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Fine bubble technology — Cleaning applications —

Part 1: Test method for cleaning salt (NaCl)-stained surfaces

Technologie des fines bulles — Applications de nettoyage —

Partie 1: Méthode d'essai pour le nettoyage de surfaces dégradées par le sel (NaCl)

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Foreword

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This document was prepared by Technical Committee ISO/TC 281, *Fine bubble technology.*

A list of all parts in the ISO 21256 series can be found on the ISO website.

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Introduction

Salt and materials derived from other pollution sources are known to coat surfaces of exterior of steel structures over time. Highway bridges and other steel structures are particularly vulnerable to anti icing salts or ocean spray. It is necessary that this contamination be removed in order to prevent growth of corrosion and to preserve the life time of the structure. Maintenance is conducted at times of inspection, possibly via the erection of suitable scaffolding and platforms and therefore a rapid efficient cleaning mechanism is essential.

High-pressure water sprays are commonly used for the cleaning method due to their hydrodynamic power. The method requires the operator long term engagement to dangerous operation in inhospitable environment.

It has been shown recently that cleaning process is much more effective and quicker once the water used for the high-pressure spray is augmented with the addition of ultrafine bubbles (UFB) and that markets of ultrafine bubble water or its generating systems are growing rapidly.

This document is intended to provide users of such products and systems with objective information on the cleaning performance of ultrafine bubble water and to facilitate the improvement of ultrafine bubble waters and their generating systems.

The test procedure correlates the ultrafine bubble enhanced performance with the presence of ultrafine bubbles under standardized conditions based on the most commonly used criteria such as hydrodynamic characteristics of high-pressure water spray, quality of raw water before mixing with ultrafine bubbles, quality of salt stain, quality and dimension of coating and substrate of test steel material and testing environmental conditions.

In this document, the presence of ultrafine bubbles is evaluated by measuring their sizes and number concentrations. The performance of the method is assessed by measuring the change in removal of salt from the test sample surface due to application of the ultrafine bubble water relative to that of plain water as control. Example application of the test procedure demonstrates the test results on various steel bridges long exposed to environments of express ways.

This document is intended to be used as a guidance for conducting tests and gathering more data to develop an International Standard.

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Fine bubble technology — Cleaning applications —

Part 1:
Test method for cleaning salt (NaCl)-stained surfaces

1 Scope

This document describes the test method to evaluate the cleaning performance of ultrafine bubble water when used in high-pressure water jet to wash out salt-stained steel surfaces.

The evaluation is carried out by measuring comparative removal of salt stain from the surface of a test plate with the ultrafine bubble water to that with control water.

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 20480-1, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology*

ISO 20480-2, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20480-1, ISO 20480-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
high-pressure water jet
equipment that forces water out of a small orifice at high speed

3.2
control water
blank water
water used as reference in comparative test on the ultrafine bubble water

4 Principle of cleaning performance test

Cleaning of salt stains is performed using water containing ultrafine bubbles that are uniformly distributed in the water medium.

The characteristics to define the ultrafine bubble water are the diameter and the density distribution of ultrafine bubbles.

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The performance of the cleaning test is dependent in principle on the characteristics of the ultrafine bubble water and the hydrodynamic performance of the high-pressure water jet as well as the characteristic of the salt stains and the test environment.

In the test method, the characteristics of the high-pressure water jet, the salt stains and the test environment are fixed, while the ultrafine bubble characteristics are modified to assess how ultrafine bubbles can enhance performance.

The change in performance is assessed by measuring the density of salt stains after removal by high-pressure water jet using ultrafine bubble water and control water.

5 Test apparatus for cleaning test

5.1 High-pressure water jet

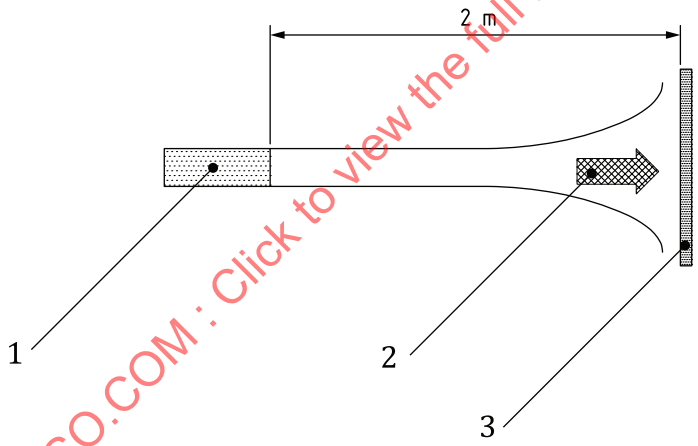
5.1.1 Test conditions

A high-pressure water jet is used to carry out the cleaning test, as shown in Figure 1.

The test conditions are as follows:

a) high-pressure water jet nozzle: inner diameter 6 mm at outlet;

b) water temperature: 15 °C to 25 °C.



Key

1 nozzle of high-pressure water jet
2 water flow
3 steel test plate

Figure 1 — Salt removal method using a high-pressure water jet

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5.1.2 Characteristics of the high-pressure water jet

The characteristics of the high-pressure water jet should be as follows.

a) The high-pressure cleaning machine should have an outlet pressure from 5 MPa to 9 MPa and the amount of outlet cleaning liquid should range from 300 l/h to 400 l/h. The cleaning width on the target should be stable, between 250 mm and 300 mm at a distance of 2 m from the outlet gate.

b) Ultrafine bubble water should be continuously supplied to the high-pressure water jet during the cleaning test.

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5.2 Measuring instrument

After removal, the adherent salt stains on the test plate shall be measured using a surface salinity meter to perform density measurements.

The following conditions apply:

a) the surface salinity density is measured based on the electrical conductivity data after conversion (see ISO 8502-9[4]);

b) precision should be ±1 % (for a temperature between 0 °C and 50 °C).

Annex A shows an example of surface salinity meter, according to ISO 8502-9.

6 Salt-stained steel test plate for cleaning performance test

The salt-stained steel test plate shall have the following features:

a) flat plate with simple configuration;

b) plate made of steel of carbon steel grade;

c) with dimensions 530 mm × 530 mm and thickness 10 mm.

7 Procedure

7.1 General

The salt density is measured before and after cleaning the surface of the steel test plate. The test shall be very carefully conducted from the beginning to the end as it is a destructive test.

7.2 Measurement before cleaning the surface of the steel test plate

Salt density shall be measured before cleaning the surface of the steel test plate in accordance with the following procedure.

a) Four even-numbered points on the surface of the steel test plate are measured with the surface salinity meter. See Figure 2.

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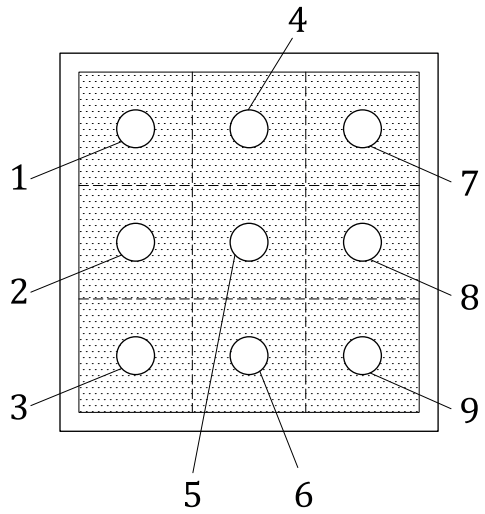

Key

1	not measured initially	6	$\rho_{initial\text{-}6}$
2	$\rho_{initial\text{-}2}$	7	not measured initially
3	not measured initially	8	$\rho_{initial\text{-}8}$
4	$\rho_{initial\text{-}4}$	9	not measured initially
5	not measured initially		

Figure 2 — Initial measuring points before cleaning

b) The initial salt density average is calculated using Formula (1):

$$\rho_{initial} = (\rho_{initial\text{-}2} + \rho_{initial\text{-}4} + \rho_{initial\text{-}6} + \rho_{initial\text{-}8})/4 \quad (1)$$

where $\rho_{initial}$ is the initial adherent average value before cleaning on the surface (mg/m^2).

7.3 Cleaning method of the surface of the steel test plate

Figure 3 shows an outline of the test method. When reproducibility of manual operation, for cleaning the surface, is significantly deteriorated, introduction of automatic operation is recommended.

a) A distance of 2 m is kept between the outlet gate of the high-pressure water jet and the surface of the steel test plate.

b) The steel test plate is tightly fixed and the cleaning liquid of the high-pressure water jet is outlet at right angle to the surface of the steel test plate.

c) The high-pressure water jet is reciprocally moved like a round-trip starting from “a”, going through “b”, “c” and “d” and returning to “a” as shown in Figure 3. The number of repetitions is arbitrary, but 20 times are enough.

d) Time needed for the nozzle to make a reciprocal move is approximately 1 s.

e) To compare removal quantities, cleaning liquid with or without ultrafine bubbles is applied for the cleaning test.

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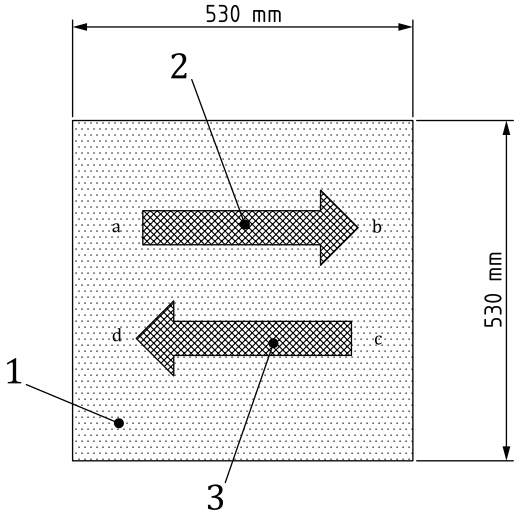


Key

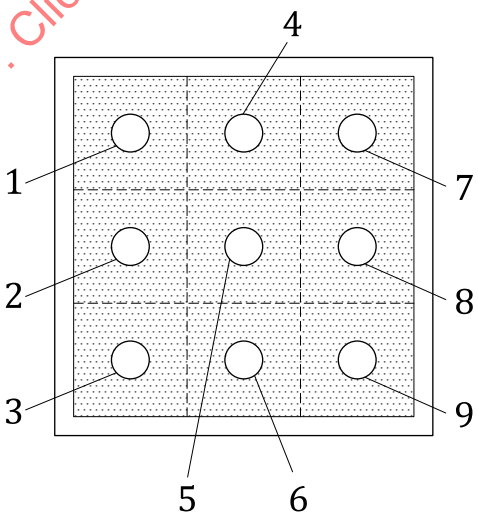
1 surface of steel test plate, standing up vertically
2 water flow from “a” to “b”
3 water flow from “c” to “d”

Figure 3 — Cleaning method

7.4 Measurement of salt stains after cleaning the surface of the steel test plate

Salt density shall be measured after cleaning the surface of the steel test plate in accordance with the following procedure.

a) Five odd-numbered points on the surface of the steel test plate are measured with the surface salinity meter, as shown in Figure 4.



Key

1 $\rho_{aw\text{-}1}$
2 not measured after cleaning
3 $\rho_{aw\text{-}3}$
4 not measured after cleaning
5 $\rho_{aw\text{-}5}$
6 not measured after cleaning
7 $\rho_{aw\text{-}7}$
8 not measured after cleaning
9 $\rho_{aw\text{-}9}$

Figure 4 — Measuring point after cleaning

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b) After cleaning, the average salt density is calculated using Formula (2):

$$\rho_{aw} = (\rho_{aw\text{-}1} + \rho_{aw\text{-}3} + \rho_{aw\text{-}5} + \rho_{aw\text{-}7} + \rho_{aw\text{-}9})/5 \quad (2)$$

where ρ_{aw} is the adherent average density after cleaning the surface (mg/m^2).

c) The surface of the steel test plate is cleaned until a specified maximum number of cleaning or until the residual salt density value reads "0". The surface is measured at every cleaning stage.

8 Calculation method of salt stain removal

8.1 Calculation method of salt removal ratio

The test results are reported by using either the salt removal ratio or the removal quantity (see 8.2).

The adherent removal ratio is defined as Formula (3):

$$R_{asr} = \frac{\rho_{initial} - \rho_{aw}}{\rho_{initial}} \quad (3)$$

where

R_{asr} is the salt removal ratio;

$\rho_{initial}$ is the initial salinity density (mg/m^2);

ρ_{aw} is the measured salinity density after cleaning (mg/m^2).

Annex B shows an example of evaluation results for the initial salinity density, the measured salt density after cleaning and the removal quantity.

8.2 Calculation method of salt removal quantity

The salt removal quantity is defined as Formula (4):

$$Q = \rho_{initial} - \rho_{aw} \quad (4)$$

where

Q is the removal quantity (mg/m^2);

ρ_{aw} is the measured adherent density after cleaning (mg/m^2);

$\rho_{initial}$ is the initial adherent density (mg/m^2).

9 Test report

The test report shall contain at least the following information:

a) description of the weather conditions, washing liquid, washing machines, measuring instrument considering they might influence the quantity of adherent stain and removal;

b) temperature and humidity;

c) test conditions (pre-treatment condition, washing machine, washing liquid type measuring machine and other conditions);

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d) test results (washing frequency, initial adherent density, and measured adherent density after washing and removal quantity);

e) any deviations from the procedure;

f) any unusual features observed;

g) test date (month, day, and year).

Annex C shows an example of a test result table.

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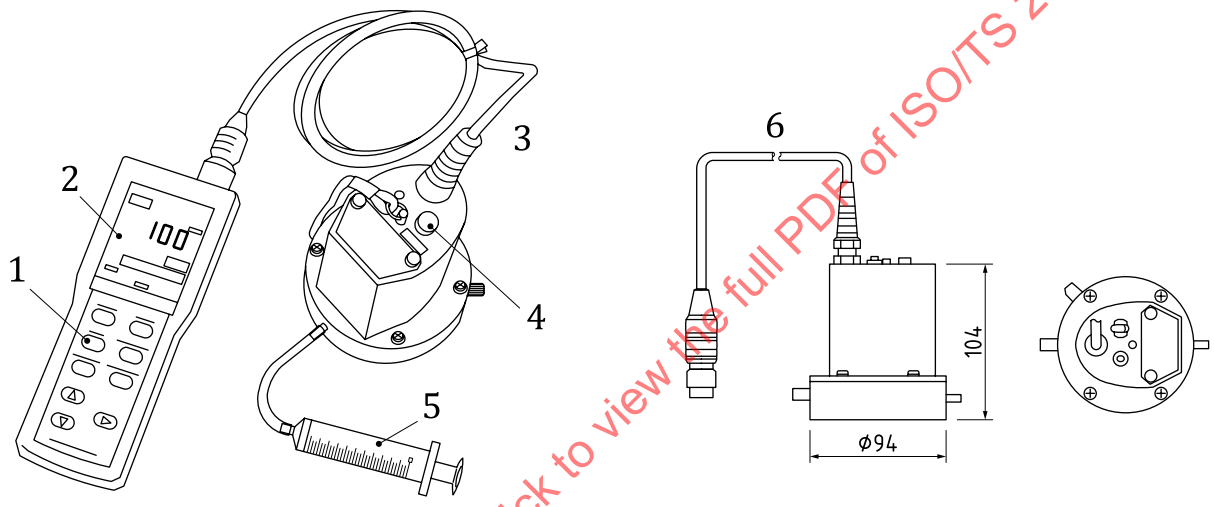
Annex A
(informative)

Surface salinity meter

The surface salinity meter measures the electrical conductivity after a certain amount of pure water is injected from an injection syringe into the measuring cell fixed on the steel surface and surface salinity is dissolved. According to the electrical conductivity, the surface salinity meter displays water-soluble salinity density and surface salinity density after calculating the NaCl density.

Figure A.1 shows a typical example of surface salinity meter, according to ISO 8502-9.

Dimensions in millimetres



General view **Measuring cell**

Key

1 operation key
2 LCD display
3 measuring cell
4 churning switch
5 injecting syringe
6 cable (1 m length)

Figure A.1 — Example of a typical surface salinity meter

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Annex B
(informative)

Example of evaluation results for cleaning of steel bridge girder edges

Table B.1 summarizes the test results for the cleaning performance of ultrafine bubble waters with salt removal ratio.

Figure B.1 and Figure B.2 show the change in the residual salinity densities due to successive increment of jet stroke operations, which visualize the ultrafine bubble enhanced cleaning.

Table B.1 — Example of test results for cleaning of steel bridge girder edges

		Without UFB (Control water)			UFB water		
		Initial value	Value after cleaning	Salt removal ratio	Initial value	Value after cleaning	Salt Removal ratio
		mg/m^2	mg/m^2	%	mg/m^2	mg/m^2	%
Chugoku Expressway	Mibu bridge	88,8	5,0	94,4	96,6	0,2	99,8
	Takata bridge	48,8	5,5	88,7	93,4	0,1	99,9
	Miwa Bridge	82,2	1,5	98,2	107,1	0,2	99,8
	Fukatani bridge	17,4	4,0	77,0	21,3	0,2	99,1
	Kouchi River bridge	38,5	2,9	92,5	25,6	0,2	99,2
	Hinokami River bridge	64,2	3,0	95,3	93,9	0,7	99,2
	Bicchu River bridge	64,3	4,2	93,5	54,3	0,3	99,4
Okayama Expressway	Hokubo JCT-B Ramp bridge	67,5	8,1	88,0	81,4	2,7	96,7

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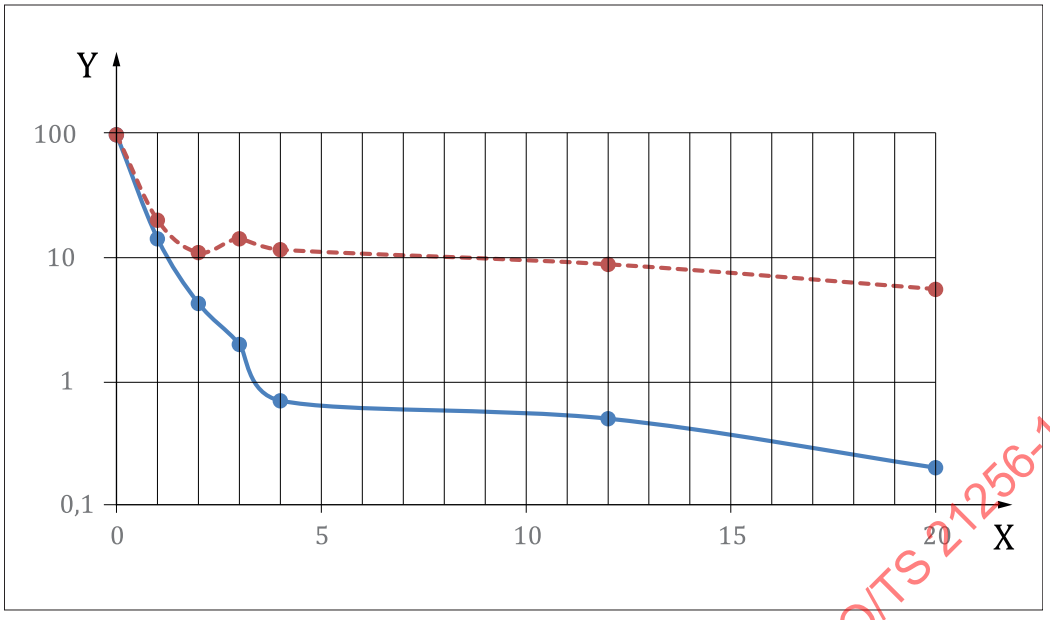


Key

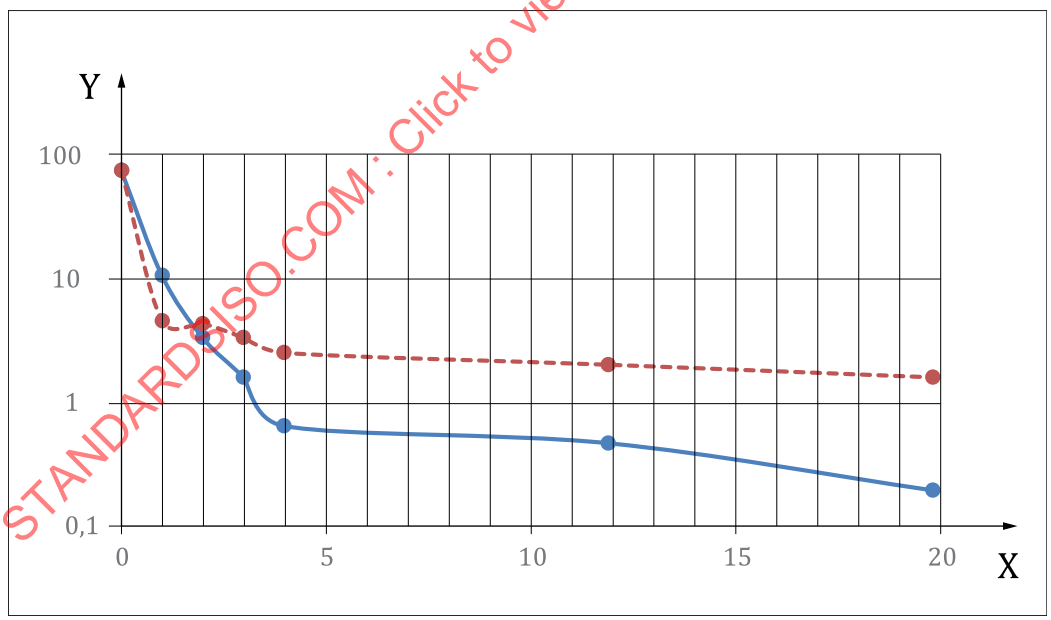
X number of strokes

Y relative residual salinity density in %

enhanced (= with UFB)

control (= without UFB)

Figure B.1 — Results reported for Mibu bridge



Key

X number of strokes

Y relative residual salinity density in %

enhanced (= with UFB)

control (= without UFB)

Figure B.2 — Results reported for Sanwa bridge

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