedure to be used for determining the level of remaining nonvisible contaminants should be addressed in the procurement documents (project specification).

A8.5 The level of nonvisible contaminants found in an extraction from the surface that may remain on the surface is usually expressed as mass per unit area; for example, µg/cm^2 or mg/m^2 (1 µg/cm^2 = 10 mg/m^2).

A8.6 The following is an example specification for salt contamination based on concentration measurements:

"Immediately prior to the application of the coating, the surface extract shall not contain more than xx µg/cm^2 of the specific contaminant (e.g., chloride) when tested with a specified method."

A8.7 The following is an example specification for salt contamination based on conductivity measurements:

"Immediately prior to the application of the coating, the conductivity of the surface extract shall not exceed xx µS/cm when tested with a specified method."

A9 Use of Corrosion Inhibitors: It may be advantageous to add corrosion inhibitors to the SP water or apply them to the surface immediately after waterjet cleaning to temporarily prevent rust formation. Some corrosion inhibitor treatments may interfere with the performance of certain coatings systems. The coatings manufacturer should be consulted to ensure the compatibility of corrosion inhibitors with the coatings.

1. A10 Specification Statement:

A10.1 The specifier should use the degree of surface cleanliness and one of the degrees of flash rust to specify the required end condition. The following are examples of a specification statement:

"All surfaces to be recoated shall be waterjet cleaned to SSPC-SP WJ-3 L/NACE WJ-3/L, Thorough Cleaning, Light Flash Rust."

"At the time of the recoating, the degree of flash rust shall be no greater than moderate (M)."

A10.2 In addition, the specifier should consider whether a surface should be cleaned as required to achieve a particular, not to exceed maximum, level of nonvisible contamination (NV) prior to recoating. A suggested specification statement for nonvisible contamination (NV) is given in Paragraph A8.

A11 Flash Rust: An oxidation product that forms as a wetted carbon steel substrate dries. With the exception of stainless steel surfaces, any steel surface may show flash rust within 30 minutes or longer while the substrate is drying (water evaporation) after waterjet cleaning, depending on environmental conditions. Flash rust has the appearance of rust bloom. Flash rust quickly changes the appearance of the waterjet cleaned surface and may be reduced or eliminated by physical or chemical methods. 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. With time, the flash rust changes from a yellow-brown, well adherent, light rust to a red-brown, loosely adherent, heavy rust. Appendix B contains additional information on methods of assessing the degree of flash rust.

2. A12 Surface Imperfections:

A12.1 Surface imperfections that can cause premature failure are often present. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to properly cover and protect include crevices, weld porosities, and laminations.

A12.2 Poorly adhering fabrication defects, such as weld slag residues, loose weld spatter, and surface laminations may be removed during the waterjet cleaning operation. Other surface defects, such as steel laminations, weld porosities, or deep corrosion pits may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work should be given prior consideration because the timing of the repairs may occur before, during, or after the waterjet cleaning operation. The SSPC-SP COM[10] and NACE SP0178[11] contain additional information on surface imperfections.

A12.3 The high cost of the methods to remedy surface imperfections (e.g., edge rounding and weld spatter removal) should be compared with the benefits of preventing premature coating failure. Therefore, those responsible for establishing the requirements and those responsible for performing the work should agree on the procedures to be used to repair surface imperfections to the extent required in the procurement documents (project specification).

A13 Removal of Coatings with Hazardous Components—Hygiene: Waterjet cleaning is often used to remove coatings with hazardous components. Because the particles are wetted, respiratory protection requirements for waterjet cleaning may be less stringent than for other methods of surface preparation. However, the wetted particles tend to stay on the skin. Applicable industrial hygiene tests should be performed to determine the destination of the wetted particles. Good industrial hygiene should be followed.

A14 Film Thickness: It is essential that ample coating be applied after waterjet cleaning to adequately cover the peaks of the surface profile. The dry film thickness of the coating above the peaks of the surface profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[12] for verification of accuracy of Type 1 and Type 2 gauges should be used.

Appendix B

Methods of Assessing the Degree of Flash Rust (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

The degree of flash rust is related to the quantity of loose, clean rust dust that is present on the surface. One of the following alternative methods may be used to assess the degree of flash rust, or other methods may be used if specified

3. B1 Wipe Test

The following procedure is suggested to standardize the amount of pressure used to perform a wipe test on a flash-rusted surface:

(a) Neatly wrap a white, lint-free, woven cloth around a standard 100 mm (4 in) nylon paint brush, and hold it in place in a manner that prevents the cloth from slipping.

(b) Swipe the cloth-wrapped paint brush across the flash-rusted surface in one motion, using pressure equivalent to that used to apply house paint to a door. The length of the swipe should be consistent (e.g., one pass covering 1,500 mm [6 in] in length).

(c) Remove the white cloth from the paint brush and evaluate the color and amount of rust on the cloth. "Recommended Guidelines for Evaluating Flash Rust,"[13] issued by the NSRP, provides guidance to perform this evaluation of flash rust.

If lint deposition is a concern, the project specification may require use of an alternate technique to determine the degree of flash rust.

4. B2 Tape Pull Test

The tape pull test is a modification of the pressure-sensitive tape method in ISO 8502-3.[14] The procedure is as follows:

(a) Select a test area on the flash-rusted surface to perform the test.
(b) Place a 50 mm (2 in) long piece of tape (as specified in ASTM D 3359[15]) on the selected test area and rub it thoroughly with a fingertip (not a fingernail) to ensure that the tape adheres firmly. Then peel the tape off the surface and place it on a piece of white paper forreference.
(c) Repeat the procedure in (b) nine times (for a total of 10 times) using a fresh piece of tape applied to the same spot on the surface (selected test area) each time.
(d) Assess the appearance of the 10th tape and the appearance of the test area on the flash-rusted surface after the 10th tape is pulled off in accordancewith Table B1.

Appendix C:

Waterjet Cleaning Equipment and Operating Parameters (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any orall of the the provisions herein.

5. C1 Waterjet Cleaning Equipment

Multiple configurations of pumps, heads, and containment systems are suitable for waterjet cleaning operations. The equipment systems may include manual lances, fixed lances on platforms, or robot-driven systems. Additional descriptions relevant to waterjet cleaning systems are in the WaterJet Technology Association's "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment,"[16] which also addresses concerns relevant to waterjet cleaning operations. The commercial waterjet cleaning unit can be mounted on a skid, trailer, or truck; can be equipped with various prime movers (diesel, electric motor, etc.); and usually consists of a pump, hoses, and various tools. The tools can be hand-held or mounted on a robot or controlled by a traversing mechanism. Water is propelled through a single jet, fan jet, pulse generator, or multiple rotating jets. Rotation of the nozzle head is provided by small electric, air, or hydraulic motors, or by slightly inclined orifices in a multiple-orifice nozzle.

C1.1 All waterjet cleaning units normally use a hydraulic hose with a minimum bursting strength of 2.5 times the capability of its maximum-rated operating strength.

C1.2 Waterjet streams are produced by orifices, or tips, that can have different forms–the higher the pressure, the more limited is the choice of forms. Round jets are most commonly used, but orifices of other shapes are available. Tips can be designed to produce multiple jets of water that are normally rotated to achieve higher material-removal rates. Interchangeable nozzle tips should be used to produce the desired streams. The manufacturer should be consulted for specific recommendations.

C1.3 Effect of Corrosion Inhibitors and Detergents on Equipment: If corrosion inhibitors are to be used with the SP water, the manufacturer of the waterjet cleaning equipment should be consulted to ensure compatibility of corrosion inhibitors with the equipment. Compatibility of detergents with the special seals and high-alloy metals of the waterjet cleaning equipment should be carefully investigated to ensure that the cleaning equipment is not damaged.

6. C2 Operating Parameters

C2.1 Waterjet Cleaning Method Selection: The person performing the work should have sufficient experience to select the waterjet cleaning method and the specific combination of water pressure and flow (velocity and volume) to achieve the specified degree of surface cleanliness. A water flow rate of 4 to 53 L/min (1 to 14 gal/min) is typical.

(a) LP WC or HP WC (the flow rate of the water is the dominant energy characteristic);
(b) HP WJ (pressure or water velocity and flow rate are equally important); or
(c) UHP WJ (pressure or water velocity is the dominant energy characteristic).

C2.2 Stand-off Distance: The distance from the nozzle to the work piece surface (stand-off distance) is critical for effective cleaning with any of the waterjet cleaning methods. Typical stand-off distances for HP WJ and UHP WJ range from 25 to 150 mm (1.0 to 6.0 in) for coatings removal. Typical stand-off distances range up to 600 mm (24 in) to remove foreign matter that is not tightly adherent. Excessive stand-off distance does not produce the desired cleaning.

C2.3 Threshold Pressure: The threshold pressure of a coating can be determined. In general, the tougher, more resilient, or harder the coating (i.e., the more resistant to probing or cutting by a pocket knife), the higher the threshold pressure; the softer and more jelly-like the coating, the lower the threshold pressure. Threshold pressure is defined by Summers[17] as the minimum required pressure to penetrate the material. Once the threshold pressure is achieved or exceeded, the production rate increases dramatically. Therefore, waterjet cleaning production rates can be classified according to two conditions:

(a) Relatively Slow—Erosion at pressures lower than the threshold pressure; and
(b) Relatively Fast—Waterjet cutting and erosion at pressures greater than the threshold pressure.

Pressure loss is a function of the flow rate of the water through the hose and the inside diameter of the hose. The manufacturer should be consulted for specific information on potential pressure loss for each type of equipment.

C2.4 Depending on the initial condition of the area and the materials to be removed, the choice of waterjet cleaning method to achieve Thorough Cleaning (WJ-3) is ultimately based on the capabilities of the equipment and its components. Dwell time, traverse rate, pressure, flow, stand-off distances, the number of nozzles, and rotation speed all interact in determining materials that remain and those that are removed.

C2.5 Reuse of Effluent Water: If effluent water is captured for reuse by the waterjet cleaning equipment, caution should be used to avoid introducing any removed contaminants back onto the cleaned substrate. The effluent water may be placed in a clean holding tank and tested to determine the contaminant content prior to reintroduction into the water supply stream to the waterjet cleaning equipment. The effluent water should be monitored for suspended particulates, hydro-carbons, salts, hazardous materials, or other by-products of the surface preparation procedures.

C2.6 Additives: Any detergents, degreasers, or other types of cleaners used in conjunction with the waterjet cleaning method should be removed prior to applying a coating. If corrosion inhibitors are to be used with the SP water, the coating manufacturer should be consulted to ensure compatibility of corrosion inhibitors with the coating.

C2.7 Containment Systems: Containment systems may consist of water-impermeable membranes or vacuum collection heads or the systems described in SSPC-Guide 6.[18] The containment design should consider the pressures used and water volumes produced and if the process may be open or closed loop (with a single pass or multiple passes of the waterthrough the system).

TABLE B1

ASSESSMENT OF DEGREE OF FLASH RUST—TAPE PULL TEST

Degree of Flash Rust	*Appearance of 10th Tape* **(after final pull from test area)**	*7. Appearance of Test Area (after 10th tape pull)*
Light	No rust on tape	No change, or only slight changein test area appearance
Moderate	Slight, localized red-brown rust on tape	Significant change of test area appearance, showing localizedareas of black rust
Heavy	Significant, uniform red-brown rust on tape, also showing grains of black rust	Significant change of test area appearance, showing localized areas of black rust

SSPC: The Society for Protective Coatings/NACE International
Joint Surface Preparation Standard
Waterjet Cleaning of Metals
SSPC-SP WJ-4/NACE WJ-4 – Light Cleaning

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Foreword

This SSPC/NACE joint standard defines the Light Cleaning degree of surface cleanliness of coated or uncoated metallic substrates achieved by the use of waterjet cleaning prior to the application of a protective coating or lining. Waterjet cleaning is the use of pressurized surface preparation water for removing coatings and other materials, including hazardous materials, from a substrate to achieve a defined degree of surface cleanliness. Waterjet cleaning includes various methods such as low-pressure water cleaning (LP WC), high-pressure water cleaning (HP WC), high-pressure waterjetting (HP WJ), and ultrahigh-pressure waterjetting (UHP WJ).

The four degrees of surface cleanliness achieved by waterjet cleaning, which are addressed in separate standards, are as follows:

Degree of Surface Cleanliness	Designation
Clean to Bare Substrate	WJ-1
Very Thorough Cleaning	WJ-2
Thorough Cleaning	WJ-3
Light Cleaning	WJ-4

Light Cleaning (WJ-4) provides a a lesser degree of cleaning than Thorough Cleaning (WJ-3).

Waterjet cleaning to achieve the Light Cleaning (WJ-4) degree of surface cleanliness is used when the objective is to allow as much of the tightly adherent rust and other corrosion products, coating, and mill scale to remain as possible, but when the extra effort required to remove more of these materials is determined to be unwarranted. Discoloration of the surface may be present.

Waterjet cleaning does not provide the primary anchor pattern on the metallic substrate known as “surface profile.” The coatings industry uses waterjet cleaning primarily for recoating or relining projects in which there is an adequate pre-existing surface profile. The degrees of surface cleanliness cited above to be achieved by waterjet cleaning methods are not intended to require that a surface profile be present or defined prior to coating application.

Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates. Waterjet cleaning also helps remove oil, grease, rust and other corrosion products, and other foreign matter (for example, shotcrete spatter) from the surface, and is used when it is a more feasible method of surface preparation than, for example, abrasive blast cleaning, power or hand tool cleaning, or chemical stripping. Waterjet cleaning may be used when the application of high-performance coatings requires extensive surface preparation, surface decontamination, or both.

This standard is intended for use by coating or lining specifiers, applicators, inspectors, or others who have responsibility to define a standard degree of surface cleanliness to be achieved by waterjet cleaning methods.

This standard was prepared by SSPC/NACE Joint Task Group (TG) 278, “Surface Preparation of Metals to WJ-4 (LightCleaning) by High-Pressure Waterjetting.” TG 278 is administered by Specific Technology Group (STG) 04, “Coatings and Linings, Protective–Surface Preparation,” and is sponsored by STG 02, “Coatings and Linings, Protective–Atmospheric,” and STG 03, “Coatings and Linings, Protective–Immersion and Buried Service.” This standard is issued by SSPC Group Committee C.2 on Surface Preparation, and by NACE under the auspices of STG 04. This standard is one of a set of four standards on degrees of surface cleanliness to be achieved by waterjet cleaning that are intended to replace SSPC-SP 12/NACE No. 5,[1] which includes all four degrees of surface cleanliness.

> In SSPC/NACE standards, the terms *shall, must, should*, and *may* are used in accordance with Paragraph 2.2.1.8 of the Agreement between SSPC: The Society for Protective Coatings and NACE International. The terms *shall* and *must* are used to state mandatory requirements. The term *should* is used to state something considered good and is recommended, but is not mandatory. The term *may* is used to state something considered optional.

1. Section 1: General

1.1 This standard defines the Light Cleaning (WJ-4) degree of surface cleanliness of uncoated or coated metallic substrates by use of waterjet cleaning. The defined degree of cleanliness shall be achieved prior to the application of a specified protective coating or lining system. These requirements include the end condition of the surface and materials and procedures necessary to achieve and verify the end condition, as determined by visual inspection. This standard also may be used in situations in which the degree of cleanliness is required, but protective coatings or linings are not immediately applied. (Paragraphs A1 and A2 of Appendix A provide additional information.) Waterjet cleaning does not establish but may reveal an existing surface profile on a metallic substrate. If the existing surface profile is not acceptable for subsequent coating application, alternative surface preparation methods to create the required surface profile must be considered. (Paragraph A3 of Appendix A provides additional information.)

1.1.1 Light Cleaning (WJ-4) is essentially equivalent to the International Organization for Standardization (ISO)(1) 8501-4[2] degree of cleanliness Wa 4, light cleaning. ISO 8502-4 notes the use of various common terms for methods of waterjet cleaning: water jetting, water blast cleaning, hydrojetting, aqua-jetting, hydroblasting, aquablasting, and “cleaning by directing a jet of pressurized water onto the surface to be cleaned.”

1.1.2 Within the hierarchy of degrees of surface cleanliness achieved by waterjet cleaning, Light Cleaning (WJ-4)is intended to be similar to the degree of surface cleanliness of SSPC-SP 7/NACE No. 4,[3] except that tightly adherent material, rather than only stains, is permitted to remain on the surface.

1.2 Although carbon steel is the metallic substrate most frequently cleaned in the field using waterjetting technology, waterjet cleaning may be used on metallic substrates other than carbon steel, including other ferrous substrates suchas alloy steels, stainless steels, ductile iron and cast irons, nonferrous substrates such as aluminum, and copper alloys such as bronze. For convenience, the written definitions of the degrees of surface cleanliness of the metallic substrate use the general term “rust and other corrosion products.” The term “rust” is intended to apply to carbon steel substrates and the term “other corrosion products” (such as surface oxides) is intended to apply to metallic substrates other than carbon steel that are being waterjet cleaned. “Flash rust” is an oxidation product that forms as a wetted carbon steel substrate dries. The visual guides and comparators referenced for cleanliness and flash rust only illustrate carbon steel substrates.

1.3 This standard does not address surface preparation of concrete. Information on surface preparation of concrete can be found in SSPC-SP 13/NACE No. 6.[4]

1.4 This standard is limited to requirements for visible surface contaminants. Information on nonvisible contamination can be found in Paragraph A8 of Appendix A.

2. Section 2: Definitions

2.1 Light Cleaning (WJ-4): A metal surface after Light Cleaning, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust and other corrosion products, and loose coating. Any residual material shall be tightly adhered to the metal substrate and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.

2.1.1 Coatings, mill scale, and foreign matter are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. (Paragraphs A4 and A5 of Appendix A provide additional information.)

2.1.2 The gray to brown-black discoloration remaining on corroded and pitted carbon steel that cannot be removed by further waterjet cleaning is allowed.

2.1.3 SSPC-VIS 4/NACE VIS 7[5] or other visual guide or comparator may be specified to supplement the written definition. In any dispute, the written standard shall take precedence over the visual guide or comparator. (Paragraph A6 of Appendix A provides additional information.)

3. Section 3: Additional Technical Considerations

3.1 Flash Rust

Flash rust is an additional consideration when a carbon steel substrate is subjected to waterjet cleaning. Gray or brown-black discoloration remaining in the pits of waterjet cleaned carbon steel is not the same as flash rust. Metals other than carbon steel can manifest discoloration as well. Degrees of flash rust may be qualitatively described as follows:

3.1.1 No flash rust: A carbon steel surface that, when viewed without magnification, exhibits no visible flash rust.

3.1.2 Light (L) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits small quantities of a rust layer through which the carbon steel substrate may be observed. The rust or discoloration maybe evenly distributed or present in patches, but it is tightly adherent and not easily removed by lightly wiping with a cloth.

3.1.3 Moderate (M) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of rust that obscures the original carbon steel surface. The rust layer may be evenly distributed or present in patches,but it is reasonably well adherent and leaves light marks on a cloth that is lightly wiped over the surface.

3.1.4 Heavy (H) flash rusted surface: A carbon steel surface that, when viewed without magnification, exhibits a layer of heavy rust that hides original carbon steel surface completely. The rust may be evenly distributed or presentin patches, but it is loosely adherent, easily comes off, and leaves significant marks on a cloth that is lightly wiped over the surface.

(Paragraphs A6, A9, and A10 of Appendix A provide additional information. Appendix B provides additional information on methods of assessing the degree of flash rust.)

3.2 Appearance Variations

3.2.1 Acceptable variations in appearance that do not affect the degree of surface cleanliness defined in Paragraph include variations caused by composition of the metallic substrate, original surface condition, thickness of the metal, weld metal, mill or fabrication marks, heat treating, heat-affected zones, and differences resulting from the initial abrasive blast cleaning abrasives or the abrasive blast pattern if previously blast cleaned, or waterjet cleaning pattern.

3.2.1.1 Carbon steel surfaces cleaned by waterjet cleaninginitially exhibit a matte finish with a color that can range from light gray to dark brown-black but immediately acquires a golden hue unless a corrosion inhibitor or environmental controls are used. The matte finish on older carbon steel surfaces that have areas from which coating was removed and areas that were coating-free at the time of cleaning varies even when all visible surface material has been removed.

3.2.2 Metallic substrates show variations in texture, shade, color, tone, pitting, flaking, and mill scale that should be considered during the waterjet cleaning process. (Paragraph A6 of Appendix A provides additional information.)

3.2.3 Direct correlation to existing dry abrasive blasting standards and visual comparators is inaccurate or inappropriate.

4. Section 4: Associated Documents

4.1 Documents associated with this standard and cited in its mandatory sections include:

Document	Title
SSPC-SP 7/NACE No. 4	"Brush-Off Blast Cleaning"
SSPC-SP 13/NACE No. 6	"Surface Preparation of Concrete"
SSPC-VIS 4/NACE VIS 7	"Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting"
SSPC-SP 1[6]	"Solvent Cleaning"

4.1 If there is a conflict between the requirements of any of the documents listed in Paragraph 4.1 and this standard, the requirements of this standard shall govern.

5. Section 5: Procedures Before Waterjet Cleaning

5.1 Precleaning: Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, and A10 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

5.2 Prior to beginning waterjet cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag shall be addressed to the extent required by the procurement documents (project specifications). (Paragraph A12 of Appendix A provides additional information.)

5.3 CAUTION: Waterjet cleaning can be destructive to nonmetallic surfaces. Wood, rubber, insulation, electric installations, instrumentation, etc., must be protected from direct and indirect impingement of water streams.

5.4 If a visual guide or comparator is specified to supplement the written standard, the condition of the substrate prior to waterjet cleaning should be determined before the waterjet cleaning commences. (Paragraph A6 of Appendix A provides additional information.)

6. Section 6: Waterjet Cleaning Methods

6.1 Any of the following waterjet cleaning methods may be used to achieve the Light Cleaning (WJ-4) degree of surface cleanliness. These waterjet cleaning methods all require the use of surface preparation water (hereinafter referred to as "SP water") in accordance with Paragraph 6.2. The presence of toxic metals in a coating being removed can place restrictions on the methods of cleaning permitted. The chosen method shall comply with applicable regulations. (Paragraph A13 of Appendix A and Paragraph C2.3 of Appendix C provide additional information.)

6.1.1 Water cleaning (WC): Use of pressurized SP water discharged from a nozzle to remove unwanted matter from a surface.

6.1.1.1 Low-pressure water cleaning (LP WC): Water cleaning performed at pressures less than 34 MPa (5,000 psig). This is also called "power washing" or "pressure washing."

6.1.1.2 High-pressure water cleaning (HP WC): Water cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig).

6.1.2 Waterjetting (WJ): Use of SP water discharged from a nozzle at pressures of 70 MPa (10,000 psig) or greater to prepare a surface for coating or inspection. The velocity of the SP water exiting the orifice is greater than 340 m/s (1,100 ft/s).

6.1.2.1 High-pressure waterjetting (HP WJ): Waterjetting performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig).

6.1.2.2 Ultrahigh-pressure waterjetting (UHP WJ): Waterjetting performed at pressures greater than 210 MPa (30,000 psig).

6.2 Surface preparation water (SP water): Water of sufficient purity and quality that it does not prevent the surface being cleaned from achieving the WJ-4 degree of surface cleanliness or nonvisible contamination criteria when contained in the procurement documents. SP water should not contain sediments or other impurities that are destructive to the proper functioning of the cleaning equipment. (Paragraph A7 of Appendix A provides additional information.)

7. Section 7: Procedures Following Waterjet Cleaning and Immediately Prior to Coating

7.1 Visible deposits of oil, grease, foreign matter, and other contaminants shall be removed by waterjet cleaning, by methods in accordance with SSPC-SP 1, or as specified. (Paragraphs A4, A5, A10, and A11 of Appendix A and Paragraph C2.6 of Appendix C provide additional information.)

7.2 The existing surface profile shall be assessed to determine conformance with the requirements of the procurement documents. (Paragraphs A3 and A14 of Appendix A provide additional information.)

7.3 Immediately prior to coating application, the entire surface shall comply with the degree of surface cleanliness specified herein, and to the extent established, the procurement document (project specification) requirements, and degree of flash rust.

7.4 Flash rust shall be mitigated in accordance with the requirements of the procurement documents. An example of a specification statement is provided in Paragraph A10 of Appendix A. It is common practice to remove heavy flash rust by LP WC, HP WC, or dry abrasive sweep blasting.

7.5 Dust and loose residues shall be removed from cleaned surfaces by brushing; blowing off with clean, dry air; vacuum cleaning; or other specified methods. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air. (Paragraph A13 of Appendix A provides additional information.)

References

1. SSPC-SP 12/NACE No. 5 (latest revision), "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating" (Pittsburgh, PA: SSPC and Houston, TX: NACE).

2. ISO 8501-4 (latest revision), "Preparation of steel substrates before application of paints and related products–Visual assessment of surface cleanliness–Part 4: "Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting" (Geneva, Switzerland: ISO).

3. SSPC-SP 7/NACE No. 4 (latest revision), "Industrial Blast Blast Cleaning" (Pittsburgh, PA: SSPC and Houston, TX: NACE).

4. SSPC-SP 13/ NACE No. 6 (latest revision), "Surface Preparation of Concrete" (Pittsburgh, PA: SSPC and Houston, TX: NACE).

5. SSPC-VIS 4/NACE VIS 7 (latest revision), "Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting" (Pittsburgh, PA: SSPC and Houston, TX: NACE).

6. SSPC-SP 1 (latest revision), "Solvent Cleaning" (Pittsburgh, PA: SSPC).

7. SSPC-PA Guide 4 (latest revision), "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems" (Pittsburgh, PA: SSPC).

8. SSPC-Guide 15 (latest revision), "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates" (Pittsburgh, PA: SSPC).

9. SSPC-SP COM (latest revision), "Surface Preparation Commentary for Steel and Concrete Substrates" (Pittsburgh, PA: SSPC).

10. NACE SP0178 (formerly RP0178) (latest revision), "Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service" (Houston, TX: NACE).

11. SSPC-PA 2 (latest revision), "Measurement of Dry Coating Thickness with Magnetic Gages" (Pittsburgh, PA: SSPC).

12. "Recommended Guidelines for Evaluating Flash Rust" (Charleston, SC: National Shipbuilding Research Program [NSRP],(2) 2009). (Available from SSPC and NACE.)

13. ISO 8502-3 (latest revision), "Preparation of steel substrates before application of paints and related products–Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)" (Geneva, Switzerland: ISO).

14. ASTM(3) D 3359 (latest revision), "Standard Test Methods for Measuring Adhesion by Tape Test" (West Conshohocken, PA: ASTM).

15. "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment" (latest revision) (St. Louis, MO: WaterJet Technology Association [WJTA]).(4)

16. D.A. Summers, WaterJetting Technology (London, UK: Chapman and Hall, 1995).

17. SSPC-Guide 6 (latest revision), "Guide for Containing Debris Generated During Paint Removal Operations" (Pittsburgh, PA: SSPC).

1. Appendix A: Explanatory Notes(Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any orall of the the provisions herein.

A1 Function: Light Cleaning (WJ-4) provides a lesser degree of cleaning than Thorough Cleaning (WJ-3). The hierarchy of waterjet cleaning standards is as follows: WJ-1, WJ 2, WJ-3, and WJ-4. Light Cleaning (WJ-4) should be used when the service environment is mild enough to permit tight mill scale, coating, rust, and other foreign matter to remain on the surface. WJ-4 is typically used when a compatible coating is to be applied over existing coatings. The primary functions of waterjet cleaning before coating are

(a) To remove material from the surface that can cause early failure of the coating system;
(b) To enhance the adhesion of the new coating system;
(c) To expose the surface profile of the substrate that is underneath the existing coating or rust and other corrosion products. (Paragraph A3 provides additional information.); and
(d) To reduce or remove nonvisible contamination.

Light Cleaning (WJ-4) is used when the objective is to allow as much of the tightly adherent rust and other corrosion products, coating, and mill scale to remain as possible. Discoloration of the metal substrate may be present. Discoloration of the metal substrate surface may be present. Waterjet cleaning reduces and may completely remove water-soluble surface contaminants, notably those contaminants found at the bottom of pits on the surface of corroded metallic substrates.

Light Cleaning (WJ-4) allows as much of the tightly adherent matter to remain as possible. Thorough Cleaning (WJ-3) allows staining or tightly adherent matter to a maximum of 33 percent of each unit area of the surface. Very Thorough Cleaning (WJ-2) allows staining or tightly adherent matter to a maximum of 5 percent of each unit area of the surface, and a Clean to Bare Substrate (WJ-1) surface is free of all visible rust and other corrosion products, dirt, previous coatings, mill scale, and foreign matter.

A2 Maintenance Coating Work: When this standard is used in maintenance coating work, specific instructions should be provided on the extent of surface to be waterjet cleaned or spot-waterjet cleaned to this degree of surface cleanliness. In these cases, the surface cleanliness should be achieved across the entire area specified. For example, if all weld seams are to be cleaned in a maintenance operation, the degree of surface cleanliness applies to 100 percent of all weld seams. If the entire structure is to be cleaned, this degree of surface cleanliness applies to 100 percent of the entire structure. SSPC-PA Guide 4[7] provides a description of accepted practices for retaining old sound coating, removing unsound coating, feathering, and spot cleaning.

A3 Surface Profile: Waterjet cleaning reveals the surface profile (roughness) of the substrate that exists under the original coatings or rust and other corrosion products. When a coating is specified, another surface preparation method may be needed in addition to the waterjet cleaning to achieve the surface profile suitable for the specified coating system.

A4 Rust Scale: If rust scale is present, it must be removed. Rust scale is not a suitable substrate over which to apply coatings, and, if not removed, may also prevent removal of water-soluble salts that may accelerate corrosion. Methods other than waterjet cleaning may be used.

A5 Mill Scale: Mill scale is not allowed in this degree of surface cleanliness. Mill scale is that dark blue-black layer of iron oxide on the surface of hot-rolled steel. Over time, the adherence of the mill scale can change. Older mill scale might be removed easily in the field with waterjetting at 100 MPa (15,000 psi) and above. Waterjetting at pressures greater than 240 MPa (35,000 psig) is capable of removing tightly adherent mill scale, but production rates are not always cost effective. When the mill scale comes off, the steel surface under the mill scale has whatever surface profile is under the mill scale.

Reference Photographs: Photographs may be specified to supplement the written definition. SSPC-VIS 4/ NACE VIS 7 depicts various precleaning conditions and the appearance of a carbon steel surface that is consistent with the Light Cleaning (WJ-4) degree of surface cleanliness defined in this standard. In any dispute, the written standard shall take precedence over the visual guide. The visual appearance of carbon steel that has heavily flash rusted after initial waterjet cleaning and is then recleaned by LP WC has a different appearance from the original light flash-rusted steel depicted in SSPC-VIS 4/ NACE VIS 7.

A7 Quality of Water: SP water used by waterjet cleaning equipment should be clean and free of erosive silts or other contaminants that damage pump valves and/or prevent the surface from achieving the specified degree of surface cleanliness. A general rule is that the cleaner the water, the longer the service life of the waterjet cleaning equipment. The use of deionized water may be detrimental to some water pumps and care should be taken to ensure compatibility.

A8 Nonvisible Contamination (NV)

A8.1 Nonvisible contamination (NV): Nonvisible contamination is the presence of organic matter, such as thin films of oil and grease, and inorganic and/or soluble ionic materials such as chlorides, ferrous salts, nitrates, and sulfates that may be present on the substrate. (Paragraphs A6, A7, and A8 provide additional information.)

A8.2 Steel contaminated with water-soluble salts (e.g., sodium chloride and potassium sulfate) rapidly develops rust-back. Rust-back can be minimized by removing these salts from the steel surface and eliminating sources of recontamination during and after cleaning. These contaminants, along with their concentrations, may be identified using laboratory and field tests as described in SSPC Guide 15.[8] Conductivity measurement is another method for testing for water-soluble salts.

A8.3 Other nonvisible contaminants (e.g., oil, acid, base, silicone, wax) may have an effect on coating performance. Coatings manufacturers should be consulted for recommendations of maximum surface contamination allowed. The specifier should determine what level of nonvisible contaminants may remain.

A8.4 The test method or procedure to be used for determining the level of remaining nonvisible contaminants should be addressed in the procurement documents (project specification).

A8.5 The level of nonvisible contaminants found in an extraction from the surface that may remain on the surface is usually expressed as mass per unit area; for example, $\mu g/cm^2$ or mg/m^2 ($1\ \mu g/cm^2 = 10\ mg/m^2$).

A8.6 The following is an example specification for salt contamination based on concentration measurements:

"Immediately prior to the application of the coating, the surface extract shall not contain more than xx $\mu g/cm^2$ of the specific contaminant (e.g., chloride) when tested with a specified method."

A8.7 The following is an example specification for salt contamination based on conductivity measurements:

"Immediately prior to the application of the coating, the conductivity of the surface extract shall not exceed xx μS/cm when tested with a specified method."

A9 Use of Corrosion Inhibitors: It may be advantageous to add corrosion inhibitors to the SP water or apply them to the surface immediately after waterjet cleaning to temporarily prevent rust formation. Some corrosion inhibitor treatments may interfere with the performance of certain coatings systems. The coatings manufacturer should be consulted to ensure the compatibility of corrosion inhibitors with the coatings.

A10 Specification Statement:

A10.1 The specifier should use the degree of surface cleanliness and one of the degrees of flash rust to specify the required end condition. The following are examples of a specification statement:

"All surfaces to be recoated shall be waterjet cleaned to SSPC-SP WJ-4 L/NACE WJ-4/L, Light Cleaning, Light Flash Rust."

"At the time of the recoating, the degree of flash rust shall be no greater than moderate (M)."

A10.2 In addition, the specifier should consider whether a surface should be cleaned as required to achieve a particular, not to exceed maximum, level of nonvisible contamination (NV) prior to recoating. A suggested specification statement for nonvisible contamination (NV) is given in Paragraph A8.

A11 Flash Rust: An oxidation product that forms as a wetted carbon steel substrate dries. With the exception of stainless steel surfaces, any steel surface may show flash rust within 30 minutes or longer while the substrate is drying (water evaporation) after waterjet cleaning, depending on environmental conditions. Flash rust has the appearance of rust bloom. Flash rust quickly changes the appearance of the waterjet cleaned surface and may be reduced or eliminated by physical or chemical methods. 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. With time, the flash rust changes from a yellow-brown, well adherent, light rust to a red-brown, loosely adherent, heavy rust. Appendix B contains additional information on methods of assessing the degree of flash rust.

A12.1 Surface imperfections that can cause premature failure are often present. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to properly cover and protect include crevices, weld porosities, and laminations.

A12.2 Poorly adhering fabrication defects, such as weld slag residues, loose weld spatter, and surface laminations may be removed during the waterjet cleaning operation. Other surface defects, such as steel laminations, weld porosities, or deep corrosion pits may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work should be given prior consideration because the timing of the repairs may occur before, during, or after the waterjet cleaning operation. The SSPC-SP COM[9] and NACE SP0178[10] contain additional information on surface imperfections.

A12.3 The high cost of the methods to remedy surface imperfections (e.g., edge rounding and weld spatter removal) should be compared with the benefits of preventing premature coating failure. Therefore, those responsible for establishing the requirements and those responsible for performing the work should agree on the procedures to be used to repair surface imperfections to the extent required in the procurement documents (project specification).

A13 Removal of Coatings with Hazardous Components—Hygiene: Waterjet cleaning is often used to remove coatings with hazardous components. Because the particles are wetted, respiratory protection requirements for waterjet cleaning may be less stringent than for other methods of surface preparation. However, the wetted particles tend to stay on the skin. Applicable industrial hygiene tests should be performed to determine the destination of the wetted particles. Good industrial hygiene should be followed.

A14 Film Thickness: It is essential that ample coating be applied after waterjet cleaning to adequately cover the peaks of the surface profile. The dry film thickness of the coating above the peaks of the surface profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or coating failure will occur. To ensure that coating thicknesses are properly measured, the procedures in SSPC-PA 2[11] for verification of accuracy of Type 1 and Type 2 gauges should be used.

1. *A12 Surface Imperfections:*

Appendix B

Methods of Assessing the Degree of Flash Rust (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the

The degree of flash rust is related to the quantity of loose, clean rust dust that is present on the surface. One of the following alternative methods may be used to assess the degree of flash rust, or other methods may be used if specified. the provisions herein.

2. *B1 Wipe Test*

The following procedure is suggested to standardize the amount of pressure used to perform a wipe test on a flash-rusted surface:

(a) Neatly wrap a white, lint-free, woven cloth around a standard 100 mm (4 in) nylon paint brush, and hold it in place in a manner that prevents the cloth from slipping.

(b) Swipe the cloth-wrapped paint brush across the flash-rusted surface in one motion, using pressure equivalent to that used to apply house paint to a door. The length of the swipe should be consistent (e.g., one pass covering 1,500 mm [6 in] in length).

(c) Remove the white cloth from the paint brush and evaluate the color and amount of rust on the cloth. "Recommended Guidelines for Evaluating Flash Rust,"[12] issued by the NSRP, provides guidance to perform this evaluation of flash rust.

If lint deposition is a concern, the project specification may require use of an alternate technique to determine the degree of flash rust.

3. *B2 Tape Pull Test*

The tape pull test is a modification of the pressure-sensitive tape method in ISO 8502-3.[13] The procedure is as follows:

(a) Select a test area on the flash-rusted surface to perform the test.
(b) Place a 50 mm (2 in) long piece of tape (as specified in ASTM D 3359[14]) on the selected test area and rub it thoroughly with a fingertip (not a fingernail) to ensure that the tape adheres firmly. Then peel the tape off the surface and place it on a piece of white paper forrereference.
(c) Repeat the procedure in (b) nine times (for a total of 10 times) using a fresh piece of tape applied to the same spot on the surface (selected test area) each time.
(d) Assess the appearance of the 10th tape and the appearance of the test area on the flash-rusted surface after the 10th tape is pulled off in accordance with Table B1.

Appendix C:

Waterjet Cleaning Equipment and Operating Parameters (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the the provisions herein.

C1 Waterjet Cleaning Equipment

Multiple configurations of pumps, heads, and containment systems are suitable for waterjet cleaning operations. The equipment systems may include manual lances, fixed lances on platforms, or robot-driven systems. Additional descriptions relevant to waterjet cleaning systems are in the WaterJet Technology Association's "Recommended Practices for the Use of Manually Operated High-Pressure Waterjetting Equipment,"[15] which also addresses concerns relevant to waterjet cleaning operations. The commercial waterjet cleaning unit can be mounted on a skid, trailer, or truck; can be equipped with various prime movers (diesel, electric motor, etc.); and usually consists of a pump, hoses, and various tools. The tools can be hand-held or mounted on a robot or controlled by a traversing mechanism. Water is propelled through a single jet, fan jet, pulse generator, or multiple rotating jets. Rotation of the nozzle head is provided by small electric, air, or hydraulic motors, or by slightly inclined orifices in a multiple-orifice nozzle.

C1.1 All waterjet cleaning units normally use a hydraulic hose with a minimum bursting strength of 2.5 times the capability of its maximum-rated operating strength.

C1.2 Waterjet streams are produced by orifices, or tips, that can have different forms–the higher the pressure, the more limited is the choice of forms. Round jets are most commonly used, but orifices of other shapes are available. Tips can be designed to produce multiple jets of water that are normally rotated to achieve higher material-removal rates. Interchangeable nozzle tips should be used to produce the desired streams. The manufacturer should be consulted for specific recommendations.

C1.3 Effect of Corrosion Inhibitors and Detergents on Equipment: If corrosion inhibitors are to be used with the SP water, the manufacturer of the waterjet cleaning equipment should be consulted to ensure compatibility of corrosion inhibitors with the equipment. Compatibility of detergents with the special seals and high-alloy metals of the waterjet cleaning equipment should be carefully investigated to ensure that the cleaning equipment is not damaged.

4. C2 Operating Parameters

C2.1 Waterjet Cleaning Method Selection: The person performing the work should have sufficient experience to select the waterjet cleaning method and the specific combination of water pressure and flow (velocity and volume) to achieve the specified degree of surface cleanliness. A water flow rate of 4 to 53 L/min (1 to 14 gal/min) is typical.

(a) LP WC or HP WC (the flow rate of the water is the dominant energy characteristic);
(d) HP WJ (pressure or water velocity and flow rate are equally important); or
(e) HP WJ (pressure or water velocity is the dominant energy characteristic).

C2.2 Stand-off Distance: The distance from the nozzle to the work piece surface (stand-off distance) is critical for effective cleaning with any of the waterjet cleaning methods. Typical stand-off distances for HP WJ and UHP WJ range from 25 to 150 mm (1.0 to 6.0 in) for coatings removal. Typical stand-off distances range up to 600 mm (24 in) to remove foreign matter that is not tightly adherent. Excessive stand-off distance does not produce the desired cleaning.

C2.3 Threshold Pressure: The threshold pressure of a coating can be determined. In general, the tougher, more resilient, or harder the coating (i.e., the more resistant to probing or cutting by a pocket knife), the higher the threshold pressure; the softer and more jelly-like the coating, the lower the threshold pressure. Threshold pressure is defined by Summers[16] as the minimum required pressure to penetrate the material. Once the threshold pressure is achieved or exceeded, the production rate increases dramatically. Therefore, waterjet cleaning production rates can be classified according to two conditions:

(a) Relatively Slow–Erosion at pressures lower than the threshold pressure; and
(b) Relatively Fast–Waterjet cutting and erosion at pressures greater than the threshold pressure.

Pressure loss is a function of the flow rate of the water through the hose and the inside diameter of the hose. The manufacturer should be consulted for specific information on potential pressure loss for each type of equipment.

C2.4 Depending on the initial condition of the area and the materials to be removed, the choice of waterjet cleaning method to achieve Light Cleaning (WJ-4) is ultimately based on the capabilities of the equipment and its components. Dwell time, traverse rate, pressure, flow, stand-off distances, the number of nozzles, and rotation speed all interact in determining materials that remain and those that are removed.

C2.5 Reuse of Effluent Water: If effluent water is captured for reuse by the waterjet cleaning equipment, caution should be used to avoid introducing any removed contaminants back onto the cleaned substrate. The effluent water may be placed in a clean holding tank and tested to determine the contaminant content prior to reintroduction into the water supply stream to the waterjet cleaning equipment. The effluent water should be monitored for suspended particulates, hydrocarbons, salts, hazardous materials, or other by-products of the surface preparation procedures.

C2.6 Additives: Any detergents, degreasers, or other types of cleaners used in conjunction with the waterjet cleaning method should be removed prior to applying a coating. If corrosion inhibitors are to be used with the SP water, the coating manufacturer should be consulted to ensure compatibility of corrosion inhibitors with the coating.

C2.7 Containment Systems: Containment systems may consist of water-impermeable membranes or vacuum collection heads or the systems described in SSPC-Guide 6.[17] The containment design should consider the pressures used and water volumes produced and if the process may be open or closed loop (with a single pass or multiple passes of the water through the system).

TABLE B1
ASSESSMENT OF DEGREE OF FLASH RUST—TAPE PULL TEST

Degree of Flash Rust	Appearance of 10th Tape (after final pull from test area)	Appearance of Test Area (after 10th tape pull)
Light	No rust on tape	No change, or only slight changein test area appearance
Moderate	Slight, localized red-brown rust on tape	Significant change of test area appearance, showing localized areas of black rust
Heavy	Significant, uniform red-brown rust on tape, also showing grains of black rust	Significant change of test area appearance, showing localized areas of black rust

ANEXO Nº 8

Designation: D 610 – 01

Steel Structures Painting Council

SSPC-VIS-2

Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces[1]

This standard is issued under the fixed designation D 610; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (e) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers the evaluation of the degree of rusting on painted steel surfaces. The visual examples which depict the percentage of rusting given in the written specifications form part of the standard. In the event of a dispute, the written definition prevails. These visual examples were developed in cooperation with SSPC: The Society for Protective Coatings to further standardization of methods.

1.2 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2.

3. Referenced Documents

3.1 ASTM Adjunct/SSPC: The Society for Protective Coat- ings SSPC-VIS 2/ASTM D 610 Standard Method of EvaluatingDegrees of Rusting on Painted Steel Surfaces[2]

4. Significance and Use

4.1 The amount of rusting beneath or through a paint film is a significant factor in determining whether a coating system should be repaired or replaced. This test method provides a standardized means for quantifying the amount and distributionof visible surface rust.

4.2 The degree of rusting is evaluated using a zero to ten scale based on the percentage of visible surface rust.

4.3 The distribution of the rust is classified as spot rust, general rust, pinpoint rust or hybrid rust.

5. Interferences

5.1 The visual examples that are part of this test method and the associated rust-grade scale cover only rusting evidenced by visible surface rust.

5.2 The use of the visual examples requires the following cautions:

5.2.1 Some finishes are stained by rust. This staining must not be confused with the actual rusting involved.

5.2.2 Accumulated dirt or other material may make accurate determination of the degree of rusting difficult.

5.2.3 Certain types of deposited dirt that contain iron or iron compounds may cause surface discoloration that should not be mistaken for corrosion.

5.2.4 Failure may vary over a given area. Discretion must therefore be used when selecting a single rust grade or rust distribution that is to be representative of a large area or structure, or in subdividing a structure for evaluation.

5.2.5 The color of the finish coating should be taken into account in evaluating surfaces as failures will be more apparenton a finish that shows color contrast with rust, such as used in these reference standards, than on a similar color, such as an iron oxide finish.

6. Procedure

6.1 Select an area to be evaluated.

6.2 Determine the type of rust distribution using definitionsin Table 1 and visual examples in Fig. 1, Fig. 2, and Fig. 3.

6.3 Estimate percentage of surface area rusted using the visual examples in Fig. 1, Fig. 2, and Fig. 3 or SSPC-VIS 2, or both, by electronic scanning techniques or other method agreed upon by contracting parties.

Note 1—The numerical rust grade scale is an exponential function of the area of rust. The rust grade versus area of rust is a straight line plot on semilogarithmic coordinate from rust grade 10 to rust grade 4. The slope of the curve was changed at 10 % of the area rusted to 100 % rusted to permit inclusion of complete rusting on the 0 to 10 rust scale.

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[1] This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility ofSubcommittee D01.46 on Industrial Protective Coatings.

This test method has been jointly approved by ASTM and SSPC: The Society for Protective Coatings.

Current edition approved May 10, 2001. Published July 2001. Originally published as D 610 – 41. Last previous edition D 610 – 95.

[2] Colored visual examples are available at a nominal cost from ASTM Headquarters (request Adjunct ADJD0610a), SSPC Publication No. 00-08 from SSPC: The Society for Protective Coatings, 40 24th Street, Sixth Floor, Pittsburgh, PA 15213, www.sspc.org.

TABLE 1 Scale and Description of Rust Ratings

Rust Grade	Percent of Surface Rusted	Visual Examples		
		Spot(s)	General (G)	Pinpoint (P)
10	Less than or equal to 0.01 percent		None	
9	Greater than 0.01 percent and up to 0.03 percent	9–S	9–G	9–P
8	Greater than 0.03 percent and up to 0.1 percent	8–S	8–G	8–P
7	Greater than 0.1 percent and up to 0.3 percent	7–S	7–G	7–P
6	Greater than 0.3 percent and up to 1.0 percent	6–S	6–G	6–P
5	Greater than 1.0 percent and up to 3.0 percent	5–S	5–G	5–P
4	Greater than 3.0 percent and up to 10.0 percent	4–S	4–G	4–P
3	Greater than 10.0 percent and up to 16.0 percent	3–S	3–G	3–P
2	Greater than 16.0 percent and up to 33.0 percent	2–S	2–G	2–P
1	Greater than 33.0 percent and up to 50.0 percent	1–S	1–G	1–P
0	Greater than 50 percent		None	

Rust Distribution Types:

S: Spot Rusting—Spot rusting occurs when the bulk of the rusting is concentrated in a few localized areas of the painted surface. The visual examples depicting thistype of rusting are labeled 9-S thru 1-S (See Fig. 1, Fig. 2, and Fig. 3).
G: General Rusting—General rusting occurs when various size rust spots are randomly distributed across the surface. The visual examples depicting this type of rustingare labeled 9-G thru 1-G. (See Fig. 1, Fig. 2, and Fig. 3).
P: Pinpoint Rusting—Pinpoint rusting occurs when the rust is distributed across the surface as very small individual specks of rust. The visual examples depicting thistype of rusting are labeled 9-P through 1-P. (See Fig. 1, Fig. 2, and Fig. 3).
H: Hybrid Rusting—An actual rusting surface may be a hybrid of the types of rust distribution depicted in the visual examples. In this case, report the total percent ofrust to classify the surface. 9-H through 1-H.

6.4 Use percentage of surface area rusted to identify rust grade (see Table 1). Assign rust rating using rust grade of 0-10 followed by the type of rust distribution identified by *S* for spot, *G* for general, *P* for pinpoint or *H* for Hybrid.

6.5 The visual examples are not required for use of the rust-grade scale since the scale is based upon the percent of the area rusted and any method of assessing area rust may be used to determine the rust grade.

7. Report

7.1 Identify sample or area evaluated.

7.2 Report rust grade using rating of 0-10.

7.3 Report rust distribution using *S* for Spot, *G* for General, *P* for Pinpoint and *H* for Hybrid.

8. Precision and Bias

8.1 No precision or bias statement can be made for this test method.

9. Keywords

9.1 corrosion; rusting

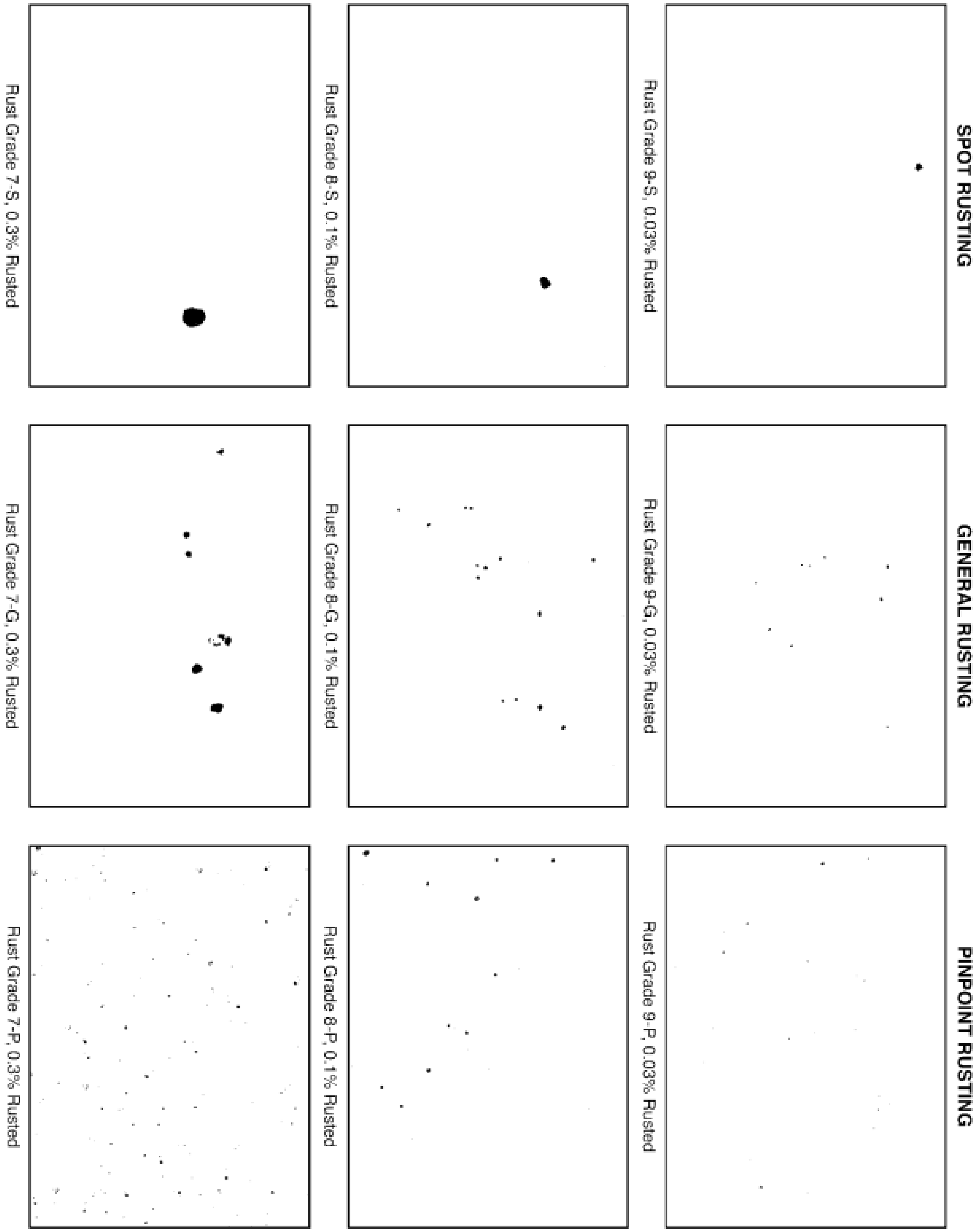

FIG. 1

FIG. 1 Examples of Area Percentages

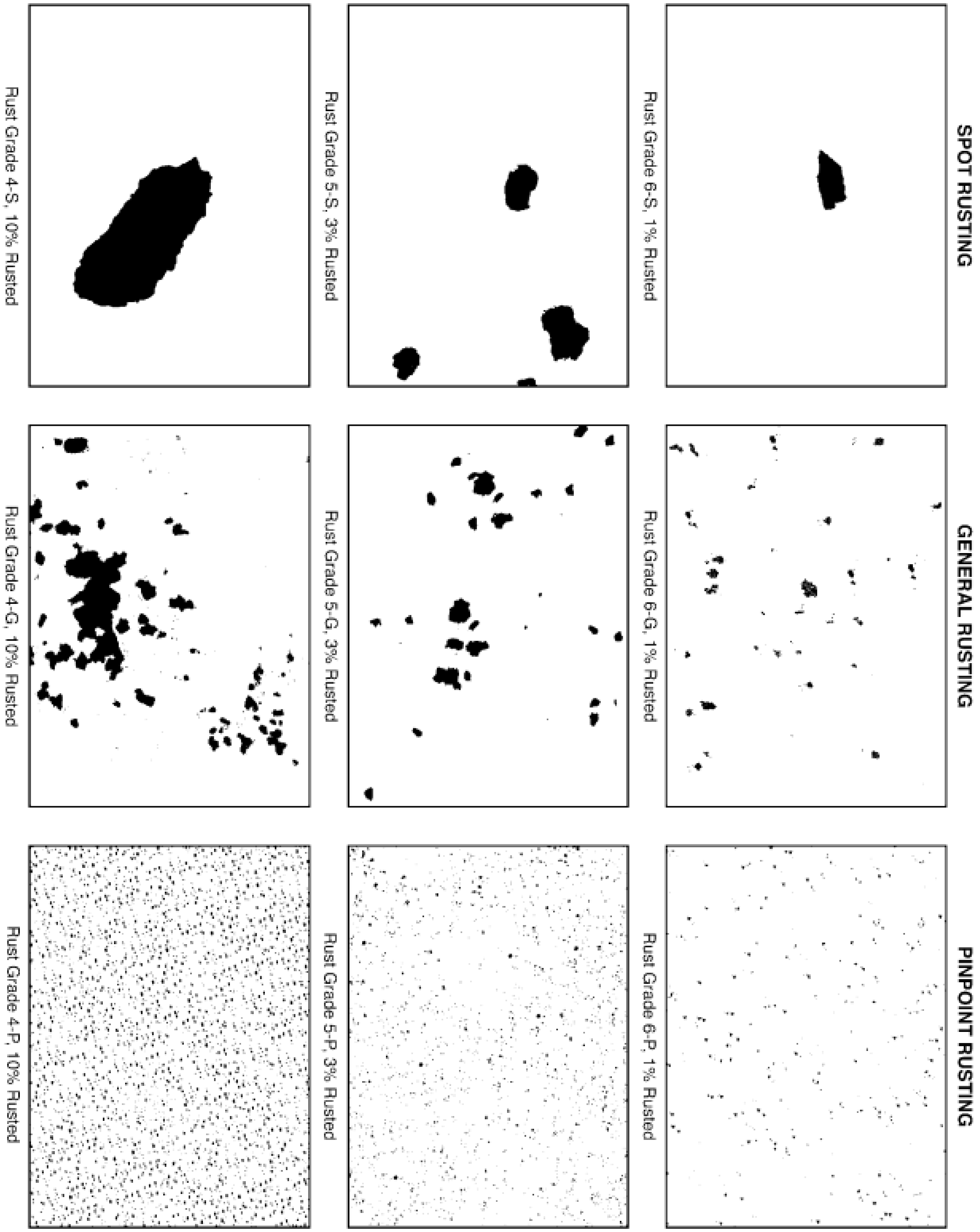

FIG. 2

FIG. 2 Examples of Area Percentages

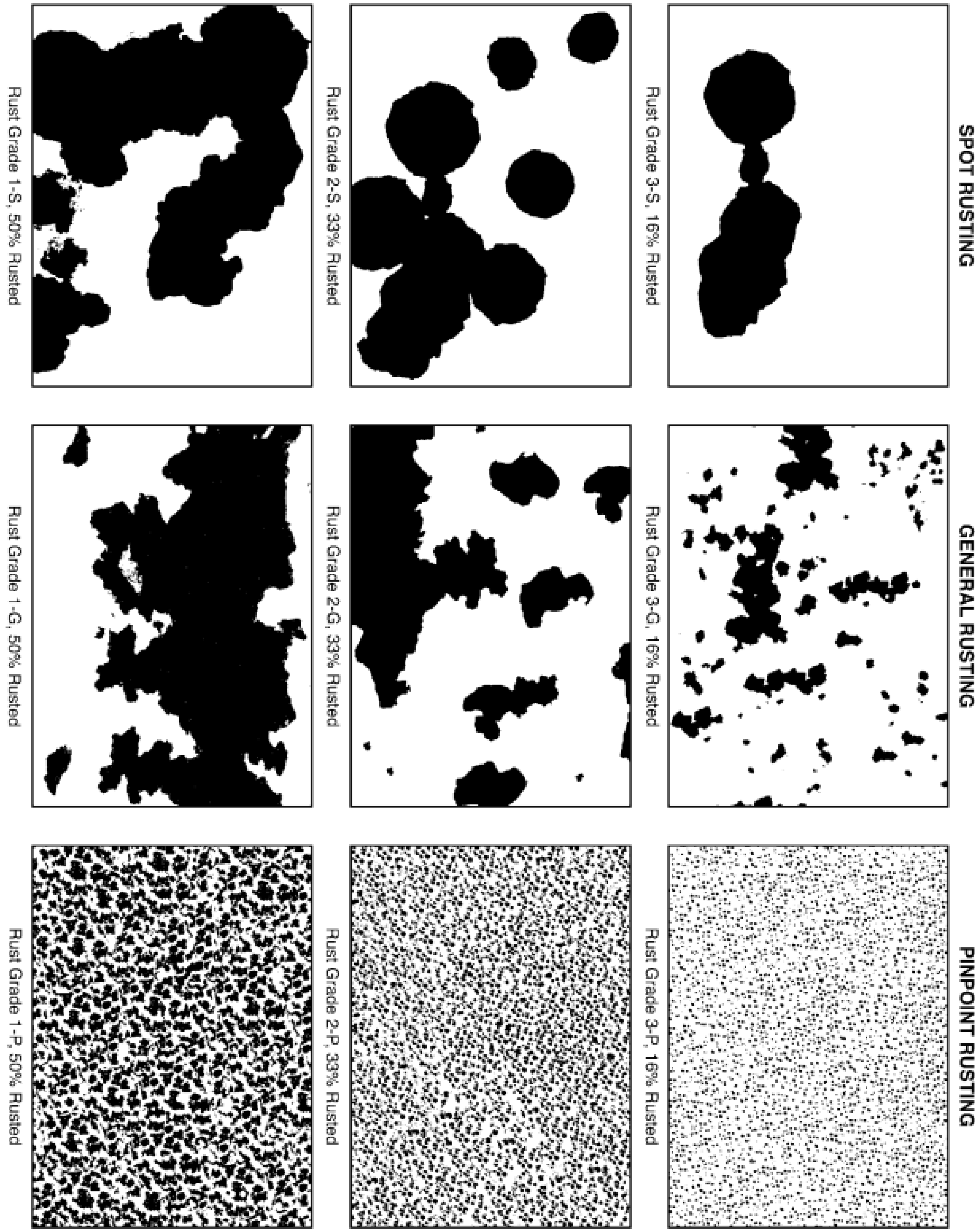

FIG. 3

FIG. 3 Examples of Area Percentages

SUMMARY OF CHANGES

Committee D01 has identified the location of selected changes to this standard since the last date of issue that may impact the use of this standard.

(1) This test method revised in 2001 to include the rust distribution information.
(2) The visual examples were changed from nine pictorial representation to twenty-seven rust grade and rust distribution visual examples.
(3) Previously numerical rust grade rating of 0-10 were used. Now rust grade of 0-10 are followed by rust distribution of *S*, *G*,*P* or *H*

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ANEXO Nº 9

Designation: D 714 – 87 (Reapproved 2000)

Standard Test Method for Evaluating Degree of Blistering of Paints[1]

This standard is issued under the fixed designation D 714; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (e) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method employs photographic reference standards to evaluate the degree of blistering that may develop when paint systems are subjected to conditions which will cause blistering. While primarily intended for use on metal and other nonporous surfaces, this test method may be used to evaluate blisters on porous surfaces, such as wood, if the size of blisters falls within the scope of these reference standards. When the reference standards are used as a specification of performance, the permissible degree of blistering of the paint system shall be agreed upon by the purchaser and the seller.

1.2 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Significance and Use

2.1 A phenomenon peculiar to painted surfaces is the formation of blisters relative to some system weakness. This test method provides a standard procedure of describing the size and density of the blisters so that comparisons of severity can be made.

3. Reference Standards

3.1 The photographic reference standards are glossy prints.[2] Figs. 1-4 are reproductions of these standards and are included to illustrate two characteristics of blistering: size and fre- quency.

3.2 *Size*—Reference standards have been selected for four steps as to size on a numerical scale from 10 to 0, in which No.10 represents no blistering. Blistering standard No. 8 represents

the smallest size blister easily seen by the unaided eye. Blistering standards Nos. 6, 4, and 2 represent progressively larger sizes.

Medium dense, *MD*,Medium, *M*, and Few, *F*.

1. *Frequency*—Reference standards have been selected for four steps in frequency at each step in size, designated as follows:
2. Pattern of distribution over the surface, andShape of blister
3. For the usual tests, an actual count is more elaborate than is necessary.

Dense, *D*,

4. Procedure

1 Subject the paint film to the test conditions agreed upon by the purchaser and the seller. Then evaluate the paint film for the degree of blistering by comparison with the photographic reference standards in Figs. 1-4.

5. Report

1 Report blistering as a number (Note 2) designating the size of the blisters and a qualitative term or symbol indicating the frequency.

2 Intermediate steps in size or frequency of blisters may be judged by interpolation.

3 When the distribution of blisters over the area has a nonuniform pattern, use an additional phrase to describe the distribution, such as “small clusters,” or “large patches.”

NOTE 2—The number refers to the largest size blister that is numerous enough to be representative of the specimen. For example, photographic standard No. 4, “Dense,” has blisters ranging in size from about No. 7 to No. 4, inclusive.

6. Keywords

1 blistering; corrosion; evaluations; reference standards

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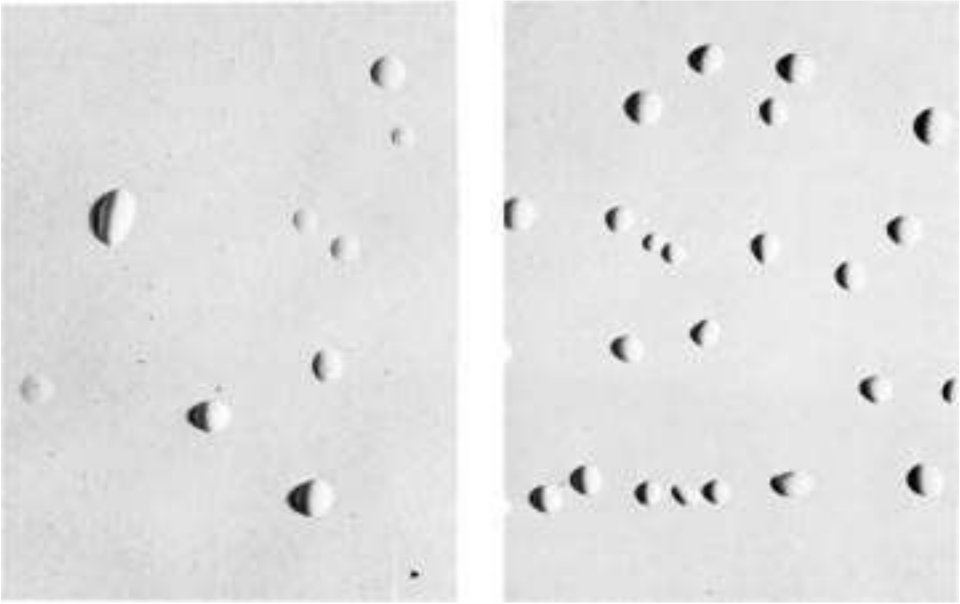
[1] This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.25 on Pictorial Standards of Coating Defects.

Current edition approved May 29, 1987. Published July 1987. Originally published as D 714 – 43 T. Last previous edition D 714 – 56 (1981).

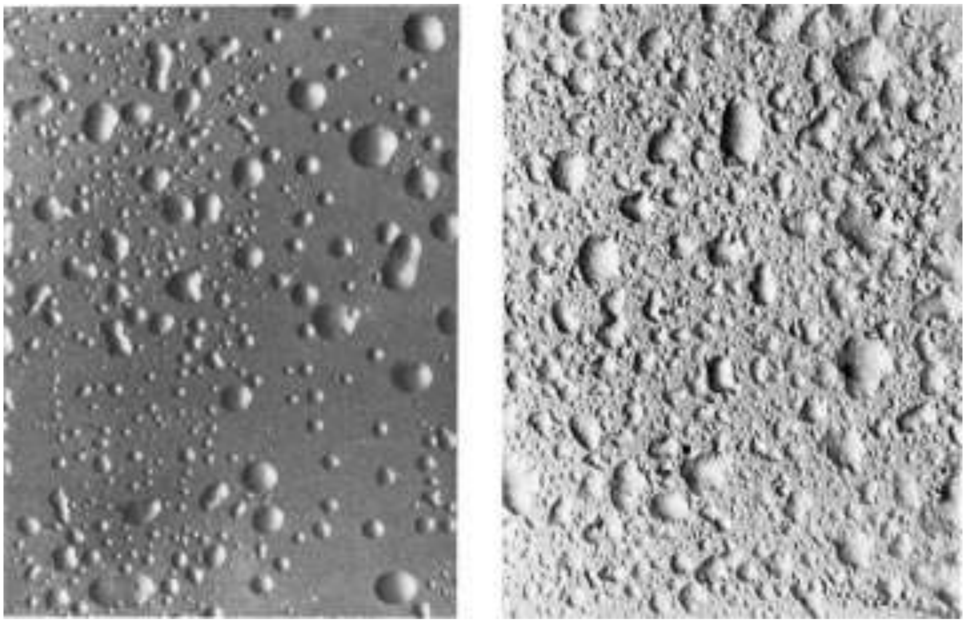
[2] Glossy prints of the photographic reference standards showing types of blistering are available at a nominal charge from ASTM Headquarters. Order Adjunct ADJD0714.



Few

Medium

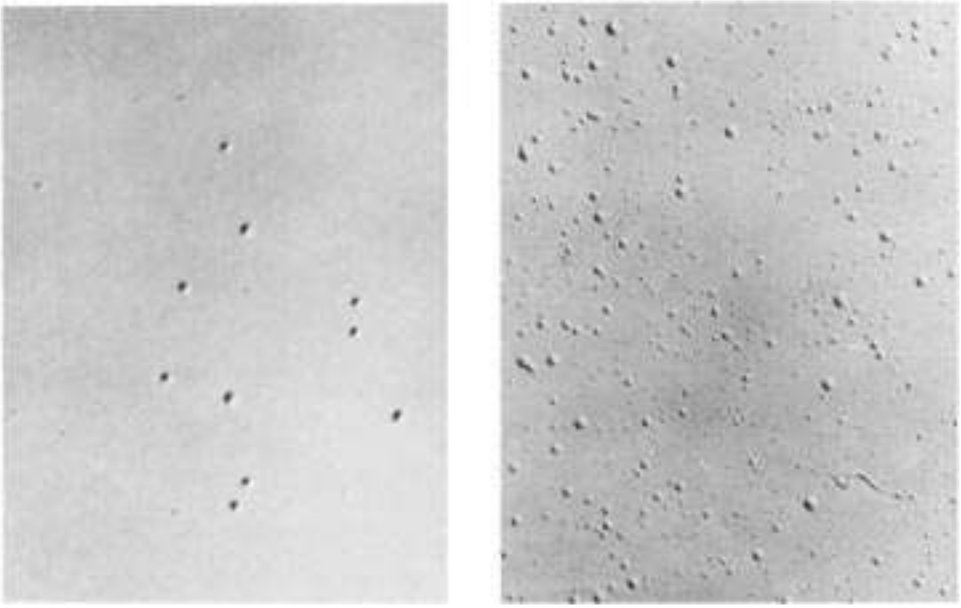
FIG. 1 Blister Size No. 2



Medium Dense

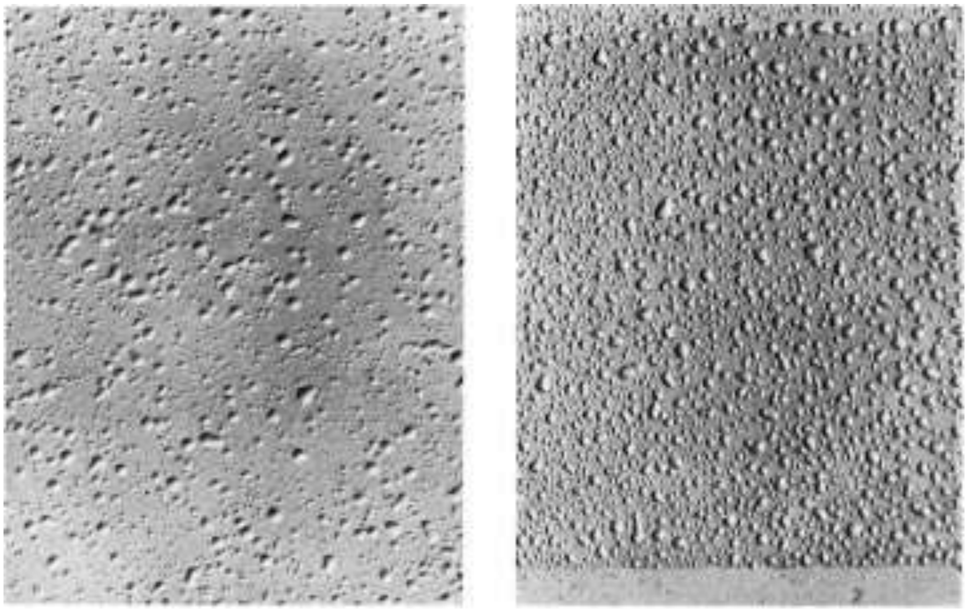
Dense

FIG. 1 *(continued)*



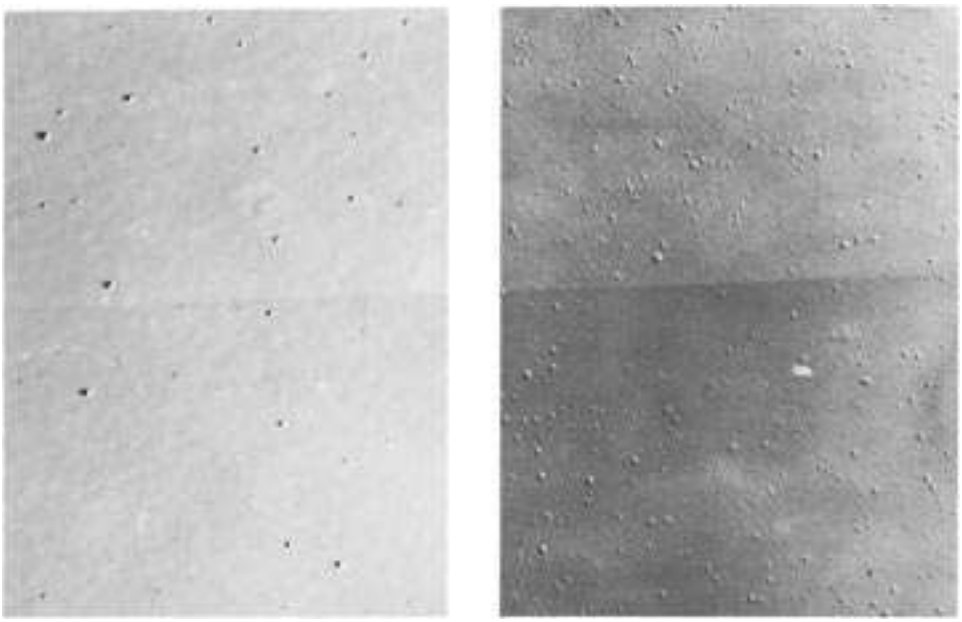
Few Medium

FIG. 2 Blister Size No. 4



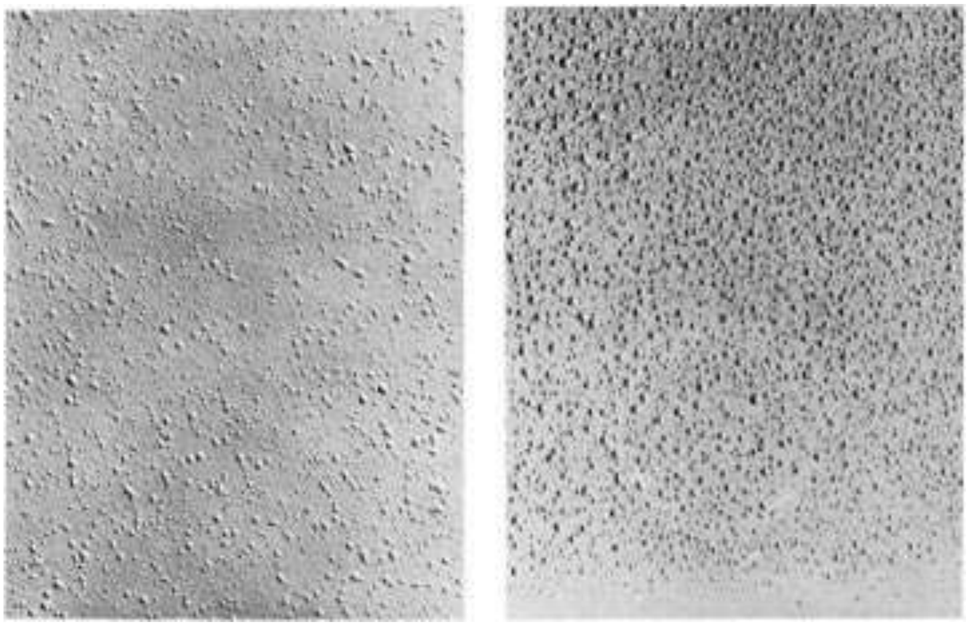
Dense Dense

FIG. 2 *(continued)*



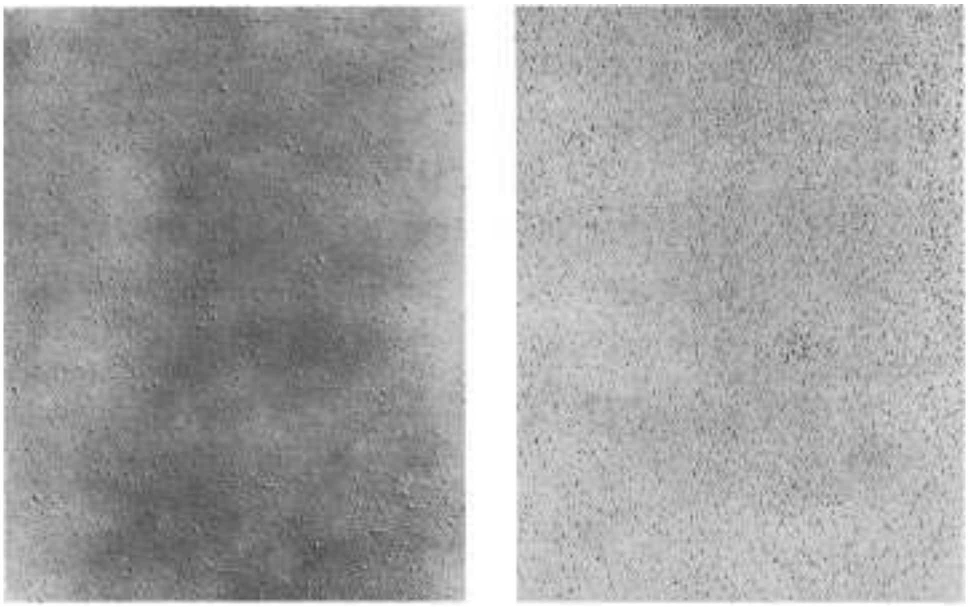
Few Medium

FIG. 3 Blister Size No. 6



Medium Dense Dense

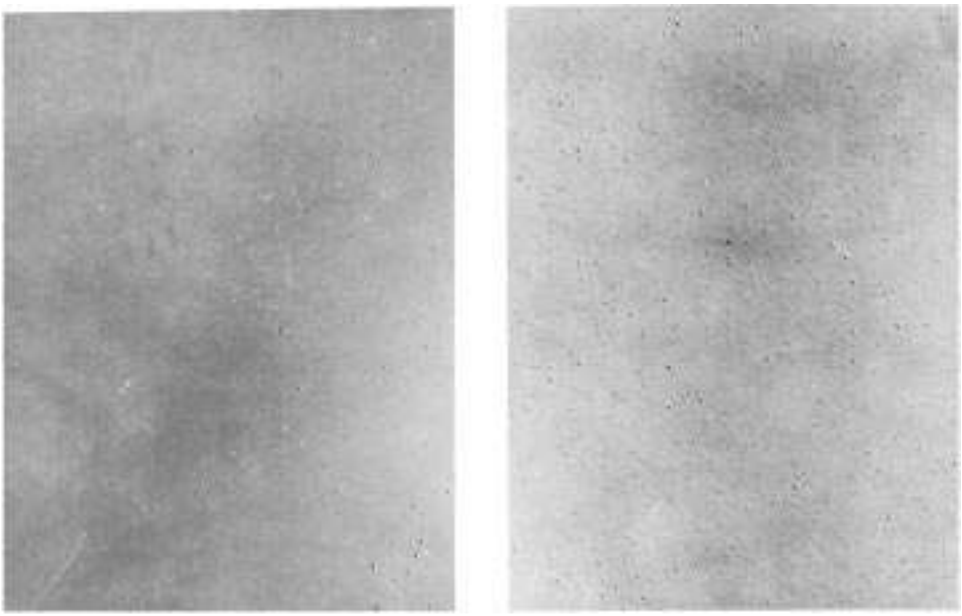
FIG. 3 *(continued)*



Medium Dense

Dense

FIG. 4 *(continued)*



Few

Medium

FIG. 4 Blister size No. 8

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ANEXO Nº 10

INTERNATIONAL
STANDARD

**ISO
4628-4**

Third edition
2016-01-15

Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance —

Part 4:

8. *Assessment of degree of cracking*

Peintures et vernis — Évaluation de la dégradation des revêtements — Désignation de la quantité et de la dimension des défauts, et de l'intensité des changements uniformes d'aspect —
Partie 4: Évaluation du degré de craquelage

Reference number
ISO 4628-4:2016(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This third edition cancels and replaces the second edition (ISO 4628-4:2003), which has been technically revised with the following changes:

a) lower limit for visual assessment of defects has been introduced in Table 2;
b) a normative reference to ISO 13076 for illumination for the assessment has been added.

ISO 4628 consists of the following parts, under the general title *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance*:

- *Part 1: General introduction and designation system*
- *Part 2: Assessment of degree of blistering*
- *Part 3: Assessment of degree of rusting*
- *Part 4: Assessment of degree of cracking*
- *Part 5: Assessment of degree of flaking*
- *Part 6: Assessment of degree of chalking by tape method*
- *Part 7: Assessment of degree of chalking by velvet method*
- *Part 8: Assessment of degree of delamination and corrosion around a scribe or other artificial defect*
- *Part 10: Assessment of degree of filiform corrosion*

9. *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, andof intensity of uniform changes in appearance —*

Part 4:

10. *Assessment of degree of cracking*

1 Scope

This part of ISO 4628 specifies a method for assessing the degree of cracking of coatings by comparison with pictorial standards.

ISO 4628-1 defines the system used for designating the quantity and size of defects and the intensity of changes in appearance of coatings and outlines the general principles of the system. This system is intended to be used, in particular, for defects caused by ageing and weathering, and for uniform changessuch as colour changes, for example yellowing.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undatedreferences, the latest edition of the referenced document (including any amendments) applies
ISO 13076, *Paints and varnishes — Lighting and procedure for visual assessments of coatings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 degree of cracking rating characterizing cracks in a coating in terms of quantity, size, and depth

4 Assessment

Assess the quantity of cracking by reference to Table 1 and using as example Figure 1 or Figure 2, depending on the type of cracking.

NOTE Figure 1 shows cracking without preferential direction and Figure 2 shows cracking in one preferential direction, which occurs with substrates such as wood ("anisotropic" substrates). Other forms of cracking occur, but the principles of assessing the quantity remain the same.

Table 1 — Rating scheme for designating the quantity of cracks

Rating	Quantity of cracks
0	none, i.e. no detectable cracks
1	very few, i.e. small, barely significant number of cracks
2	few, i.e. small but significant number of cracks
3	moderate number of cracks
4	considerable number of cracks
5	dense pattern of cracks

If specified, assess the average size of the cracks in accordance with Table 2.

Table 2 — Rating scheme for designating the size of cracks

Rating	Size of cracks
0	not visible under × 10 magnification
1	only visible under magnification up to ×10
2	just visible with normal corrected vision (up to 0,2 mm)[a]
3	clearly visible with normal corrected vision (larger than 0,2 mm up to 0,5 mm)
4	large cracks, larger than 0,5 mm up to 1 mm wide
5	very large cracks generally more than 1 mm wide

[a] Typically, defects larger than 0,2 mm are visible with normal corrected vision.

Where the test area exhibits cracks of various sizes, quote as the size rating that of the largest cracks which are numerous enough to be typical of the test area.

If possible, indicate the depth of cracking by reference to the level in the coating system to which the cracks penetrate. A distinction is made between three main types of failure by cracking:

a) surface cracks which do not fully penetrate the top coat (i.e. checking);
b) cracks which penetrate the top coat, the underlying coat(s) being substantially unaffected;
c) cracks which penetrate the whole coating system.

Carry out the assessment under good illumination, as specified in ISO 13076.

5 Expression of results

Express the numerical ratings of the quantity and, if specified, size of the cracks, together with the depth of cracking (a, b, or c), shown in Figures 1 and 2 together with the approximate dimensions of the area concerned, or its proportion to the total area, expressed as a percentage.

For example, for quantity 2, size 3 with the cracks penetrating the top coat and the underlying coat(s) are substantially unaffected, report the result as

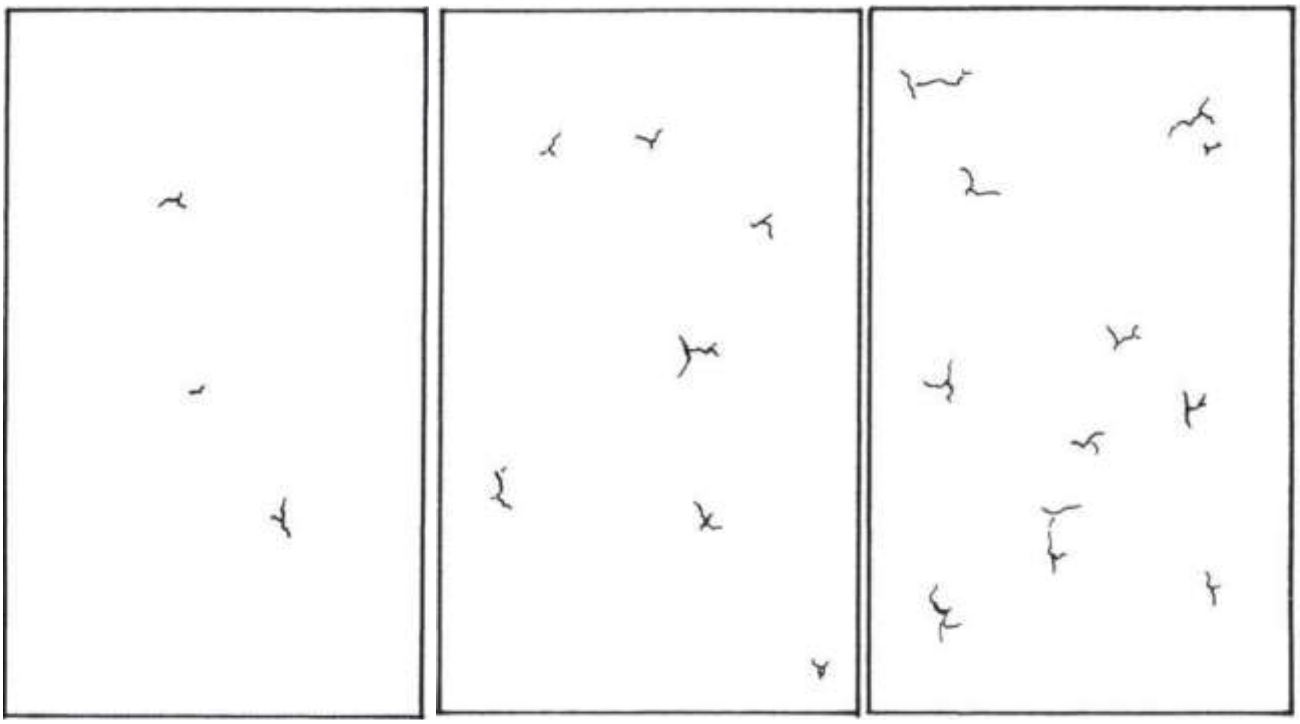
cracking; degree of cracking 2(S3)b.

If necessary, the assessment may be amplified in words, for example “cracking in one preferential direction” and by using the descriptions given in Annex A.

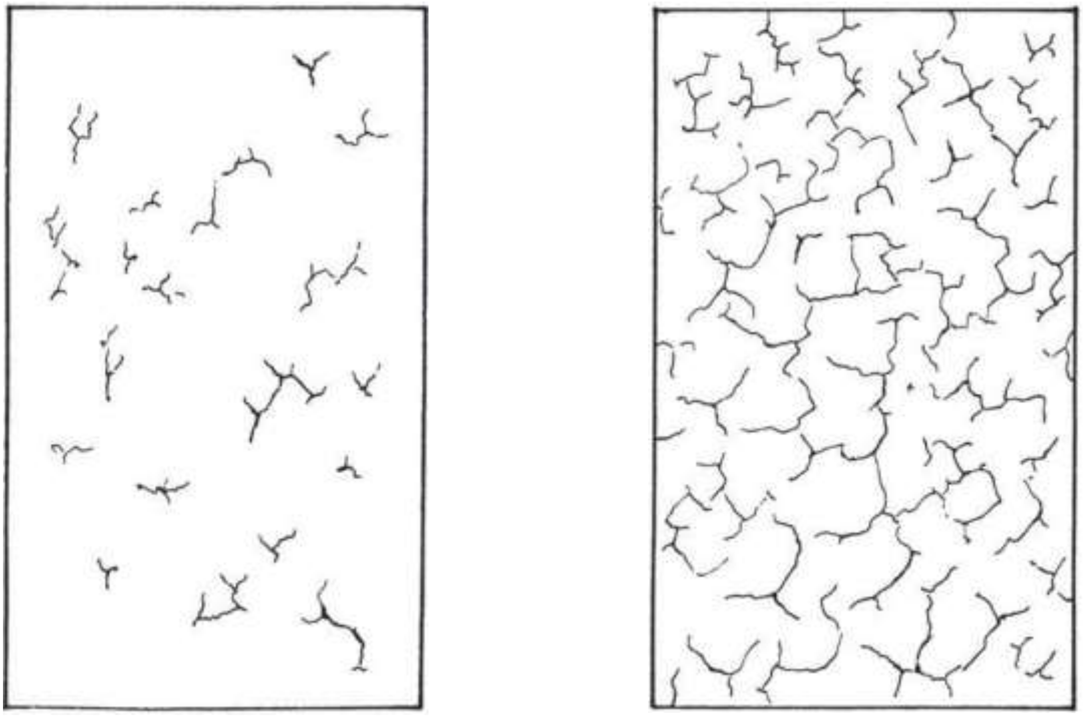
1. Test report

The test report shall contain at least the following information:

a) all details necessary to identify the coating examined;
b) a reference to this part of ISO 4628, i.e. ISO 4628-4;
c) the type of surface examined, its size and, if appropriate, its location;
d) the result of the examination in accordance with Clause 5;
e) an indication of the illumination under which the assessment was carried out;
f) any unusual features (anomalies) observed during the assessment;
g) the date of the examination.



a) Quantity (density) 1 b) Quantity (density) 2 c) Quantity (density) 3



d) Quantity (density) 4 e) Quantity (density) 5

Figure 1 — Cracking without preferential direction (panels of area 100 cm^2 to 200 cm^2)

ANEXO Nº 11

INTERNATIONAL
STANDARD

ISO
4628-5

Third edition
2016-01-15

Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance —

Part 5:

11. *Assessment of degree of flaking*

Peintures et vernis — Évaluation de la dégradation des revêtements — Désignation de la quantité et de la dimension des défauts, et de l'intensité des changements uniformes d'aspect —
Partie 5: Évaluation du degré d'écaillage

Reference number
ISO 4628-5:2016(E)

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Foreword

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a) a normative reference to ISO 13076 for illumination for the assessment has been added.

ISO 4628 consists of the following parts, under the general title *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance*:

- *Part 1: General introduction and designation system*
- *Part 2: Assessment of degree of blistering*
- *Part 3: Assessment of degree of rusting*
- *Part 4: Assessment of degree of cracking*
- *Part 5: Assessment of degree of flaking*
- *Part 6: Assessment of degree of chalking by tape method*
- *Part 7: Assessment of degree of chalking by velvet method*
- *Part 8: Assessment of degree of delamination and corrosion around a scribe or other artificial defect*
- *Part 10: Assessment of degree of filiform corrosion*

12. Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, andof intensity of uniform changes in appearance

Part 5:

13. Assessment of degree of flaking

1 Scope

This part of ISO 4628 specifies a method for assessing the degree of flaking of coatings by comparison with pictorial standards.ISO 4628-1 defines the system used for designating the quantity and size of defects and the intensity of changes in appearance of coatings and outlines the general principles of the system. This system is intended to be used, in particular, for defects caused by ageing and weathering, and for uniform changessuch as colour changes, for example yellowing.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undatedreferences, the latest edition of the referenced document (including any amendments) applies. ISO 13076, *Paints and varnishes — Lighting and procedure for visual assessments of coatings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 degree of flaking rating characterizing flaked areas in a coating in terms of quantity, size, and depth

4 Assessment

Assess the quantity of flaking by reference to Table 1 and using as examples Figure 1 or Figure 2, depending on the type of flaking.

NOTE Figure 1 shows flaking without preferential direction and Figure 2 shows flaking in a preferential direction due to anisotropy of the substrate.

Table 1 — Rating scheme for designating the quantity of flaking

Rating	Flaked area %
0	0
1	0,1
2	0,3
3	1
4	3
5	15

Assess the average size of the individual areas exposed by flaking in accordance with Table 2.

Table 2 — Rating scheme for designating the size of areas exposed by flaking

Rating	Size of flaking
0	not visible under × 10 magnification
1	up to 1 mm
2	up to 3 mm
3	up to 10 mm
4	up to 30 mm
5	larger than 30 mm

Where a test area exhibits flaked areas of various sizes, quote as the size rating that of the largest areas which are numerous enough to be typical of the test area.

If possible, indicate the depth of flaking by reference to the level in the coating system where failure occurs. A distinction is made between two main types of failure by flaking:

a) coat(s) flaking from underlying coat;
b) the whole coating system flaking from substrate.

Carry out the assessment under good illumination, as specified in ISO 13076.

5 Expression of results

Express the numerical ratings of the quantity and size of flaking, where possible together with the depth of flaking (a or b), shown in Figures 1 and 2 together with the approximate dimensions of thearea concerned, or its proportion to the total area, expressed as a percentage.

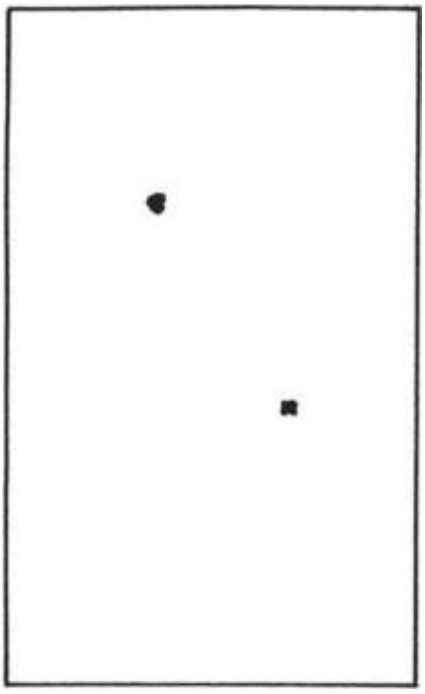
For example, for quantity 3, size 2, with the whole coating system flaking from the substrate, report the result as flaking; degree of flaking 3(S2)b. If necessary, the assessment may be amplified in words.

6 Test report

The test report shall contain at least the following information:

a) all details necessary to identify the coating examined;
b) a reference to this part of ISO 4628, i.e. ISO 4628-5;
c) the type of surface examined, its size and, if appropriate, its location;
d) the result of the assessment in accordance with Clause 5;
e) an indication of the illumination under which the assessment was carried out;
f) any unusual features (anomalies) observed during the assessment;

g) the date of the examination.



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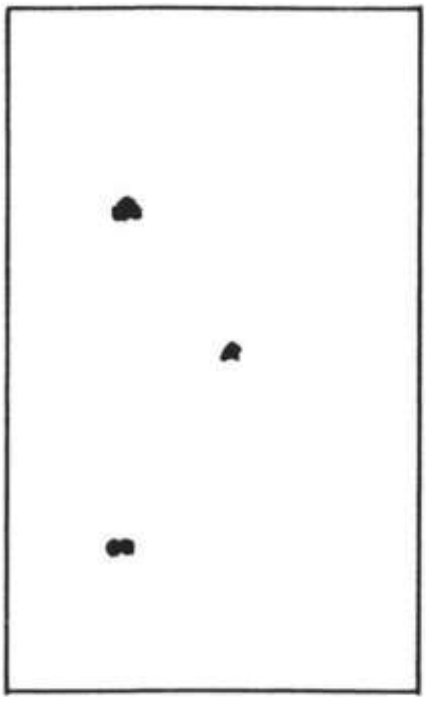
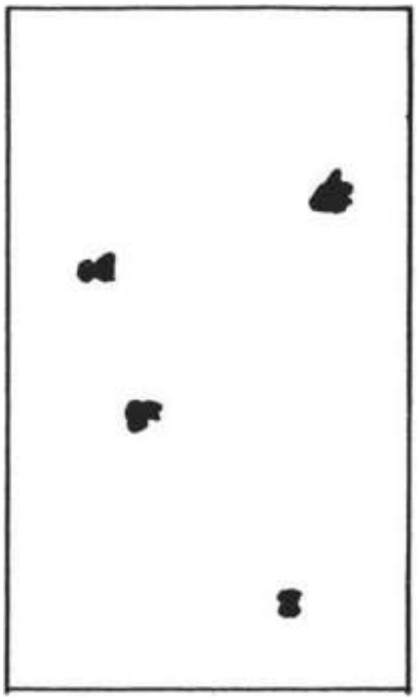
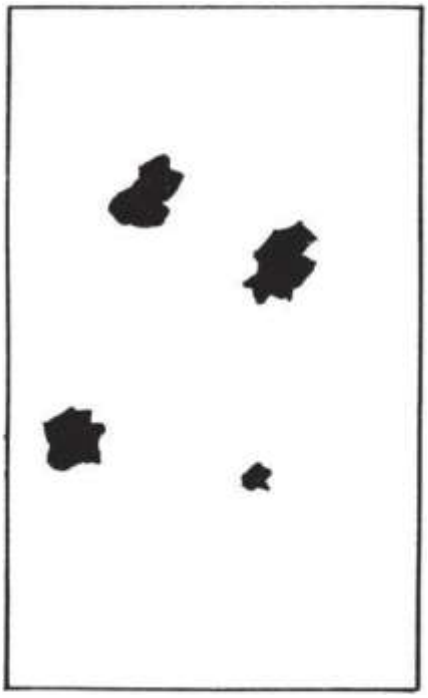


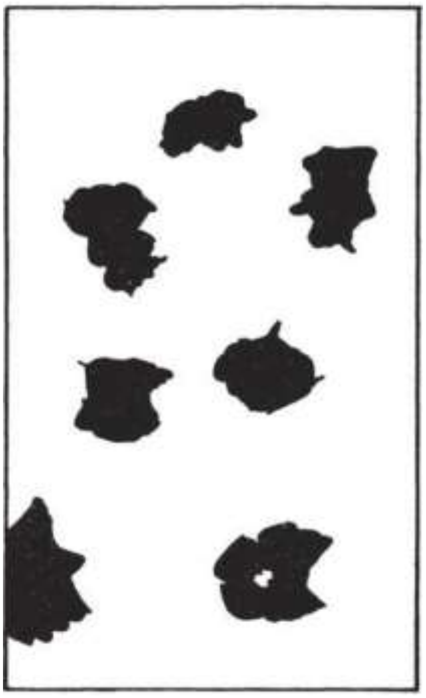
b) **Quantity (density) 2**



c) **Quantity (density) 3**

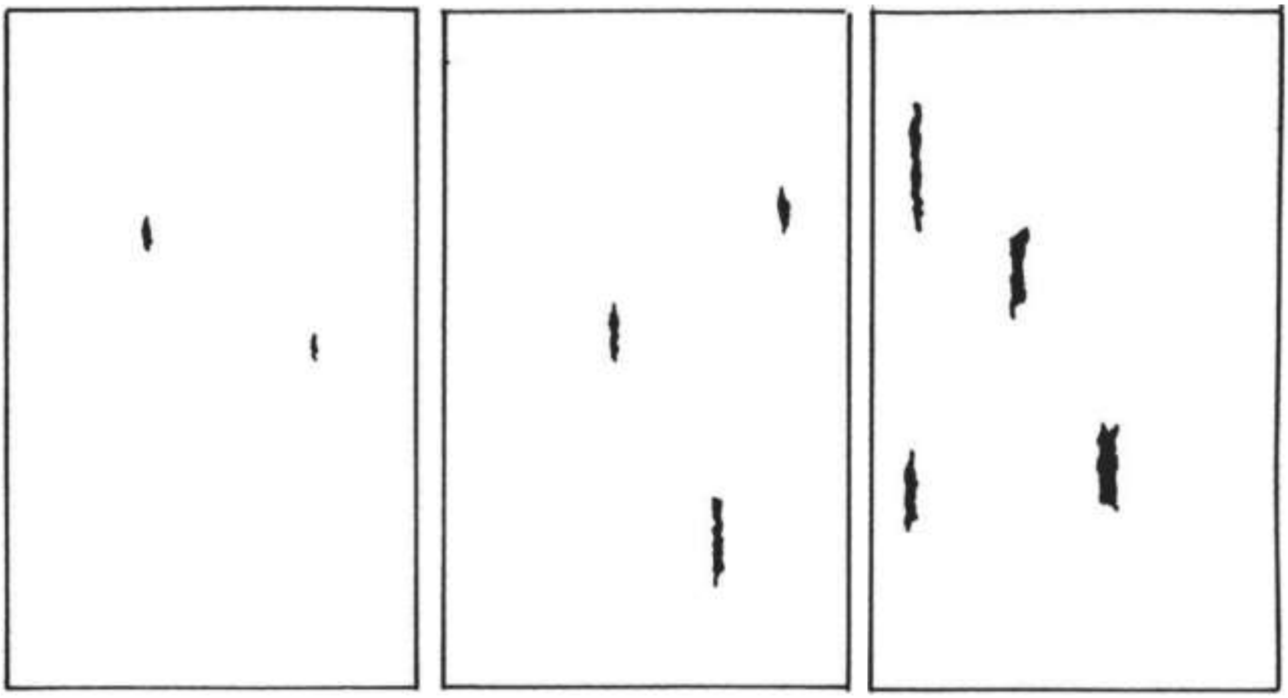


d) **Quantity (density) 4**

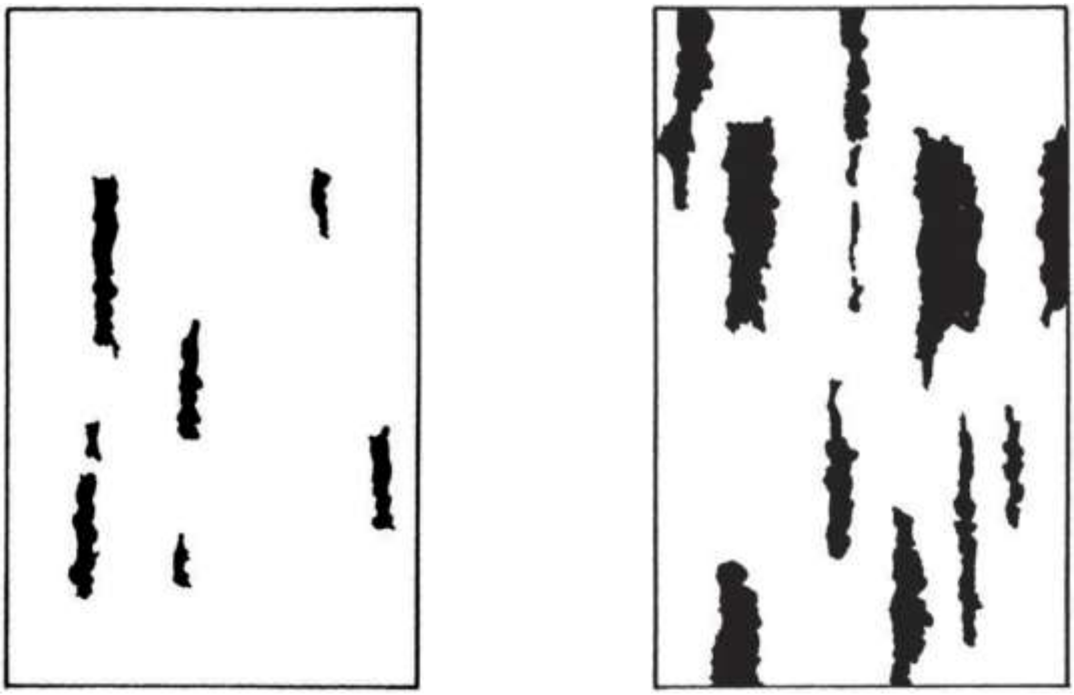


e) **Quantity (density) 5**

Figure 1 — Flaking without preferential direction
(panels of 100 cm^2 to 200 cm^2)



a) Quantity (density) 1 b) Quantity (density) 2 c) Quantity (density) 3



d) Quantity (density) 4 e) Quantity (density) 5

Figure 2 — Flaking in a preferential direction
(panels of 100 cm^2 to 200 cm^2)

Bibliography

[1] ISO 4628-1, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*

ANEXO Nº 12

INTERNATIONAL
STANDARD

ISO
4628-6

Third edition
2011-08-15

Reviewed and confirmed in 2017

Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance —

Part 6:
Assessment of degree of chalking by tape method

Peintures et vernis — Évaluation de la dégradation des revêtements — Désignation de la quantité et de la dimension des défauts, et de l'intensité des changements uniformes d'aspect —

Partie 6: Évaluation du degré de farinage par la méthode du ruban adhésif

Reference number
ISO 4628-6:2011(E)

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Foreword

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4628-6 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This third edition cancels and replaces the second edition (ISO 4628-6:2007), which has been technically revised. The main changes are as follows:

a) the pictorial standards (photographic pictures) used in the first edition (ISO 4628-6:1990) have been re- inserted because the computer-generated chalking scale used in the second edition (ISO 4628-6:2007) did not always give the same rating as that given by the scale used in the first edition (for more details, see the Introduction);

b) a limiting value of the transmittance of the tape below which chalking is considered to have taken place has been added (see 5.2).

ISO 4628 consists of the following parts, under the general title: *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance*:

- *Part 1: General introduction and designation system*
- *Part 2: Assessment of degree of blistering*
- *Part 3: Assessment of degree of rusting*
- *Part 4: Assessment of degree of cracking*
- *Part 5: Assessment of degree of flaking*
- *Part 6: Assessment of degree of chalking by tape method*
- *Part 7: Assessment of degree of chalking by velvet method*
- *Part 8: Assessment of degree of delamination and corrosion around a scribe or other artifical defect*
- *Part 10: Assessment of degree of filiform corrosion*

Introduction

ISO 4628-1 defines the system for designating the quantity and size of defects and the intensity of uniform changes of coatings and outlines the general principles of the system. This system is intended to be used, in particular, for defects caused by ageing and weathering, and for uniform changes such as colour changes, for example yellowing.

The other parts of ISO 4628 provide pictorial standards or other means for evaluating particular types of defect. As far as possible, already existing evaluation schemes have been used as the basis.

The chalking scale used in the first (1990) edition and in this third edition of ISO 4628-6 consists of photographic pictures of adhesive tapes with different amounts of pigment particles adhering to them. The pigment particles are not evenly distributed over each tape. The lower ratings in particular (i.e. 1 to 3) give the impression of cloudiness. All five ratings in the scale used in the first (1990) edition and in this edition are sufficiently different for visual-assessment purposes, however.

The scale used in the second (2007) edition was computer-generated. Thus the white dots representing the pigment particles were distributed very evenly over the tape, with the result that not all the ratings differed sufficiently well from each other for visual assessment to be carried out. While ratings 0,5 to 3,0 on the black background on the 2007 scale could be differentiated sufficiently well from each other, it was hardly possible to differentiate visually between ratings above 3,0, especially ratings 4 and 5. On the white background, the difference between ratings 0,5, 1,0 and 1,5 was not easy to discern. The differences between ratings 1,5 to 5,0 were more evident, however.

Comparing the 1990 scale with the 2007 scale, it would appear that rating 1 on the 1990 scale corresponded to 0,5 on the 2007 scale, and rating 2 on the 1990 scale corresponded to 1 on the 2007 scale.

It was therefore decided that the 2007 scale was unsuitable for use in the visual assessment of the degree of chalking of paints over the whole rating scale from 0,5 to 5,0.

Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6:

1. Assessment of degree of chalking by tape method

IMPORTANT — For the assessment of the degree of chalking by the tape method, it is necessary to use the pictorial reference standards contained in this part of ISO 4628. Owing to the fact thatelectronic copies of these standards are subject to change when viewed on screen or printed, it is recommended that only the pictorial standards contained in printed copies of this part of ISO 4628 purchased from ISO member bodies or their distributors be used when comparing test results.

1 Scope

This part of ISO 4628 provides pictorial reference standards for designating the degree of chalking of paint coatings. It also describes a method by which the degree of chalking is rated. In using this method, it is essential that care be taken to distinguish between true degradation products and adhering dirt, particularly when chalking is slight.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1 chalking appearance of a loosely adherent fine powder on the surface of a paint coating, arising from the degradationof one or more of its constituents

3 Principle

The chalking is removed from the coating under test using an adhesive tape. The chalking adhering to thetape is examined against a contrasting background (either black or white, whichever gives the greatercontrast) and the degree of chalking is assessed with reference to a rating scale.

4 Materials

4.1 Self-adhesive transparent tape, of width at least 15 mm. Commercially available flexible tapes, transparent and without perceptible colour, have been found to be satisfactory. However, the quality of the tape affects the rating obtained. The type of tape shall therefore be agreed on between the interested parties and shall be stated in the test report.

4.2 Background, black or white, with matt finish, for example card or velvet having a short pile without a tendency to be crushed.

5 Procedure

5.1 Allow the surface to dry at room temperature before carrying out the test.

Place a piece of the adhesive tape (4.1) on the dry coating by applying firm pressure and rubbing with a finger.The length of the tape should be at least 40 mm.

Remove the tape perpendicularly to the surface and lay it on a background (4.2) of the appropriate colour to give the greater contrast, with the adhesive in contact with the background. Assess light-coloured coatings on the black background and dark-coloured coatings on the white background.

Under consistent illumination, immediately assess (see 5.5) the degree of chalking by comparing the amountof chalk on the tape with the pictorial reference standards in Figure 1. The more background that is visible, thelower the rating. Report the illumination in the test report.

5.2 The degree of chalking may also be determined quantitatively using a suitable photoelectric instrument to compare the transmittance of the chalked tape with that of unused tape. In this procedure, the adhesivetape shall not be placed on a background (4.2) but on a clean glass slide or open support, which is placed in the optical beam of the instrument[2],[3]. A transmittance of less than 70 % of that of the unused tape indicates chalking.

This instrumental method shall only be used if the pattern of chalking residues on the tape is homogeneous.

5.3 The degree of chalking can vary over a given area. On large areas with a uniform surface (no texture), the determination should preferably be made at several locations and the mean and range reported.

Apply the tape to an area of the panel that has not been used for previous measurements to avoid false readings.

5.4 Ratings obtained with coatings exposed to natural weathering shall be treated with caution as dirt deposited on the surface from the atmosphere can give false values of chalking.

5.5 After removing the chalking from the coating under test, the assessment of each piece of adhesive tape shall be carried out without delay because the appearance of the chalking residues on the adhesive tape and the transmittance of the tape might change with time.

5.6 When testing low-gloss paint coatings, a certain amount of loosely adherent material might be observed, even with unweathered panels. A blank test, carried out on an unweathered panel, is therefore recommended for such coatings.

6 Rating

Rate the degree of chalking by reference to the pictorial standards shown in Figure 1.

NOTE The numerical values given correspond to those in ISO 4628-1.

For textured surfaces, the rating shall be based on the observations of the most intensively chalked parts of the tape.

7 Test report

The test report shall contain at least the following information:

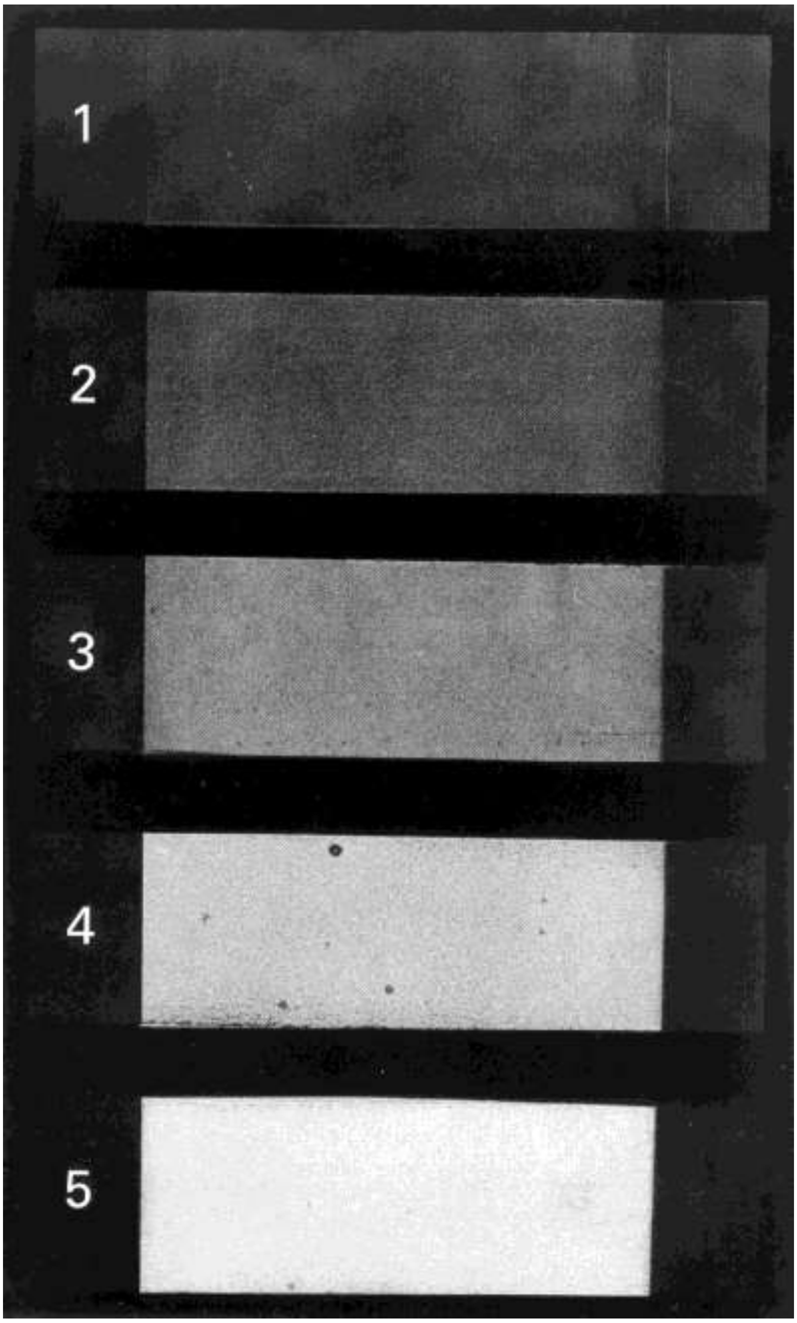
a) all information necessary for the identification of the sample tested;
b) a reference to this part of ISO 4628 (ISO 4628-6:2011);
c) details of the method used, including:

   1) the type of weathering (artificial or natural) of the coating,
   2) all details necessary for the identification of the adhesive tape used, including the manufacturer and the name of the tape,
   3) all details necessary for the identification of the substrate used as the background for the adhesivetape (see 4.2),
   4) the illumination used for the assessment;

d) the results of the test, including:

   1) the numerical rating of the degree of chalking,
   2) whether the evaluation was carried out visually or using an instrument (see 5.2);

e) any deviations from the procedure specified;
f) any unusual features (anomalies) observed during the test;
g) the date of the test.



NOTE The right-hand end of each tape corresponds to chalking rating of 0.

1. Figure 1 — Pictorial reference standards for numerical chalking ratings 1 to 5

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ANEXO Nº 13

INTERNATIONALSTANDARD **ISO 12944-2**

Second edition
2017-11

Paints and varnishes — Corrosionprotection of steel structures by protective paint systems —
Part 2:
14. Classification of environments

Peintures et vernis — Anticorrosion des structures en acier parsystèmes de peinture — Partie 2: Classification des environnements

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 14, *Protective paint systems for steel structures*.

This second edition cancels and replaces the first edition (ISO 12944-2:1998), which has been technically revised. The main changes compared to the previous edition are as follows:

— the normative references have been updated;
— 4.2.1 "General" has been added;
— the units in Table 1 have been corrected;
— the bibliography has been updated;
— the text has been editorially revised.

A list of all parts in the ISO 12944 series can be found on the ISO website.

1. Introduction

Unprotected steel in the atmosphere, in water and in soil is subjected to corrosion that can lead to damage. Therefore, to avoid corrosion damage, steel structures are normally protected to withstand the corrosion stresses to which they will be subjected during the service life required of the structure.

There are different ways of protecting steel structures from corrosion. ISO 12944 (all parts) deals with protection by paint systems and covers, in the various parts, all features that are important in achieving adequate corrosion protection. Additional or other measures are possible but require particular agreement between the interested parties.

In order to ensure effective corrosion protection of steel structures, owners of such structures, planners, consultants, companies carrying out corrosion protection work, inspectors of protective coatings and manufacturers of coating materials need to have at their disposal state-of-the-art information in concise form on corrosion protection by paint systems. It is vital that such information is as complete as possible, unambiguous and easily understandable to avoid difficulties and misunderstandings between the parties concerned with the practical implementation of protection work.

ISO 12944 (all parts) is intended to give this information in the form of a series of instructions. It is written for those who have some technical knowledge. It is also assumed that the user of ISO 12944 (all parts) is familiar with other relevant International Standards, in particular those dealing with surface preparation.

Although ISO 12944 (all parts) does not deal with financial and contractual questions, attention is drawn to the fact that, because of the considerable implications of inadequate corrosion protection, non-compliance with requirements and recommendations given in ISO 12944 (all parts) can result in serious financial consequences.

ISO 12944-1 defines the overall scope of ISO 12944. It gives some basic terms and definitions and a general introduction to the other parts of ISO 12944. Furthermore, it includes a general statement on health, safety and environmental protection, and guidelines for using ISO 12944 (all parts) for a given project.

This document describes the environmental impact on steel structures. It covers structures exposed to the atmosphere as well as those immersed in water or buried in soil. For different atmospheric environments, a classification system based on corrosivity categories is also presented. Different environments for immersed and buried structures are also described. All these environments are relevant to the choice of protective paint systems.

15. Paints and varnishes — Corrosion protection of steelstructures by protective paint systems — Part 2:
16. Classification of environments

1. Scope

This document deals with the classification of the principal environments to which steel structures are exposed, and the corrosivity of these environments. This document

— defines atmospheric-corrosivity categories, based on mass loss (or thickness loss) by standard specimens, and describes typical natural atmospheric environments to which steel structures are exposed, giving advice on the estimation of the corrosivity,

— describes different categories of environment for structures immersed in water or buried in soil, and

— gives information on some special corrosion stresses that can cause a significant increase in corrosion rate or place higher demands on the performance of the protective paint system.

The corrosion stresses associated with a particular environment or corrosivity category represent one essential parameter governing the selection of protective paint systems.

2. Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction*

ISO 12944-3, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 3: Design considerations*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems —Part 4: Types of surface and surface preparation*

ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems*

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems —Part 6: Laboratory performance test methods*

ISO 12944-7, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems —Part 7: Execution and supervision of paint work*

ISO 12944-8, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 8: Development of specifications for new work and maintenance*

ISO 12944-9, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures*

3. Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12944-1, ISO 12944-3, ISO 12944-4, ISO 12944-5, ISO 12944-6, ISO 12944-7, ISO 12944-8, ISO 12944-9 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1 corrosivity ability of an environment to cause corrosion of a metal in a given corrosion system [SOURCE: ISO 8044:2015, 2.14]

3.2 climate weather prevailing at a given location or in a given area, as established statistically by meteorological parameters recorded over a prolonged period

3.3 atmosphere mixture of gases, and normally also aerosols and particles, that surrounds a given object

3.4 atmospheric corrosión corrosion with the earth's *atmosphere* (3.3) at ambient temperature as the corrosive environment [SOURCE: ISO 8044:2015, 3.4]

3.5 type of atmosphere characterization of the *atmosphere* (3.3) on the basis of the corrosive agents present and their concentration

Note 1 to entry: The main corrosive agents are gases (especially sulfur dioxide) and salts (especially chlorides and/or sulfates).

3.6 local environment atmospheric conditions prevailing around a constituent element of a structure

Note 1 to entry: These conditions determine the *corrosivity* (3.1) category and include both meteorological and pollution parameters.

3.7 micro-environment environment at the interface between a constituent element of a structure and its surroundings

Note 1 to entry: The micro-environment is one of the decisive factors in the assessment of corrosion stresses.

3.8 time of wetness period when a metallic surface is covered by adsorptive and/or liquid films of electrolyte to be capable of causing atmospheric corrosión

Note 1 to entry: Guidance values for time of wetness can be calculated from temperature and relative humidity by summing the hours during which the relative humidity is above 80 % and, at the same time, the temperature is above 0 °C.

[SOURCE: ISO 9223:2012, 3.5, modified — Note 1 to entry has been added.]

4 Corrosion stresses due to the atmosphere, water and soil

4.1 Atmospheric corrosion

Atmospheric corrosion is a process that takes place in a film of moisture on the metal surface. The moisture film can be so thin that it is invisible to the naked eye.

The corrosion rate is increased by the following factors:

- an increase in the relative humidity;
- the occurrence of condensation (when the surface temperature is at or below the dew point);
- an increase in the amount of pollution in the atmosphere (the corrosive pollutants can react with the steel and can form deposits on the surface).

Experience has shown that significant corrosion is likely to take place if the relative humidity is above 80 % and the temperature above 0 °C. However, if pollutants and/or hygroscopic salts are present, corrosion occurs at much lower humidity levels.

The atmospheric humidity and air temperature in a particular region of the world will depend on the climate prevailing in that part of the world. A brief description of the most important climates is given in Annex A.

The location of the constituent element of a structure also influences corrosion. Where structures are exposed to the open air, climatic parameters such as rain and sunshine and pollutants in the form of gases or aerosols affect corrosion. Under cover, the climatic influences are reduced. Indoors, the effect of atmospheric pollutants is reduced, although a locally high corrosion rate caused by poor ventilation, high humidity or condensation is possible.

For the estimation of the corrosion stresses, an appreciation of the local environment and the micro-environment is essential. Examples of decisive micro-environments are the underside of a bridge (particularly over water), the roof of an indoor swimming pool, and the sunny and shady sides of a building.

4.2 Corrosion in water and soil

4.2.1 General

Special care shall be taken when considering structures that are partly immersed in water or partly buried in soil. Corrosion under such conditions is often restricted to a small part of the structure where the corrosion rate can be high. Exposure tests for estimating the corrosivity of water or soil environments are not recommended. However, different immersion/burial conditions can be described.

4.2.2 Structures immersed in water

The type of water — fresh, brackish or salt — has a significant influence on the corrosion of steel. Corrosivity is also influenced by the oxygen content of the water, the type and quantity of dissolved substances and the water temperature. Animal or vegetable growth can accelerate corrosion.

Three different zones for immersion in water can be defined:

- the underwater zone is the area which is permanently exposed to water;
- the intermediate (fluctuating level) zone is the area in which the water level changes due to natural or artificial effects, thus giving rise to increased corrosion due to the combined impact of water and the atmosphere;
- the splash zone is the area wetted by wave and spray action which can give rise to exceptionally high corrosion stresses, especially with sea water.

Structures buried in soil Corrosion in soil is dependent on the mineral content of the soil and the nature of these minerals, and on the organic matter present, the water content and the oxygen content. The corrosivity of soil is strongly influenced by the degree of aeration. The oxygen content will vary and corrosion cells can be formed. Where major steel structures such as pipelines, tunnels, tank installations, etc., pass through different types of soil, soils with differing oxygen contents, soils with differing ground water levels, etc., increased local corrosion (pitting) can occur due to formation of corrosion cells.

For further details, see EN 12501-1.
Different types of soil and differences in soil parameters are not considered as classification criteria in this document.

4.3 *Special cases*

For the selection of a protective paint system, special stresses to which a structure is subjected and special situations in which a structure is located shall also be taken into account. Both the design and the use of the structure can lead to corrosion stresses not taken into consideration in the classification system given in Clause 5. Examples of such special cases are given in Annex B.

5 Classification of environments

5.1 *Atmospheric-corrosivity categories*

5.1.1 According to ISO 9223, atmospheric environments are classified into six atmospheric-corrosivitycategories:

- C1 very low corrosivity
- C2 low corrosivity
- C3 medium corrosivity
- C4 high corrosivity
- C5 very high corrosivity
- CX extreme corrosivity

NOTE CX covers different extreme environments. One specific extreme environment is the offshore environment covered by ISO 12944-9. Other extreme environments are not covered in the other parts of ISO 12944.

5.1.2 To determine corrosivity categories, the exposure of standard specimens is strongly recommended. Table 1 defines the corrosivity categories in terms of the mass or thickness loss of such standard specimens made of low-carbon steel and/or zinc after the first year of exposure. For details of standard specimens and the treatment of the specimens prior to and after exposure, see ISO 9226. Extrapolation of the mass or thickness losses to one year from shorter exposure times, or back- extrapolation from longer times, will not give reliable results and is therefore not permitted. The mass or thickness losses obtained for steel and zinc specimens can sometimes give different categories. In such cases, the higher corrosivity category shall be taken.
If it is not possible to expose standard specimens in the actual environment of interest, the corrosivity category may be estimated by simply considering the examples of typical environments given in

Table 1. The examples listed are informative and might occasionally be misleading. Only the actual measurement of mass or thickness loss will give the correct classification.

NOTE Corrosivity categories can also be estimated by considering the combined effect of the following environmental factors: yearly time of wetness, yearly mean concentration of sulfur dioxide and yearly mean deposition of chloride (see ISO 9223).

Table 1 — Atmospheric-corrosivity categories and examples of typical environments

Corrosivity category	**Mass loss per unit surface/thickness loss** (after first year of exposure)				**Examples of typical environments** (informative only)	
	Low-carbon steel		**Zinc**		**Exterior**	**Interior**
	Mass loss g/m^2	**Thickness loss** µm	**Mass loss** g/m^2	**Thickness loss** µm		
C1 very low	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1	—	Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels
C2 low	> 10 to 200	> 1,3 to 25	> 0,7 to 5	> 0,1 to 0,7	Atmospheres with low level of pollution:mostly rural areas	Unheated buildings where condensation can occur, e.g. depots,sports halls
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0,7 to 2,1	Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with lowsalinity	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries,dairies
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2	Industrial areas and coastal areas with moderate salinity	Chemical plants, swimming pools, coastal ship and boatyards
C5 very high	> 650 to 1 500	> 80 to 200	> 30 to 60	> 4,2 to 8,4	Industrial areas with high humidity and ag-gressive atmosphere and coastal areas with high salinity	Buildings or areas with almost permanent condensation and with high pollution

CX extreme	> 1 500 to 5 500	> 200 to 700	> 60 to 180	> 8,4 to 25	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres	Industrial areas withextreme humidity and aggressive atmosphere
NOTE The loss values used for the corrosivity categories are identical to those given in ISO 9223.						

5.2 *Categories for water and soil*

For structures immersed in water or buried in soil, corrosion is normally local in nature and corrosivity categories are difficult to define. However, for the purpose of this document, various environments can be described. In Table 2, four different environments are given together with their designations. See 4.2 for more details.

1. Table 2 — Categories for water and soil

Category	Environment	Examples of environments and structures
Im1	Fresh water	River installations, hydro-electric power plants
Im2	Sea or brackish water	Immersed structures without cathodic protection (e.g. harbour areaswith structures like sluice gates, locks or jetties)
Im3	Soil	Buried tanks, steel piles, steel pipes
Im4	Sea or brackish water	Immersed structures with cathodic protection (e.g. offshore structures)
NOTE For corrosivity category Im1 and Im3, cathodic protection can be used with a paint system tested accordingly		

Annex A
(informative)
Climatic conditions

Usually, only general conclusions as to the likely corrosion behaviour can be drawn from the type of climate. In a cold climate or a dry climate, the corrosion rate will be lower than in a temperate climate; it will be greatest in a hot, humid climate and in a marine climate, although considerable local differences can occur.

The main concern is the length of time a structure is exposed to high humidities, also described as time of wetness. Table A.1 provides information on calculated time of wetness and selected characteristics of various types of climate.

Table A.1 — Calculated time of wetness and selected characteristics of various types of climate

Type of climate	Mean value of the annual extreme values			Calculated time of wetness at relative humidity > 80 % andtemperature > 0 °C h/year
	Low temperature °C	High temperature °C	Highest temperature withrelative humidity > 95% °C	
Extremely cold	−65	+32	+20	0 to 100
Cold	−50	+32	+20	150 to 2 500
Cold temperate	−33	+34	+23	2 500 to 4 200
Warm temperate	−20	+35	+25	
Warm dry	−20	+40	+27	10 to 1 600
Mild warm dry	−5	+40	+27	
Extremely warm dry	+3	+55	+28	
Warm damp	+5	+40	+31	4 200 to 6 000
Warm damp, constant	+13	+35	+33	

Annex B
(informative)
Special cases

B.1 Special situations

B.1.1 *Corrosion inside buildings*

Corrosion stresses on steel structures located inside buildings sheltered from the outside environment are generally insignificant.

If the interior of the building is only partly sheltered from the outside environment, the corrosion stresses can be assumed to be the same as those associated with the type of atmosphere surrounding the building.

The effect of corrosion stresses due to the climate inside the building can be considerably intensified by the use to which the building is put, and these stresses should be dealt with as special stresses (see B.2). Such stresses can occur in indoor swimming pools with chlorinated water, livestock buildings and other special-purpose buildings.

Cooler areas on structures can be subject to higher corrosion stresses as a result of seasonal formation of condensation.

In cases where surfaces are wetted by electrolytes, even if such wetting is only temporary (e.g. in the case of saturated building materials), particularly stringent corrosion requirements are necessary.

B.1.2 *Corrosion in box members and hollow components*

Hollow components that are hermetically sealed and thus inaccessible are not subjected to any internal corrosion, whereas tightly sealed casings which are opened occasionally are subject to small corrosion stresses.

The design of sealed hollow components and box members should ensure their airtightness (e.g. no discontinuous welds, tightly bolted joints). Otherwise, depending on the outside temperature, moisture from precipitation or condensation can be drawn in and retained. If this is likely to happen, the internal surfaces have to be protected. Note that condensation is often observed even in boxes which have been designed with tightly sealed casings.

Corrosion is to be expected inside box members and hollow components that are not closed on all sides,and appropriate measures taken. For more information on design, see ISO 12944-3.

B.2 Special stresses

B.2.1 *General*

Special stresses, for the purposes of ISO 12944 (all parts), are stresses which cause a significant increase in corrosion and/or which make higher demands on the performance of protective paint systems. Owing to the diversity of such stresses, only a selected number of examples can be presented here.

B.2.2 *Chemical stresses*

Corrosion is aggravated locally by pollutants deriving from the operation of a plant (e.g. acids, alkalis or salts, organic solvents, aggressive gases and dust particles).

Such stresses occur in the vicinity of e.g. coking works, pickling shops, electroplating plants, dye mills, wood-pulp works, tanneries and oil refineries.

B.2.3 Mechanical stresses

B.2.3.1 In the atmosphere

Abrasive stresses (erosion) can occur due to particles (e.g. sand) being entrained by the wind. Surfaces which are subject to abrasion are considered to be exposed to moderate or severe mechanical stresses.

B.2.3.2 In water

In water, mechanical stresses can be produced by boulder movement, the abrasive action of sand, wave action, etc.

Mechanical stresses can be divided into three classes:

a) weak: no, or very slight and intermittent, mechanical stresses, for example due to light debris orsmall quantities of sand entrained in slow-moving water;
b) moderate: moderate mechanical stresses, due, for example, to

    — solid debris, sand, gravel, shingle or ice entrained in moderate quantities in moderately fast-flowing water,
    — a strong current without entrained matter flowing past vertical surfaces,
    — moderate growth (animal or vegetable), and
    — moderate wave action,

c) severe: high mechanical stresses due, for example, to

    — solid debris, sand, gravel, shingle or ice entrained in large quantities by fast-flowing water over horizontal or inclined surfaces, and
    — dense growth (animal or vegetable), particularly if, for operational reasons, it is removedmechanically from time to time.

B.2.4 *Stresses due to condensation*

If the temperature at the surface of a structure remains below the dew point for several days, the condensation produced will represent a particularly high corrosion stress, especially if such condensation can be expected to recur at regular intervals (e.g. in water works, on cooling-water pipes).

B.2.5 *Stresses due to medium or high temperatures*

In this document, medium temperatures are those between +60 °C and +150 °C, and high temperatures are those between +150 °C and +400 °C. Temperatures of this magnitude only occur under special conditions during construction or operation (e.g. medium temperatures occur during the laying of asphalt on roads, and high temperatures occur in chimneys made of sheet steel, flue gas ducts, or gas off-take mains in coking works).

B.2.6 *Increased corrosion due to combinations of stresses*

Corrosion can develop more quickly on surfaces exposed simultaneously to mechanical and chemical stresses. This applies particularly to steel structures near roads on which grit and salt have been spread.

Passing vehicles will splash salty water and throw up grit on to parts of such structures. The surface is then exposed to corrosion stresses from the salt and at the same time to mechanical stresses due to the impact of grit.

Other parts of the structure will be wetted by salt spray. This affects, for example, the underside of flyovers above roads that have been salted. The spray zone is generally assumed to extend to a distance of 15 m from the road concerned.

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[4] EN 12501-1, *Protection of metallic materials against corrosion — Corrosion likelihood in soil —Part 1: General*