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Methods of salt spray testing

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS Z 2371:1994** is replaced with **JIS Z 2371:2000**.

This revision has been prepared based on **ISO 9227:1990** *Corrosion tests in artificial atmospheres — Salt spray tests* for the purposes of comparison and conformity with the International Standard.

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Methods of salt spray testing

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 9227** *Corrosion tests in artificial atmospheres — Salt spray tests* published in 1990. However, some items and contents not specified in the corresponding International Standard have been added, and some parts have been rejected because the experimental results of the reference specimens specified have not conformed to the requirements. The main differences are shown as follows:

The rejected part: The evaluation method for reproducibility of testing apparatus

The portions underlined with dots or sidelined in this Standard are the items not specified in the corresponding International Standard.

1 Scope This Japanese Industrial Standard specifies the required apparatus, reagent, technique or acceptance criteria when the corrosion resistance test of metallic materials or of those electroplated or treated with inorganic or organic films by the methods of neutral salt spray test (NSS), acetic acid salt spray test (AASS) or CASS test (CASS).

Remarks: The International Standard corresponding to this Standard is listed as follows.

ISO 9227: 1990 *Corrosion tests in artificial atmospheres — Salt spray tests*

2 Normative references The following standards contain provision which, through reference in this Standard, constitute provisions of this Standard, the most recent editions of the standards (including amendments) indicated below shall be applied.

JIS G 3141 *Cold-reduced carbon steel sheets and strip*

Remarks: The provisions cited from **ISO 3574: 1986** *Cold-reduced carbon steel sheet of commercial and drawing qualities* are equivalent to the corresponding provisions of the said standard.

JIS K 0557 *Water used for industrial water and wastewater analysis.*

JIS K 8145 *Copper (II) chloride dihydrate*

JIS K 8150 *Sodium chloride*

JIS K 8180 *Hydrochloric acid*

JIS K 8355 *Acetic acid*

JIS K 8576 *Sodium hydroxide*

JIS K 8847 *Hexamethylenetetramine*

JIS Z 8802 *Methods for determination of pH of aqueous solutions*

3 Apparatus The apparatus necessary to salt spray testing shall be composed of an atomizing chamber equipped with an atomizer, a testing salt solution reservoir, a specimen support, atomized solution sampling containers, a temperature controller,

etc.; a salt water supply tank, a compressed air feeder, an air saturator, an exhaustor, etc., and shall conform to the following requirements:

- a) The atomizer shall have the performance to spray atomized solution uniformly on a specimen from the upper part (refer to Annex 2).
- b) The atomizing chamber shall be not less than 0.2 m³ in volume. Its shape and dimensions may be optional.
- c) The ceiling or cover of the atomizing chamber shall be so constructed that no drops of solution adhering to its inner surface fall on a specimen.
- d) Corrosive materials shall not be used for the apparatus.
- e) The apparatus shall be so constructed that the temperature and atomization in the atomizing chamber are not influenced by the open air and the solution fallen from the specimen is not reused for the testing.
- f) The specimen support shall be capable of keeping the specimen at a specific angle ⁽¹⁾.

Note ⁽¹⁾ The materials of specimen supports shall be glass, rubber, plastics, or suitably coated wood, and the specimen should preferably be supported from the underside of the bottom or the side face. The specimen may be hung by a glass hook or a vinyl string, provided it is kept in a specific position. If necessary, the specimen is supported from the bottom.

- g) The atomized solution sampling container shall be a clean container of 100 mm in diameter in sampling surface and 80 cm² in horizontal sampling area, and the containers shall be placed at not less than two positions so as to ensure the uniformity of atomization, for example, near the specimens, and one close to the atomizer and one remote from.
- h) The exhaustor shall not be influenced by the wind pressure of the open air.
- i) The maintenance and control of the apparatus shall always be correctly carried out to meet the specified requirements.

4 Specimen The dimensions and shape of the specimen should preferably be a flat sheet of 70 mm × 150 mm × 1.0 mm or 60 mm × 80 mm × 1.0 mm. However, other dimensions or member may be used subject to the agreement between the parties concerned with delivery.

Informative reference: For the specimen of different metal possible to be mutually influenced, the test should not carried out at the same time.

5 Preparation of specimen The specimen shall be free from stains or flaws. The preparation of the specimen shall be as follows:

- a) The section of the specimen shall be protected by a stable covering material under test conditions, as required ⁽²⁾.

Note ⁽²⁾ The covering material includes a tape, paint, paraffin, etc.

- b) Metallic and metallic coated specimens shall be suitably cleaned beforehand. Cleaning shall be carried out by an appropriate method according to the nature of surface and the contaminants. Abrasives other than pasty precipitated calcium carbonate, aluminium oxide and magnesium oxide, or detergents causing a corrosive or protective coating shall not be applied.

The specimen, after cleaning, shall be protected from contamination.

- c) The specimen coated with paint and non-metallic coatings shall not be, prior to test, subjected to cleaning or other treatments. However, the adhering matter inconvenient to test may be removed. Further, when it is required to measure the development of corrosion from an abraded area, the coating shall be scratched in order to expose the underlying metal prior to the test. The method for scratching shall be subject to an agreement between the parties concerned with delivery.

The following method is an example:

Example: After coating about 5 mm of the periphery of a specimen for protection, scratch the specimen with shaped like × at 1/2 to 1/3 of the bottom on the long side. The flaw shall have a depth reaching the underlying metal surface, and the size of the incision should preferably be constant. The type of the cutting tool should preferably be a cutter knife, a razor blade, etc.

6 Angle and position of specimens during testing The angle and position of the specimens in the atomizing chamber during testing shall conform to the following conditions (refer to Annex 3):

- a) The angle of the specimens shall be $20^\circ \pm 5^\circ$ to the vertical line. In the case of a member, it shall be placed with its significant surface at $20^\circ \pm 5^\circ$ to the vertical line.

Other angles may be employed subject to the agreement between the parties concerned with delivery.

The surfaces of the specimens shall be exposed to the motion of free atomization, and shall be placed in the atomizing chamber not to intersect the stream of spray from the atomizing nozzle at right angles.

- b) The specimens shall contact with nothing other than the support.
- c) Each specimen shall be so positioned and spaced as not to interfere with the free falling of the spray.
- d) The salt solution dripping from one specimen shall not fall on other specimens.

7 Salt solution for testing

7.1 Preparation method of salt solution for testing The preparation method of salt solution shall be as follows:

- a) **Salt** The salt shall be the sodium chloride of special grade specified in **JIS K 8150** or equal to or higher grade⁽³⁾.

Note ⁽³⁾ The equal to or higher grade means that copper content shall be less than 0.01 g/kg and nickel content shall be less than 0.01 g/kg when sodium chloride is measured by the means of atomic absorption spectrometry or other analytical method with the same accuracy. Furthermore, the content of sodium iodide shall not exceed 1.0 g/kg or the total amount of impurities as converted to dry salt shall not exceed 5.0 g/kg.

- b) **Water** The water shall be the deionized water or distilled water not more than 20 $\mu\text{S/cm}$ in electric conductivity at $25^\circ\text{C} \pm 2^\circ\text{C}$.

It is recommended that the electric conductivity ought to be not more than 1 $\mu\text{S}/\text{cm}$.

- c) **Preparation method** Dissolve the salt in a) in the water in b), and adjust the salt concentration to $50 \text{ g/l} \pm 5 \text{ g/l}$. As to the adjusted result, measure the density using a hydrometer, and confirm that it is within the range of 1.029 to 1.036 at 25°C .

If it is found to be outside this range, adjust the solution again.

7.2 pH control

7.2.1 Neutral salt spray test The salt solution for testing shall be free from suspended substance⁽⁴⁾ before atomization and the atomized solution sampled at spraying shall be within the range of 6.5 to 7.2 in pH⁽⁵⁾.

In regulating pH, 0.1 mol/l solution of the sodium hydroxide specified in **JIS K 8576** or hydrochloric acid specified in **JIS K 8180** shall be used, as required.

The measurement of pH shall be carried out at $25^\circ\text{C} \pm 2^\circ\text{C}$ in accordance with **JIS Z 8802**.

In routine checks, the pH may be examined with a pH test paper readable to the place of 0.3.

Notes (4) If suspended substance does not disappear by sufficient mixing, the solution filtered through filter paper or the like is used.

(5) The following methods can be used in order that the pH of atomized solution sampled, during atomization of salt solution for testing at 35°C , is within the range of 6.5 to 7.2.

- a) When the pH of salt solution is regulated at a room temperature and the solution is sprayed at 35°C , pH of the sampled solution generally becomes higher than that of the original due to the volatilization of carbon dioxide dissolved in the solution. Therefore, when the pH of salt solution is regulated at $25^\circ\text{C} \pm 2^\circ\text{C}$, it is kept at about 6.5 level.
- b) After boiling quietly for about 30 s, the salt solution is cooled to 25°C , or after keeping at 35°C for 48 h, the pH is regulated.
- c) Salt solution is prepared by using the water in which carbon dioxide is not contained by heating at 35°C or higher (Remarks 4 in 4 of **JIS K 0557**) and then the pH is regulated.

7.2.2 Acetic acid salt spray test The salt solution for testing shall be free from suspended substance⁽⁴⁾ before atomization and the acetic acid specified in **JIS K 8355** shall be sufficiently added so that the atomized solution sampled at spraying is within the range of 3.1 to 3.3 in pH. The pH of salt solution should be regulated at 3.0 to 3.1 at first for the purpose of making the pH of sampled solution fall under the specified range.

The measurement of pH shall be carried out at $25^\circ\text{C} \pm 2^\circ\text{C}$ in accordance with **JIS Z 8802** and corrected appropriately by adding the acetic acid specified in **JIS K 8355** or sodium hydroxide specified in **JIS K 8576**, as required.

In routine checks, the pH may be examined with a pH test paper readable to the place of 0.1.

Remarks: For acetic acid and sodium hydroxide, it is recommended that 0.1 mol/l solution ought to be used.

7.2.3 CASS test Add $0.205 \text{ g} \pm 0.015 \text{ g}$ of copper (II) chloride ($0.26 \text{ g} \pm 0.02 \text{ g}$ of copper (II) chloride dihydrate specified in **JIS K 8145**) per 1 l of the salt solution for testing. Next, regulate the pH in accordance with the method specified in **7.2.2**.

8 Supplied air The compressed air to be supplied to the nozzle for atomizing salt solution shall be free from oil and dust, and its pressure shall be kept at 0.07 MPa to 0.17 MPa.

It is recommended that it ought to be kept at $0.098 \text{ MPa} \pm 0.010 \text{ MPa}$.

9 Conditions in atomizing chamber The conditions in atomizing chamber shall be as follows:

- a) **Temperature** The temperature around the specimen holder in the atomizing chamber shall be kept at $35 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ for the neutral and acetic acid salt spray test, and at $50 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ for the CASS test. The measuring position of temperature shall be at least 100 mm apart from the wall.
- b) **Temperature and water level of salt solution reservoir for testing** The temperature of the salt solution reservoir for testing shall be kept at $35 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ for the neutral and acetic acid salt spray test and at $50 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ for the CASS test. The water level of the salt solution reservoir for testing shall be kept at constant level.
- c) **Spray** The sprayed particles shall, as a rule, fall free, and be baffled from impinging directly on a specimen by facing the atomizing nozzle to the direction where the specimen is clear of the direct spray.
- d) **Atomization sampling solution** After an operation of consecutive 24 h under a state where the inside of the atomizing chamber is filled up with specimens of specified dimensions and shape, the sampling amount of atomized solution collected shall average $1.5 \text{ ml} \pm 0.5 \text{ ml}$ per 1 h for each 80 cm^2 of horizontal sampling area. In this case, the salt concentration of sampled atomized solution shall be $50 \text{ g/l} \pm 5 \text{ g/l}$. Further its pH shall be 6.5 to 7.2 for the neutral salt spray test and 3.1 to 3.3 for the acetic acid salt spray test and CASS test. The measurement of pH shall be carried out in accordance with the method specified in **7.2**.

Informative reference: If the density is in the range of 1.029 to 1.036 at $25 \text{ }^{\circ}\text{C}$ when measured using a hydrometer in the case of the neutral salt spray test, the salt concentration of atomizing solution is considered to conform to the specified requirements.

10 Reuse of apparatus When the apparatus has been used for the spray test with a different salt solution for testing or for other purpose, the apparatus shall be cleaned before use.

When the test is started again, the apparatus shall be operated at least for 24 h before the specimen is placed in the chamber and it shall be verified that the pH of sampled solution is within the specified value throughout the entire spraying period.

11 Evaluation method of reproducibility of testing apparatus In order to verify the reproducibility of test results by one set of testing apparatus or by the same type of apparatus in different laboratories, the apparatus shall be required to verify the motions periodically in accordance with 11.1 to 11.3.

11.1 Neutral salt spray test

11.1.1 Reference specimens In order to verify the motions of apparatus, use four pieces of the reference specimens of Grade SPCE steel sheets specified in **JIS G 3141** of which the dimensions are 70 mm × 150 mm and 1 mm ± 0.2 mm in thickness and the surface is free from defects [roughness (arithmetic mean) deviation: $R_a=0.8 \pm 0.3$ μm, the value along the rolling direction]. These reference specimens shall be taken by cutting from cold-rolled steel sheets.

The reference specimens shall be carefully cleaned immediately before testing. The dirt, oil and other impurities capable of influencing the test results shall be removed by cleaning. In such a case, either of the following methods shall be used.

- a) Thoroughly clean the reference specimens with an appropriate organic solvent (the range of boiling point of hydrocarbon, 60 °C to 120 °C) using a clean, soft brush or an ultrasonic cleaning device. Carry out the cleaning in a vessel full of solvent at room temperature. After cleaning, rinse the reference specimens with fresh solvent and then dry them.
- b) If the similar results are obtained, other methods may be used in accordance with the agreement between the parties concerned with delivery.

Weigh the reference specimens to the place of 1 mg. Protect the one surface of the reference specimens with a removable coating material, for example, an adhesive tape.

11.1.2 Arrangement of the reference specimens Position the four reference specimens in four different corners in the test chamber, with the unprotected surface upwards, and at an angle of $20^\circ \pm 5^\circ$. The support for the reference specimens shall be made of, or coated with, inert materials such as plastics. The lower edge of the reference specimens shall be approximately level with the upper edge of the salt spray collector so as to be exposed in the same manner as the ordinary plane specimens. The test duration shall be 96 h.

11.1.3 Determination of decrement At the end of test, remove the coating material, rinse the reference specimens with cold water and remove the salt deposit. Immerse the reference specimens in the cleaning solution prepared by the method in which 3.5 g of the hexamethylenetetramine specified in **JIS K 8847** is added as a corrosion inhibitor in 1 l of the solution [50 % (v/v)] prepared so that 1 volume of the water in 7.1 b) is added in 1 volume of the hydrochloric acid specified in **JIS K 8180**, repeat the cleaning until the decrement change almost disappears and remove the corrosion products thoroughly. It is recommended that the temperature of cleaning solution ought to be $25^\circ\text{C} \pm 2^\circ\text{C}$. After removing, clean the reference specimens thoroughly with water at ordinary temperature and dry them at the end.

Remarks: In order to clean sufficiently with water, it is recommended that the floating matter on the surface ought to be washed out with service water.

Weigh the reference specimens to the place of 1 mg and calculate the decrement of mass by the unit of g/m^2 .

11.1.4 Inspection of apparatus operation If the mass loss of each reference specimen at four positions is $140 \text{ g/m}^2 \pm 30 \text{ g/m}^2$, the apparatus shall be considered to operate satisfactorily.

Remarks: Zinc plate may be used in place of steel plate. In such a case, the dimensions of specimen, cleaning method and measuring method of decrement shall be in accordance with 11.2, and if the mass loss is $50 \text{ g/m}^2 \pm 15 \text{ g/m}^2$, the apparatus shall be considered to operate satisfactorily.

11.2 Acetic acid salt spray test

11.2.1 Reference specimens In order to verify the motions of apparatus, use four pieces of the reference specimens of zinc plate conforming to the chemical composition given in Table 1 and of which the dimensions are $70 \text{ mm} \times 150 \text{ mm}$ and $1 \text{ mm} \pm 0.2 \text{ mm}$ in thickness and the surface is free from defects [roughness (arithmetic mean) deviation: $R_a = 0.05 \mu\text{m} \pm 0.02 \mu\text{m}$, the value along the rolling direction]. These reference specimens shall be taken by cutting. Four pieces shall be cut from plate materials along the rolling directions.

Table 1 Chemical composition of reference specimen (zinc plate)

unit: %				
Zn	Pb	Fe	Cd	Cu
98.5 min.	1.3 max.	0.09 max.	0.40 max.	0.01 max.

The reference specimens shall be carefully cleaned immediately before testing.

The dirt, oil and other impurities capable of influencing the test results shall be removed. In such a case, either of the following methods shall be used.

- Thoroughly clean the reference specimens with an appropriate organic solvent (the range of boiling point of hydrocarbon, 60°C to 120°C) using a clean, soft brush or an ultrasonic cleaning device. Carry out the cleaning in a vessel full of solvent at room temperature. After cleaning, rinse the reference specimens with fresh solvent and then dry them.
- If the similar results are obtained, other methods may be used in accordance with the agreement between the parties concerned with delivery.

Weigh the reference specimens to the place of 1 mg. Protect the one surface of the reference specimens with a removable coating material, for example, an adhesive tape.

11.2.2 Arrangement of the reference specimens Position the four reference specimens in four different corners in the test chamber, with the uncoated surface upwards, and at an angle of $20^\circ \pm 5^\circ$. The support for the reference specimens shall be made of, or coated with, inert materials such as plastics. The lower edge of the reference specimens shall be approximately level with the upper edge of the salt spray collector so as to be exposed in the same manner as the ordinary plane specimens. The test duration shall be 24 h.

11.2.3 Determination of decrement At the end of test, remove the coating, rinse the reference specimens with cold water and remove the salt deposit. Immerse them in the aqueous solution of chromic acid (300 g/l) prepared in such a manner that the chromic acid aqueous solution⁽⁶⁾ conforming to the chemical composition given in Table 2 is diluted with the water of 7.1 b), at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for 3 min, or immerse them in chromic acid aqueous solution (200 g/l) at $80\text{ }^{\circ}\text{C}$ for 1 min, repeat the cleaning until the decrement change almost disappears and thoroughly remove the corrosion products. Rinse the reference specimens with warm water ($40\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$), then dry them in a dryer at $105\text{ }^{\circ}\text{C}$, and furthermore cool them at room temperature.

Weigh the mass of reference specimens to the place of 1 mg, and calculate the decrement of mass by the unit of g/m^2 .

Note ⁽⁶⁾ Chrome oxide and aqueous solution of chromic acid are toxic, therefore care shall be thoroughly taken so as not to touch on skin or mucous membrane on handling.

Table 2 Chemical composition of chrome (VI) oxide (chromic anhydride)

Unit: %

Aqueous solution	Chloride (Cl)	Sulphate (SO_4)	Alkali earth and alkali (sulphate)	Precipitated substance by aqueous ammonia	Content
Limit	0.005 max.	0.005 max.	0.1 max.	0.03 max.	98.0 min.

11.2.4 Inspection of apparatus operation If the mass loss of each reference specimen at four positions is $40\text{ g}/\text{m}^2 \pm 12\text{ g}/\text{m}^2$, the apparatus shall be considered to operate satisfactorily.

11.3 CASS test

11.3.1 Reference specimens The reference specimens shall be as shown in 11.2.1

11.3.2 Arrangement of reference specimens The arrangement of reference specimens shall be as shown in 11.2.2

11.3.3 Determination of decrement The determination of decrement shall be as shown in 11.2.3

11.3.4 Inspection of apparatus operation If the mass loss of each reference specimens at four positions is $95\text{ g}/\text{m}^2 \pm 25\text{ g}/\text{m}^2$, the apparatus shall be considered to operate satisfactorily.

12 Start of test After the confirmation of 9, the spray is temporarily suspended, and a specimen is placed in the atomizing chamber to start the test.

13 Continuation of test The test shall be carried out continuously during the test period. However, it may be intermittently carried out subject to the agreement between the parties concerned with delivery.

When the test is interrupted to inspect and put in and take out of the specimen, the time of interruption shall be minimized by only stopping the atomization.

14 Duration of test The duration of the test shall be as specified according to the materials to be tested, product standards, etc. When not specified, it shall be subjected to the agreement between the parties concerned with delivery.

The recommended exposure duration are 2 h, 6 h, 24 h, 48 h, 96 h, 168 h, 240 h, 480 h, 720 h and 1 000 h.

Informative reference: When the appearance of corrosion is observed, the test may be carried out until corrosion appears.

15 Treatment of specimen after test The specimen after the test shall be treated as follows:

- a) The specimen shall be carefully taken out from the test chamber and immediately dried for 0.5 h to 1.0 h.
- b) In order to remove the sodium chloride adhering to the surface of the specimen, the specimen shall be washed with water at ordinary temperature of 15 °C to 40 °C and dried immediately.

Informative reference: The drying may be carried out by blowing the air of not exceeding 200 kPa in pressure at a distance of approximately 300 mm.

- c) In the case of removing corrosion products, they shall be removed by mechanical methods such as brushing, ultrasonic irradiation, grain injection, water injection, etc., chemical method or electrolytic method (refer to Informative reference Table 1 or Informative reference Table 2), or otherwise by combination of these methods.

16 Evaluation method The method for evaluation of test results shall be in accordance with either of the following methods. However, other methods⁽⁷⁾ may be applied subject to the agreement between the parties concerned with delivery.

- a) **Area method** The results shall be evaluated by the rating number method specified in Annex 1.⁽⁸⁾
- b) **Mass method** The change of mass of specimen before test and after removal of corrosion products by testing shall be examined and evaluated.

Note (7) For other methods, the method of appearance, record of change by microscopic photograph, elapsed time by the appearance of first sign of corrosion etc., are known.

⁽⁸⁾ When the corrosion results are evaluated by the area method, a plane plate of 70 mm × 150 mm × 1 mm shall be used.

17 Record The following items should preferably be recorded:

- a) Classification of test
- b) Name and type of test apparatus and system of atomizer.

- c) Shape and dimensions of specimens and members, or otherwise number or type of parts.
- d) Cleaning method of specimen before and after test
- e) Number of the specimens to be supplied for testing
- f) Preparation method of specimen
- g) Existence and size of scratch, and device for scratching.
- h) Supporting angle of specimen. In the case of members, its supporting angle and method.
- i) Types of salt and water used for preparation of salt solution for testing
- j) Temperature around the specimen holder in the atomizing chamber
- k) Daily records of numerical values obtained from each sampling container on the following items.
 - 1) Volume (ml) of atomized solution sampled per hour for approximately 80 cm²
 - 2) Salt concentration of sampled atomized solution and its measured value of density by hydrometer (25 °C) (in the case of neutral salt spray test)
 - 3) pH of sampled atomized solution
- l) When the test is carried out intermittently, the duration of atomization and the suspended time of atomization.
- m) When the test is interrupted, its reason and duration of interruption
- n) Period of test
- o) Specification of reference specimens used for the evaluation method of reproducibility of testing apparatus
- p) When the corrosion products are removed, its method and details.
- q) Evaluation method and expression of results (including the results at intermediate inspection.)
- r) Photograph of specimen, if necessary.

Informative Table 1 Chemical method for removal of corrosion products

Material	Chemicals	Time	Temperature	Remarks
Aluminium and aluminium alloy	Add 50 ml of phosphoric acid (JIS K 9005) and 20 g of chromium oxide (VI) (CrO_3) into distilled water to make up to 1 000 ml.	5 min to 10 min	90 °C boiling	When the coating of corrosive product remains, the following nitric acid treatment is successively carried out.
	Nitric acid (JIS K 8541)	1 min to 5 min	20 °C to 25 °C	In order to prevent a reaction inducing excessive removal of underlying metal, peripheral extraneous matter and bulky corrosion products are removed.
Anodic oxide film of aluminium	Add 10 ml of hydrochloric acid (JIS K 8180) into distilled water to make up to 110 ml.	1 min to 5 min	20 °C to 25 °C	The film is washed with using of nylon-brush etc. immersed in solution, washed with water and then dried by ventilation. When the corrosion products remain, this operation is repeated.
Copper and copper alloy	Add 500 ml of hydrochloric acid (JIS K 8180) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	Removal of air in solution with highly pure nitrogen controls the removal of underlying metal.
	Add 4.9 g of sodium cyanide (JIS K 8447) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	Corrosion product which is not likely to be removed by hydrochloric acid treatment mentioned above is removed. For example, copper sulphide.
	Add 100 ml of sulfuric acid (JIS K 8951) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	Bulky corrosion product is removed, prior to treatment, to prevent copper from adhering again to the surface of specimen.
	Add 120 ml of sulfuric acid (JIS K 8951) and 30 g of sodium bichromate bihydrate (JIS K 8518) into distilled water to make up to 1 000 ml.	5 s to 10 s	20 °C to 25 °C	Re-adhesion of copper resulting from the above-mentioned sulfuric acid treatment is removed.

Informative Table 1 (continued)

Material	Chemicals	Time	Temperature	Remarks
Copper and copper alloy	Add 54 ml of sulfuric acid (JIS K 8951) into distilled water to make up to 1 000 ml.	30 min to 60 min	40 °C to 50 °C	Oxygen is separated from solution using nitrogen. To remove corrosion products, preferably brush the specimen and dip again for 3 s to 4 s.
Iron and steel	1 000 ml of hydrochloric acid (JIS K 8180), 20 g of antimony trioxide (III) (JIS K 8407) and 60 g of tin (II) chloride dihydrate (JIS K 8136)	1 min to 25 min	20 °C to 25 °C	Solution is sufficiently stirred, or otherwise specimen is brushed. When occasion demands, the process may be carried out for a longer time.
	Add 50 g of sodium hydroxide (JIS K 8576) and 200 g of thin strip of granular zinc (JIS K 8012) into distilled water to make up to 1 000 ml.	30 min to 40 min	80 °C to 90 °C	Since zinc powder may naturally ignite by contact with air, care shall be taken at using zinc powder.
	Add 50 g of sodium hydroxide (JIS K 8576) and 20 g of chip of granular zinc (JIS K 8012) into distilled water to make up to 1 000 ml.	30 min to 40 min	80 °C to 90 °C	Since zinc powder may naturally ignite by contact with air, care shall be taken at using zinc powder.
	Add 200 g of diammonium hydrogen citrate (JIS K 8284) into distilled water to make up to 1 000 ml.	20 min	75 °C to 90 °C	—
Lead and lead alloy	Add 500 ml of hydrochloric acid (JIS K 8180) and 3.5 g of hexamethylenetetramine (JIS K 8847) into distilled water to make up to 1 000 ml.	10 min	20 °C to 25 °C	When occasion demands, the process may be carried out for a longer time.
	Add 10 ml of acetic acid (JIS K 8355) into distilled water to make up to 1 000 ml.	5 min	Boiling	—
	Add 50 g of ammonium acetate (JIS K 8359) into distilled water to make up to 1 000 ml.	10 min	60 °C to 70 °C	—

Informative Table 1 (continued)

Material	Chemicals	Time	Temperature	Remarks
Lead and lead alloy	Add 250 g of ammonium acetate (JIS K 8359) into distilled water to make up to 1 000 ml.	10 min	60 °C to 70 °C	—
Magnesium and magnesium alloy	Add 100 g of chromium (VI) oxide (CrO_3) and 10 g of silver chromate (Ag_2CrO_4) into distilled water to make up to 1 000 ml.	1 min	Boiling	The purpose of silver chromate is to precipitate chloride.
	Add 200 g of chromium (VI) oxide (CrO_3), 10 g of silver nitrate (JIS K 8550) and 20 g of barium nitrate (JIS K 8565) into distilled water to make up to 1 000 ml.	1 min	20 °C to 25 °C	The purpose of barium nitrate is to precipitate sulfide.
Nickel and nickel alloy	Add 150 ml of hydrochloric acid (JIS K 8180) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	—
	Add 100 ml of sulfuric acid (JIS K 8951) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	—
Stainless steel	Add 100 ml of nitric acid (JIS K 8541) into distilled water to make up to 1 000 ml.	20 min	60 °C	—
	Add 150 g of diammonium hydrogen citrate (JIS K 8284) into distilled water to make up to 1 000 ml.	10 min to 60 min	70 °C	—
	Add 110 g of citric acid monohydrate (JIS K 8283), 50 ml of sulfuric acid (JIS K 8951) and 2 g of inhibitor (diorthotolylthiourea, quinoline ethiodide, or β -naphtholquinoline) into distilled water to make up to 1 000 ml.	5 min	60 °C	—

Informative Table 1 (continued)

Material	Chemicals	Time	Temperature	Remarks
Stainless steel	Add 200 g of sodium hydroxide (JIS K 8576), 30 g of potassium permanganate (JIS K 8247) and 100 g of diammonium hydrogen citrate (JIS K 8284) into distilled water to make up to 1 000 ml.	5 min	Boiling	—
	Add 100 ml of nitric acid (JIS K 8541) and 20 ml of hydrofluoric acid (JIS K 8819) into distilled water to make up to 1 000 ml.	5 min to 20 min	20 °C to 25 °C	—
	Add 200 g of sodium hydroxide (JIS K 8576) and 50 g of powdery zinc (JIS K 8013) into distilled water to make up to 1 000 ml.	20 min	Boiling	Since powdery zinc naturally ignites by contact with air, care shall be taken.
Tin and tin alloy	Add 150 g of trisodium phosphate 12-water (JIS K 9012) into distilled water to make up to 1 000 ml.	10 min	Boiling	—
	Add 50 ml of hydrochloric acid (JIS K 8180) into distilled water to make up to 1 000 ml.	10 min	20 °C	—
Zinc and zinc alloy	Add 150 ml of ammonia solution (JIS K 8085) into distilled water to make up to 1 000 ml. Then, add 50 g of chromium (VI) oxide (CrO_3) and 10 g of silver nitrate (JIS K 8550) into distilled water to make up to 1 000 ml.	5 min 15 s to 20 s	20 °C to 25 °C Boiling	Silver nitrate is dissolved in water, and add boiling chromium oxide water solution to prevent an excess of crystallization of silver chromate. In order to avoid the attack by zinc on the underlying metal, chromium oxide shall not contain sulfate.
	Add 100 g of ammonium chloride (JIS K 8116) into distilled water to make up to 1 000 ml.	2 min to 5 min	70 °C	—

Informative Table 1 (concluded)

Material	Chemicals	Time	Temperature	Remarks
Zinc and zinc alloy	Add 200 g of chromium (VI) oxide (CrO ₃) into distilled water to make up to 1 000 ml.	1 min	80 °C	The pollution in chromium oxide water solution caused by corrosion products forming in salt atmosphere shall be removed to prevent the attack by zinc on the underlying metal.
	Add 85 ml of hydriodic acid (JIS K 8917) into distilled water to make up to 1 000 ml.	15 s	20 °C to 25 °C	The underlying metal of zinc may be removed. Controlled specimen shall be used.
	Add 100 g of ammonium peroxodisulfate (JIS K 8252) into distilled water to make up to 1 000 ml.	5 min	20 °C to 25 °C	Especially effective for electroplated specimen.
	Add 100 g of ammonium acetate (JIS K 8359) into distilled water to make up to 1 000 ml.	2 min to 5 min	70 °C	—

Remarks: The JIS numbers in parentheses in column of chemicals refer to the reagents specified in Japanese Industrial Standards.

Informative Table 2 Method for removal of corrosion product by electrolysis

Material	Chemicals	Time	Temperature	Remarks
Iron, cast iron and steel	Add 75 g of sodium hydroxide (JIS K 8576), 25 g of sodium sulfate (JIS K 8987) and 75 g of sodium carbonate (JIS K 8625) into distilled water to make up to 1 000 ml.	20 min to 30 min	20 °C to 25 °C	Cathodic treatment is carried out at 100 A/m ² to 200 A/m ² in current density. Carbon, platinum, or stainless steel is used as an anode.
	Add 28 ml of sulfuric acid (JIS K 8951) and 0.5 g of inhibitor (diorthotolylthiourea, quinoline ethiodide, or β -naphtholquinoline) into distilled water to make up to 1 000 ml.	3 min	75 °C	Cathodic treatment is carried out at 2 000 A/m ² in current density. Carbon or platinum is used as an anode.
	Add 100 g of diammonium hydrogen citrate (JIS K 8284) into distilled water to make up to 1 000 ml.	5 min	20 °C to 25 °C	Cathodic treatment is carried out at 100 A/m ² in current density. Carbon or platinum is used as an anode.
Lead and lead alloy	Add 28 ml of sulfuric acid (JIS K 8951) and 0.5 g of inhibitor (diorthotolylthiourea, quinoline ethiodide, or β -naphtholquinoline) into distilled water to make up to 1 000 ml.	3 min	75 °C	Cathodic treatment is carried out at 2 000 A/m ² in current density. Carbon or platinum is used as an anode.
Copper and copper alloy	Add 7.5 g of potassium chloride (JIS K 8121) into distilled water to make up to 1 000 ml.	1 min to 3 min	20 °C to 25 °C	Cathodic treatment is carried out at 100 A/m ² in current density. Carbon or platinum is used as an anode.
Zinc and cadmium	Add 50 g of disodium hydrogenphosphate (JIS K 9020) into distilled water to make up to 1 000 ml.	5 min	70 °C	Cathodic treatment is carried out at 110 A/m ² in current density. Prior to dipping, a specimen is activated. Carbon, platinum, or stainless steel is used as an anode.
	Add 100 g of sodium hydroxide (JIS K 8576) into distilled water to make up to 1 000 ml.	1 min to 2 min	20 °C to 25 °C	Cathodic treatment is carried out at 110 A/m ² in current density. Prior to dipping, a specimen is activated. Carbon, platinum, or stainless steel is used as an anode.

Remarks: The **JIS** numbers in parentheses in column of chemicals refer to the reagents specified in Japanese Industrial Standards.

Annex 1 (normative) Rating number method

1 Scope This Annex specifies the rating number method used for evaluation of test results of salt spray testing.

2 Method of comparing results An area at least 5 000 mm² shall be selected on the significant surface of a specimen. To select a surface to be evaluated, a mask having a window 50 mm × 100 mm may be used. The size and number of corrosion defects present on the significant surface shall be collated with the standard drawings⁽¹⁾ shown in Annex 1 Attached Figs. 1 to 12, and the serial number of the standard drawing nearest in appearance to the specimen, for instance, 9.8-2, 9.5-5, etc. shall be determined as the rating number for the corrosion evaluation. However, corrosion defects generated from a section (edge) are excluded from evaluation.

Note ⁽¹⁾ The standard drawings of rating number is expressed by the ratio of maximum corrosion area for individual rating number.

Rating number 10 indicates corrosion which can not be identified by the naked eye, and rating number 0 indicates the maximum value of corrosion defect.

The expression of the test results shall be made by the rating numbers determined.

The relation between the corrosion area ratio and the rating number shall be shown in Annex 1 Attached Table 1.

Annex 1 Attached Table 1 Relation between corrosion area ratio and rating number

Corrosion area ratio, A (%)	Rating number (RN)
0.00	10
0.02 max.	9.8
Over 0.02 up to and including 0.05	9.5
Over 0.05 up to and including 0.07	9.3
Over 0.07 up to and including 0.10	9
Over 0.10 up to and including 0.25	8
Over 0.25 up to and including 0.50	7
Over 0.50 up to and including 1.00	6
Over 1.0 up to and including 2.5	5
Over 2.5 up to and including 5	4
Over 5 up to and including 10	3
Over 10 up to and including 25	2
Over 25 up to and including 50	1
Over 50	0

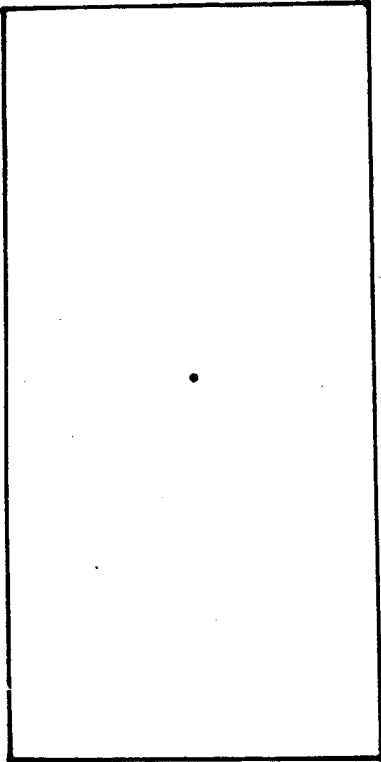
The relation between the rating number (RN) and the corrosion area ratio (A) shall be as shown in the following formula.

$$RN = 3 (2 - \log_{10} A)$$

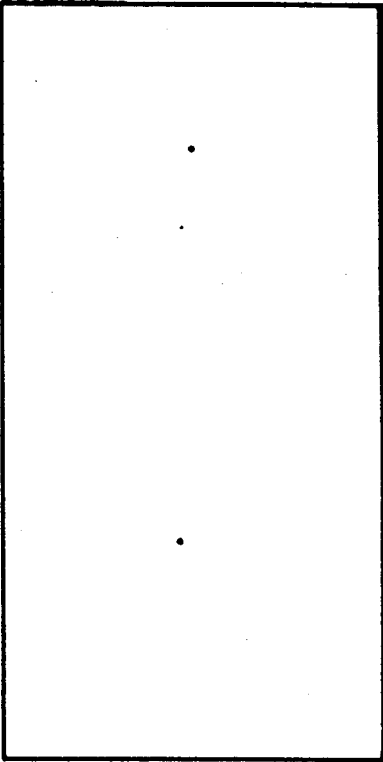
However, when the rating number (RN) is in the range between 9.3 to 9.8, it shall be as shown in the following formula.

$$RN = 10 - A/0.1$$

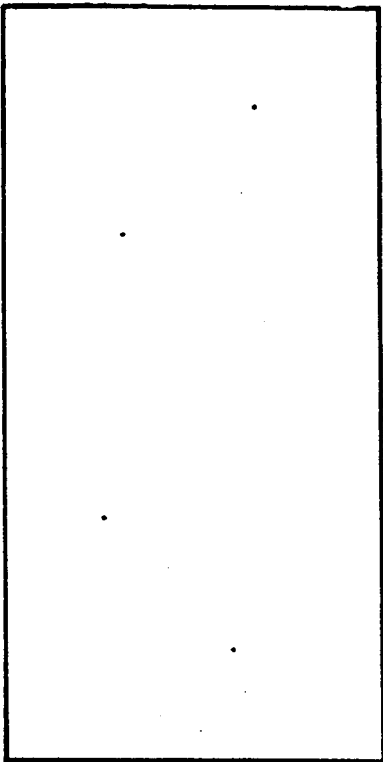
9.8-1



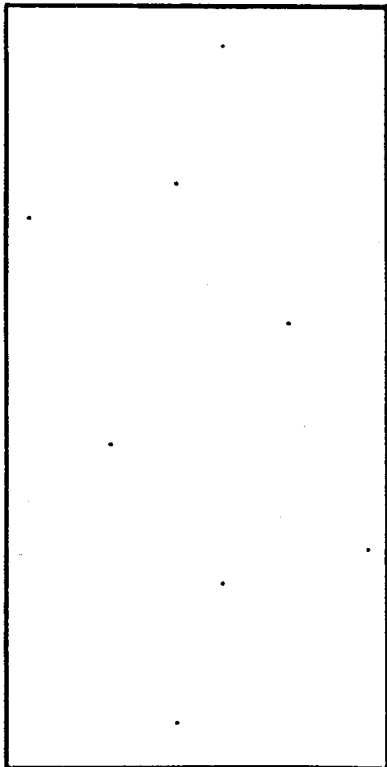
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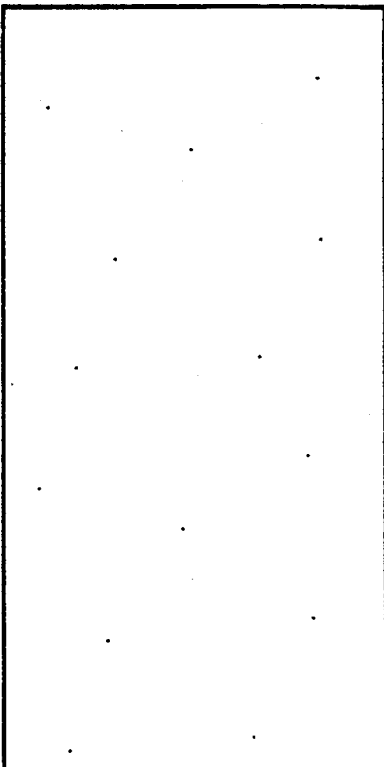
9.8-3



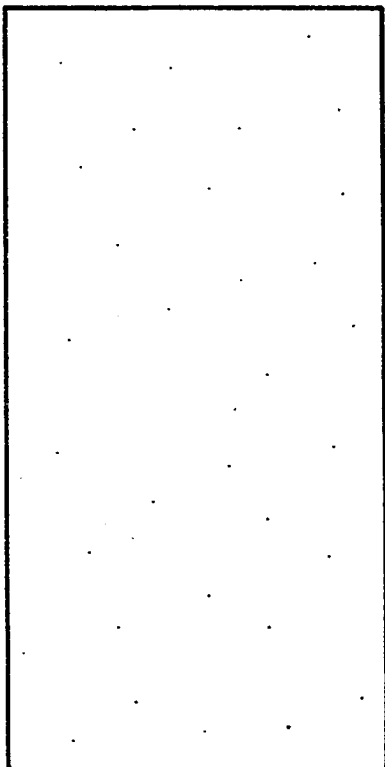
9.8-4



9.8-5

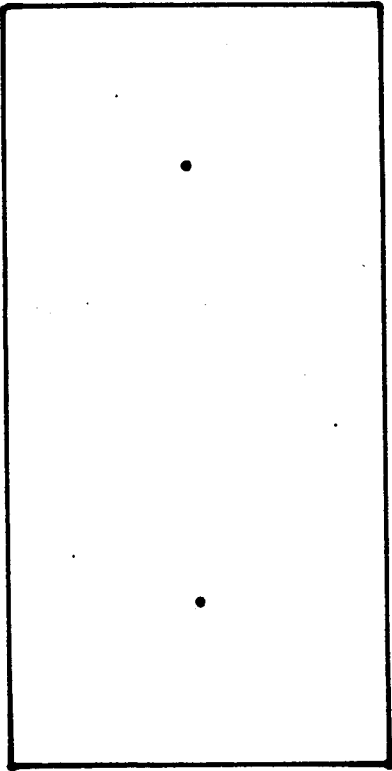


9.8-6

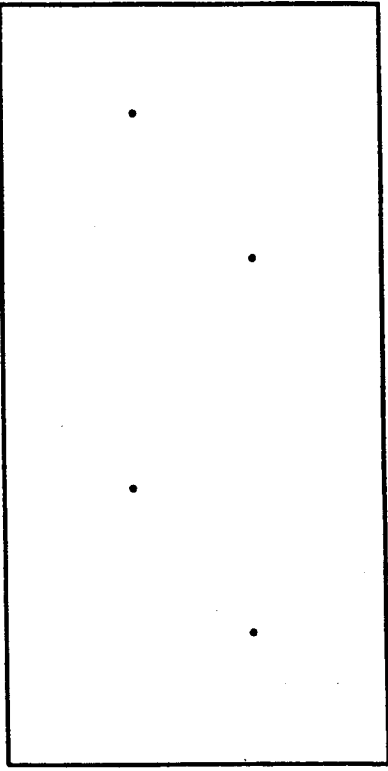


Annex 1 Attached Fig. 1 Standard drawings for rating number 9.8

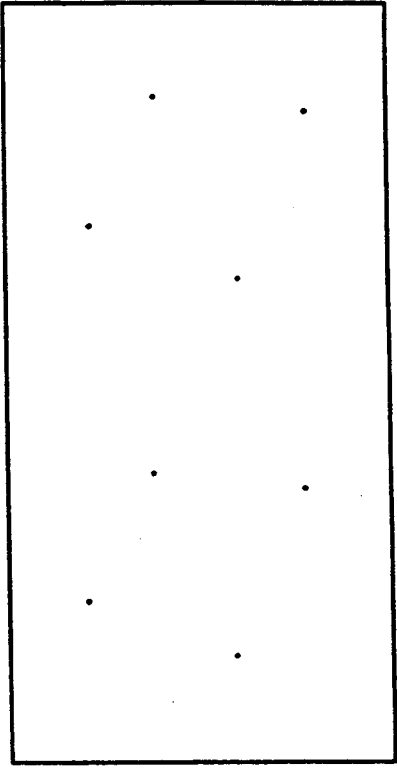
9.5-1



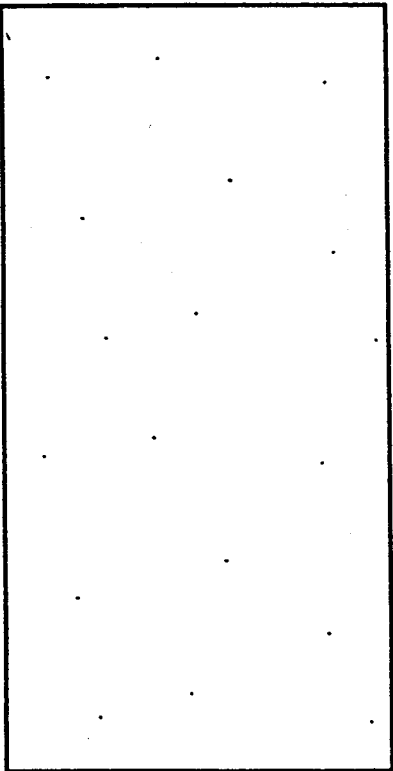
9.5-2



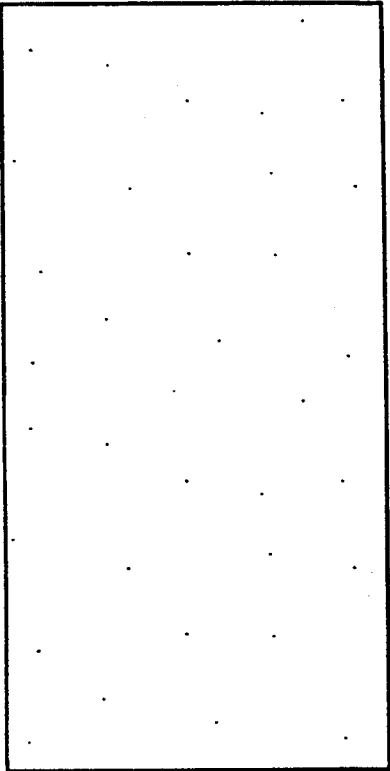
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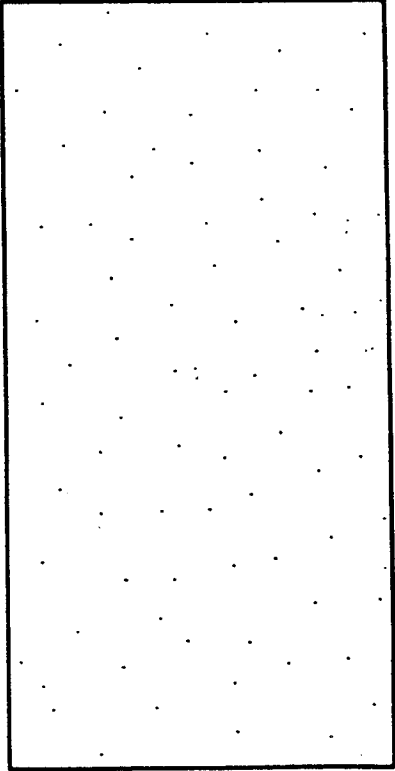
9.5-4



9.5-5

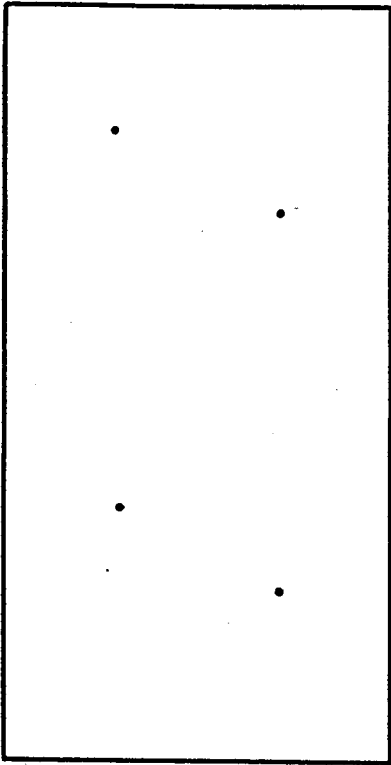


9.5-6

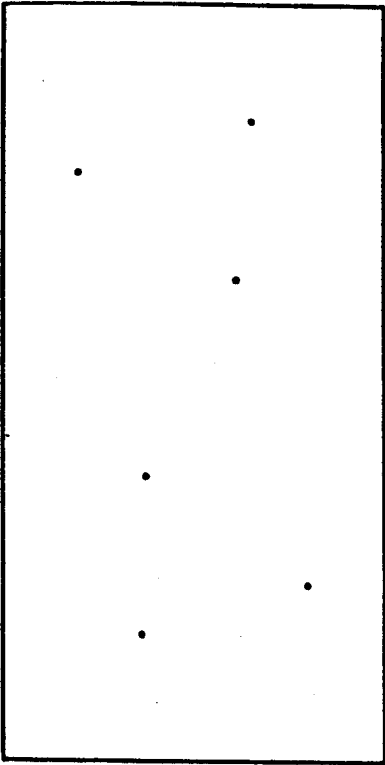


Annex 1 Attached Fig. 2 Standard drawings for rating number 9.5

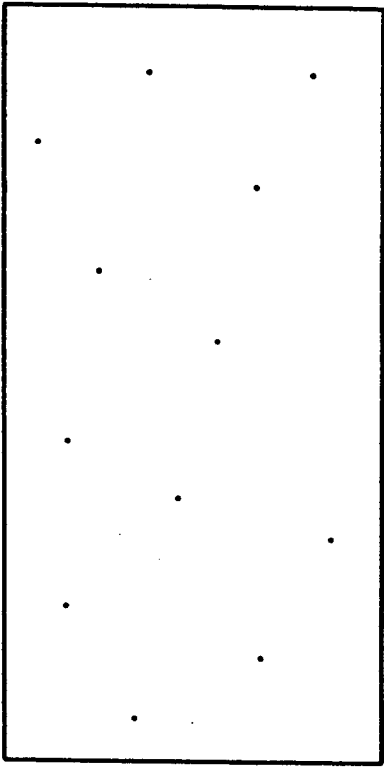
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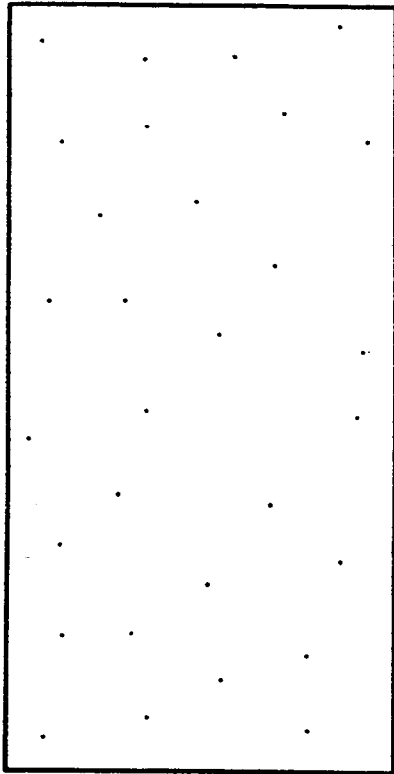
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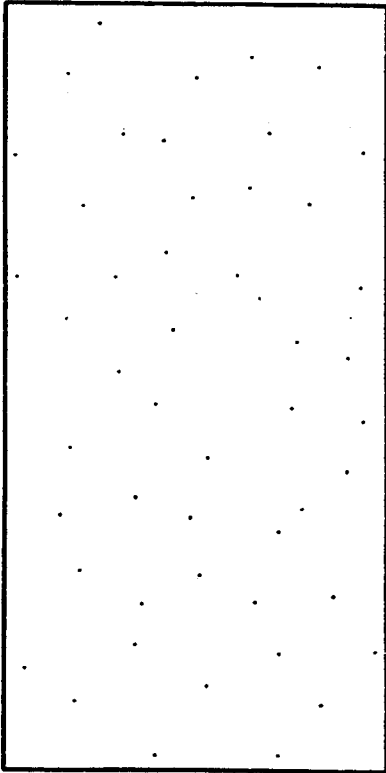
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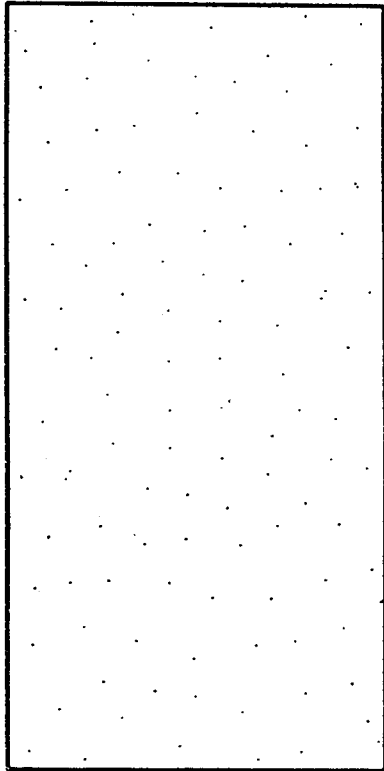
9.3-4



9.3-5



9.3-6

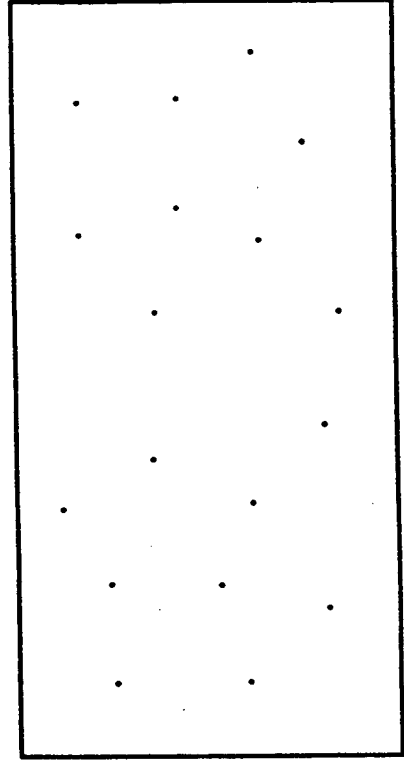
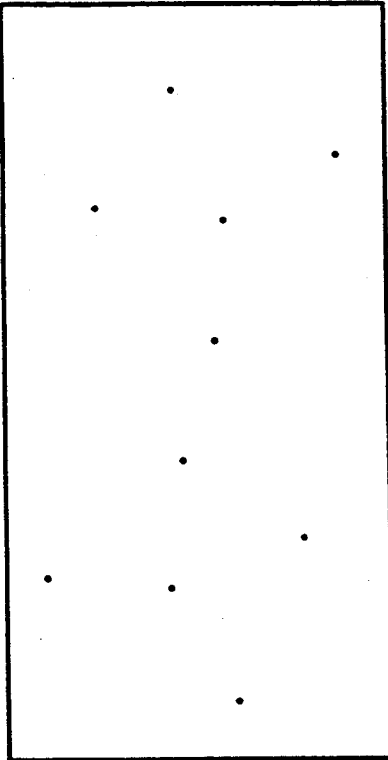
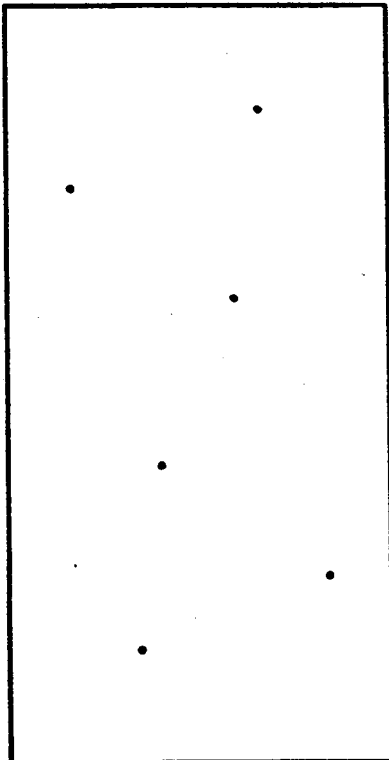


Annex 1 Attached Fig. 3 Standard drawings for rating number 9.3

9-1

9-2

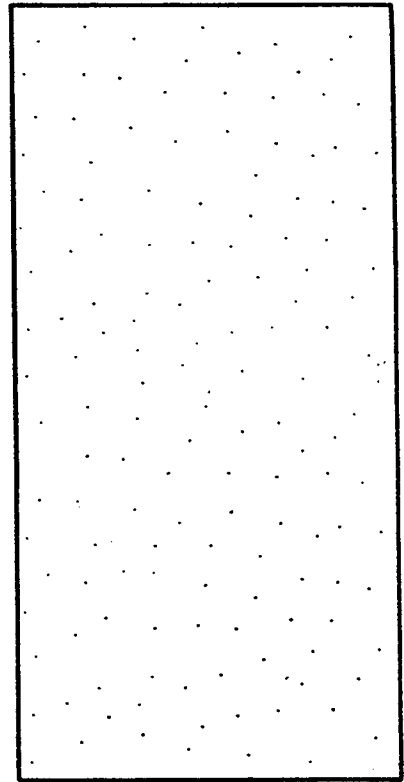
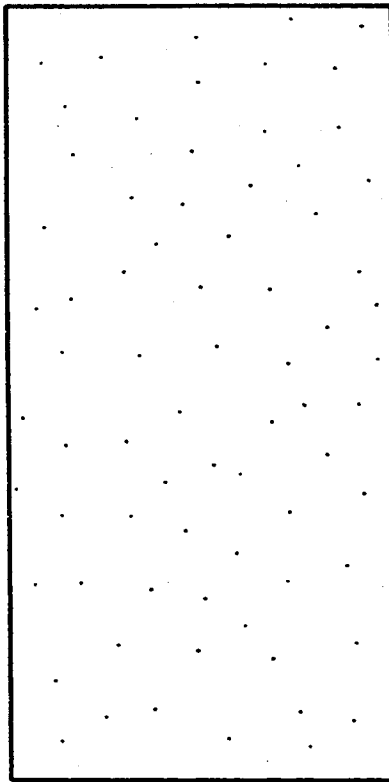
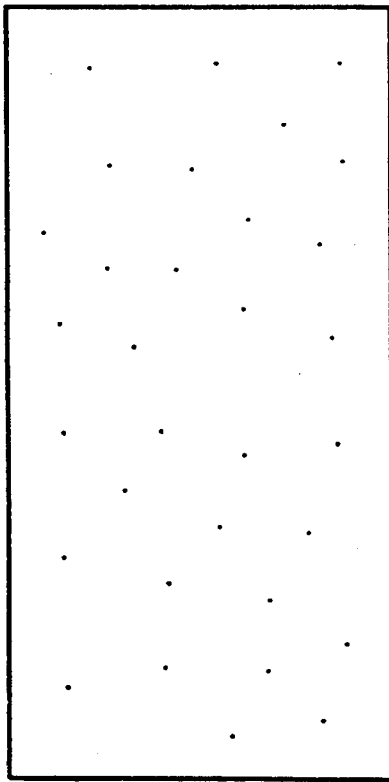
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9-4

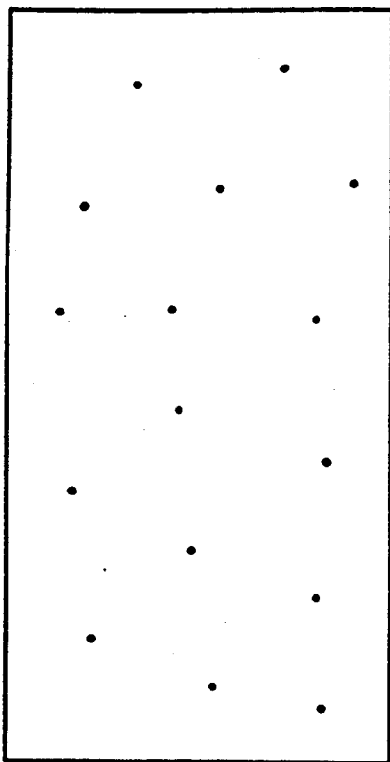
9-5

9-6

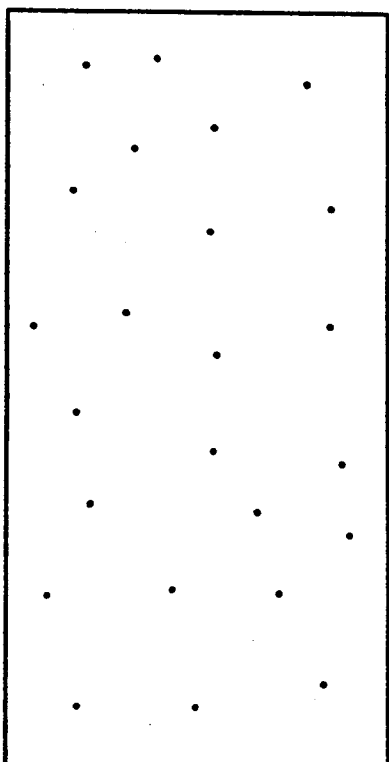


Annex 1 Attached Fig. 4 Standard drawings for rating number 9

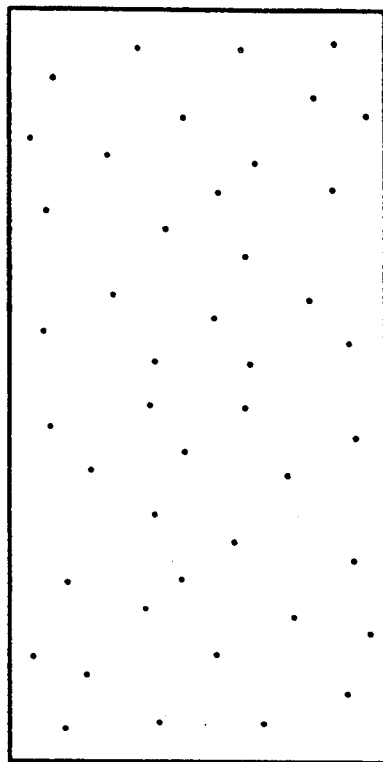
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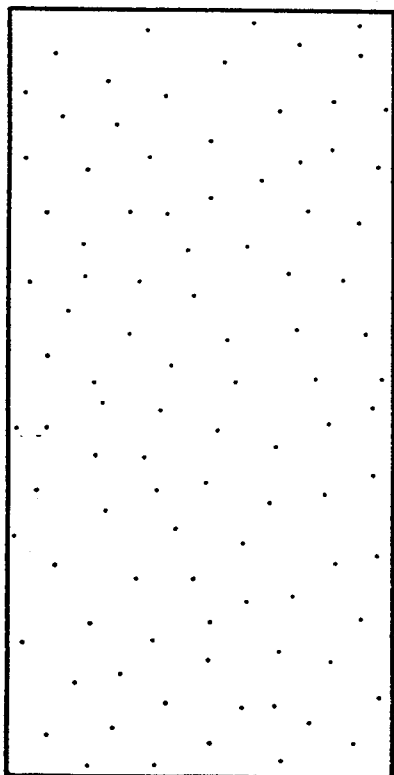
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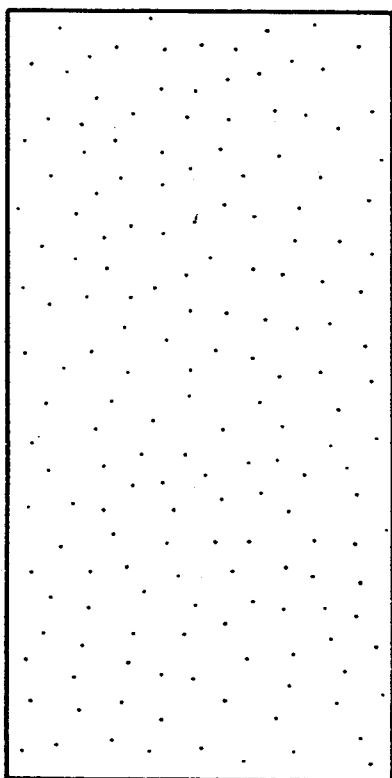
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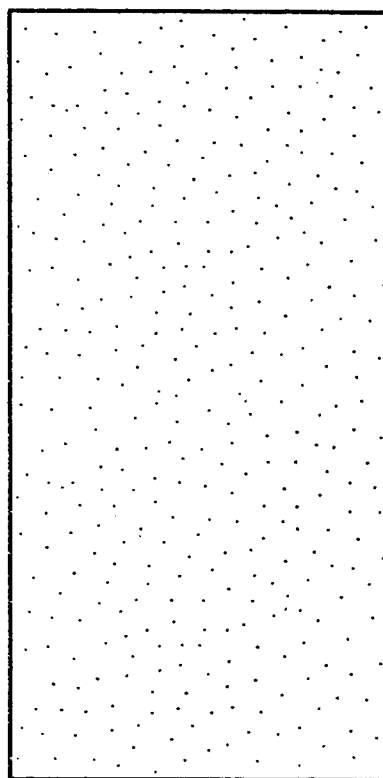
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8-5

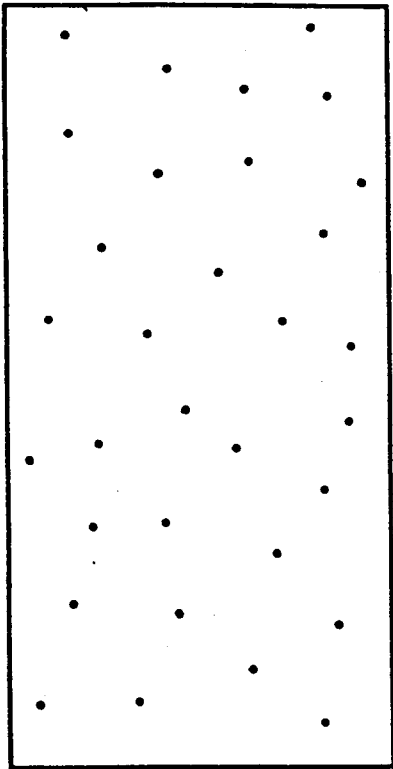


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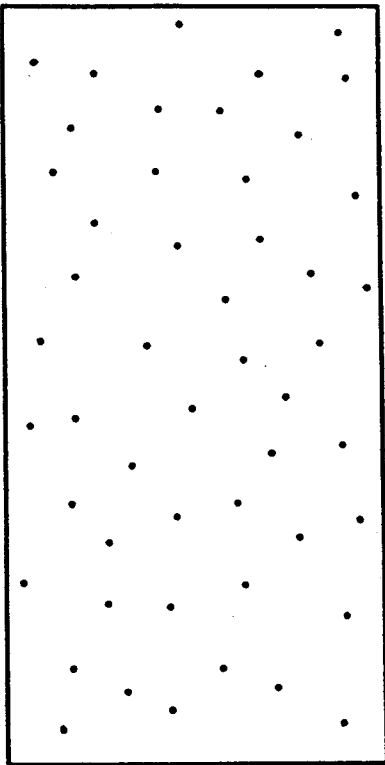


Annex 1 Attached Fig. 5 Standard drawings for rating number 8

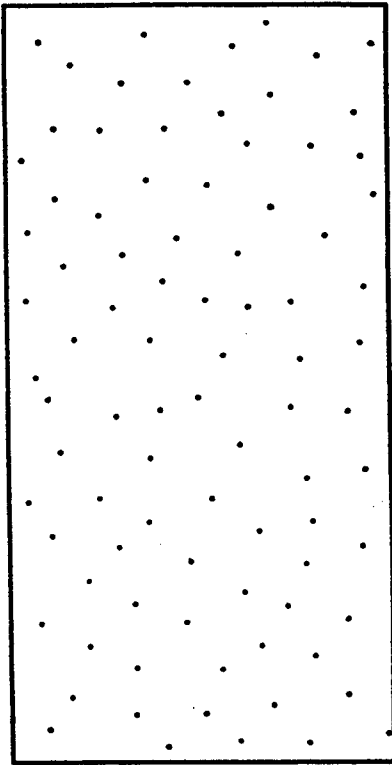
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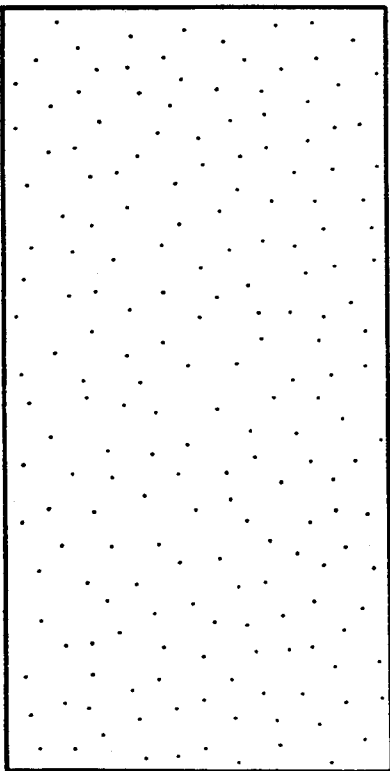
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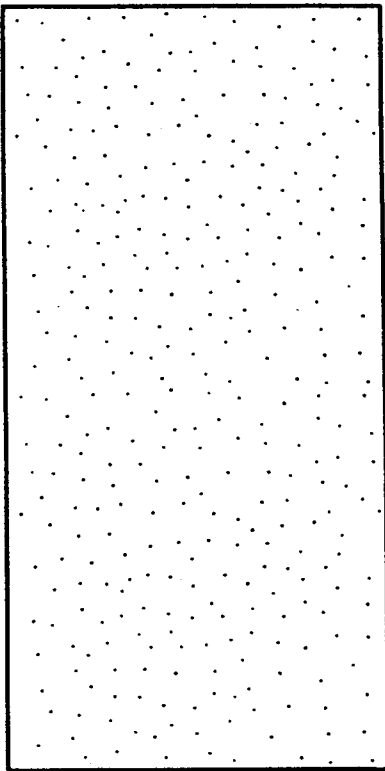
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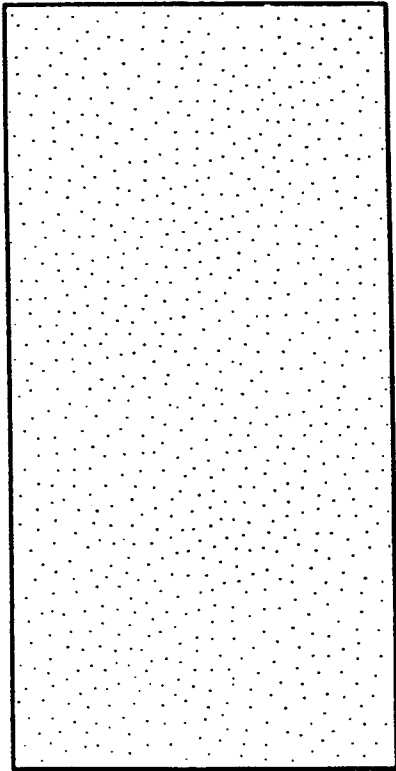
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7-5

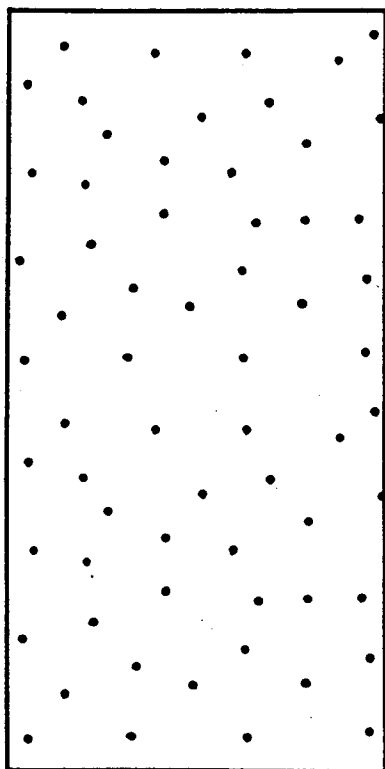


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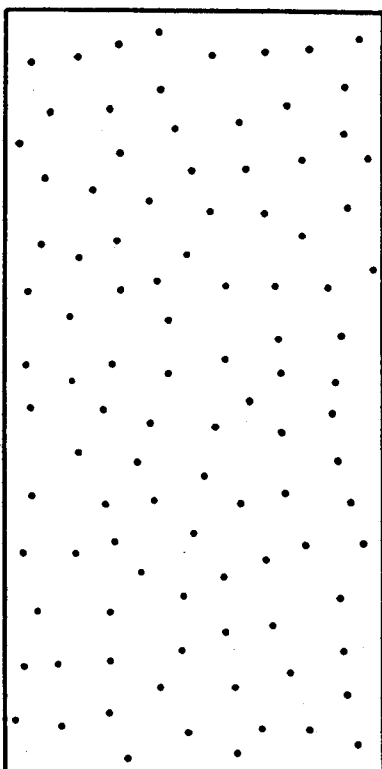


Annex 1 Attached Fig. 6 Standard drawings for rating number 7

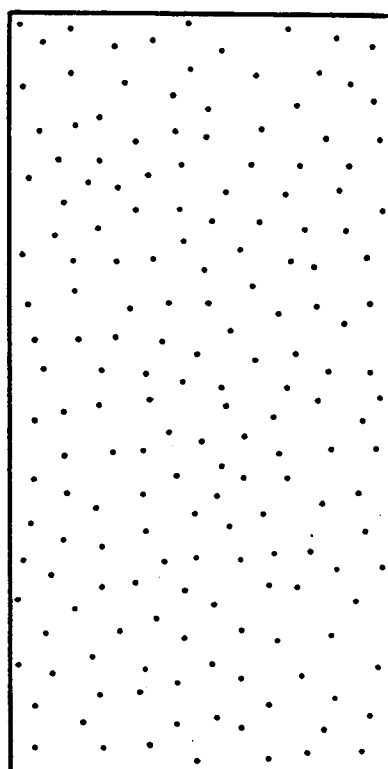
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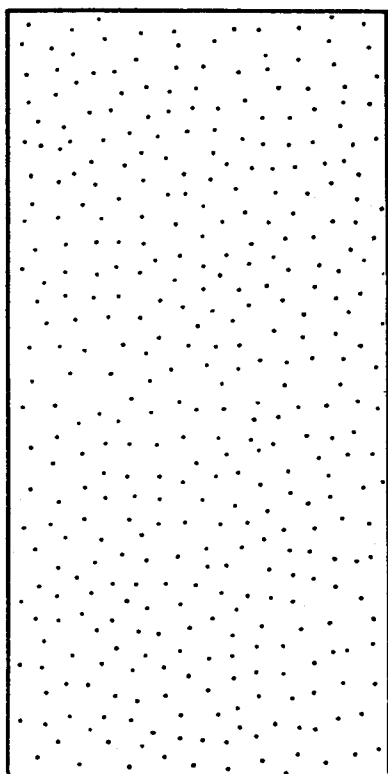
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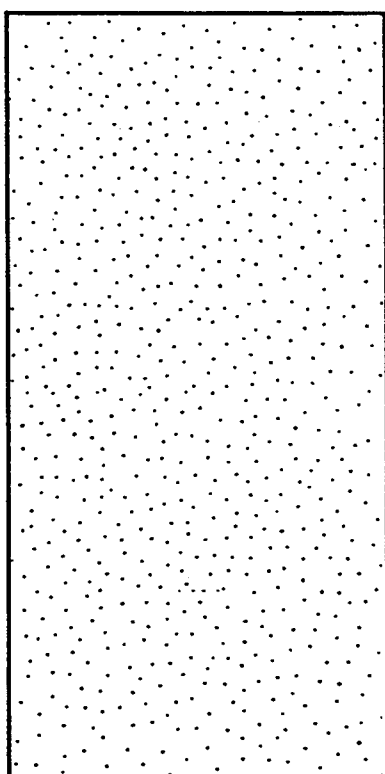
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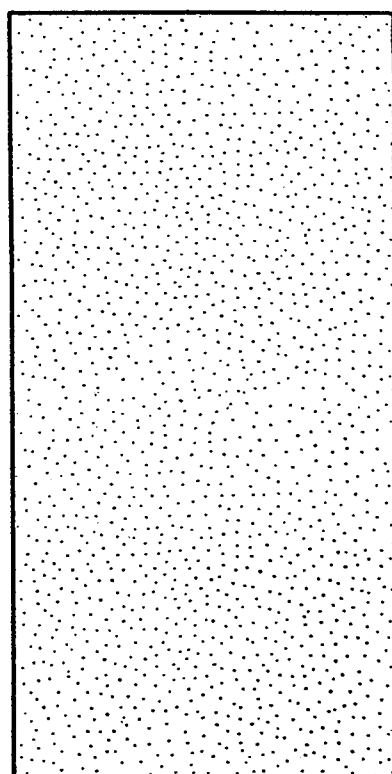
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6-5

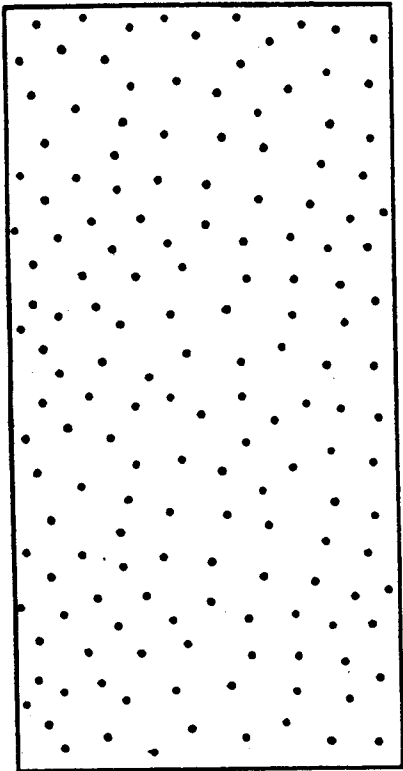


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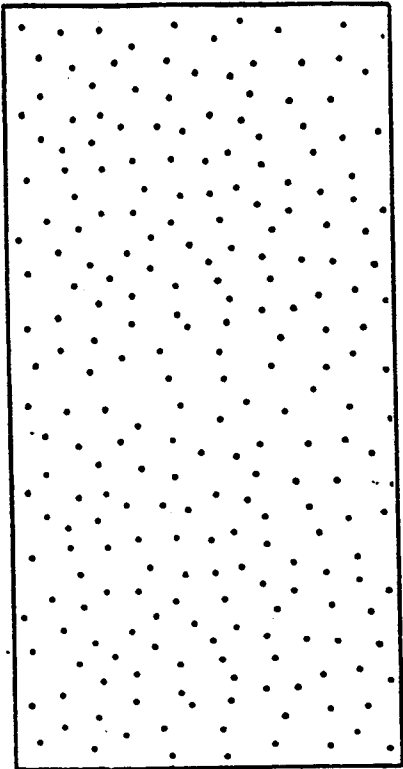


Annex 1 Attached Fig. 7 Standard drawings for rating number 6

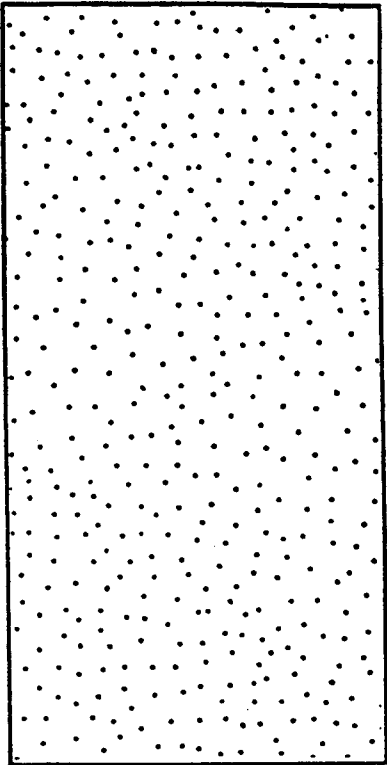
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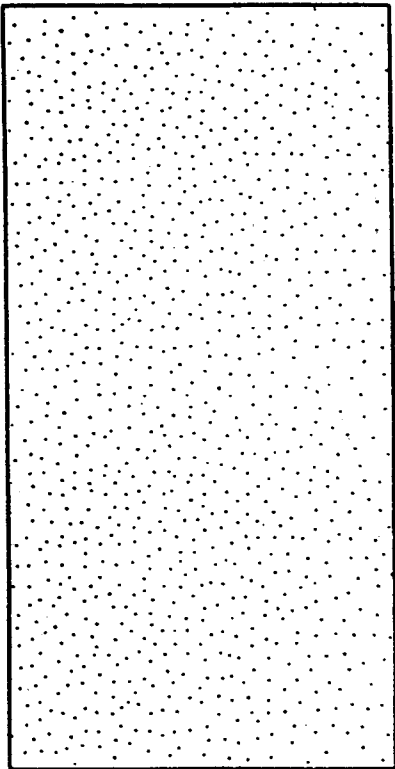
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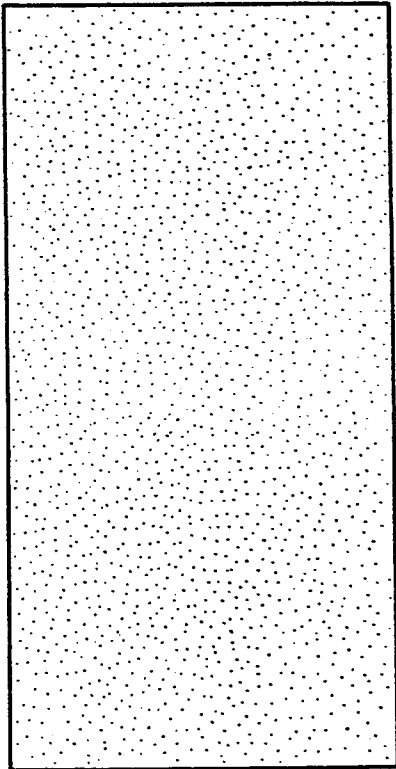
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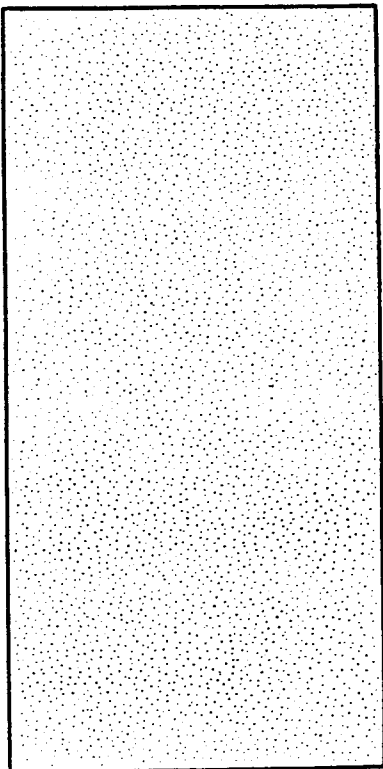
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5-5

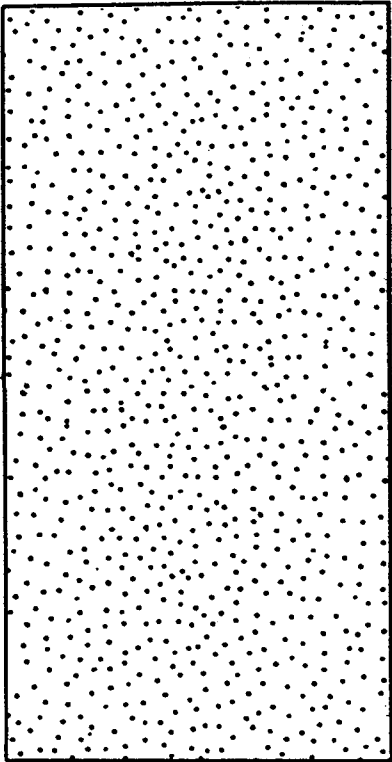


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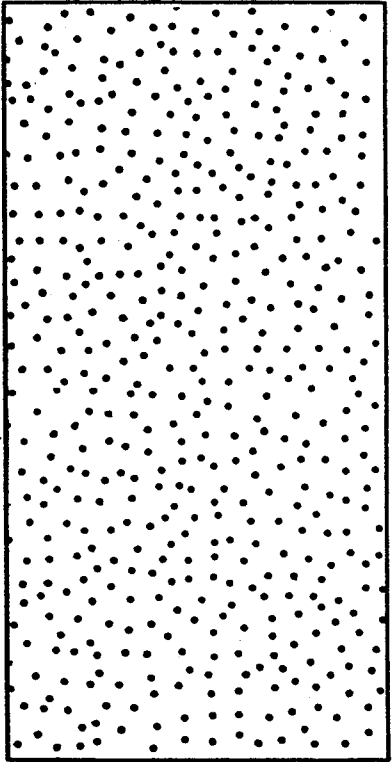


Annex 1 Attached Fig. 8 Standard drawings for rating number 5

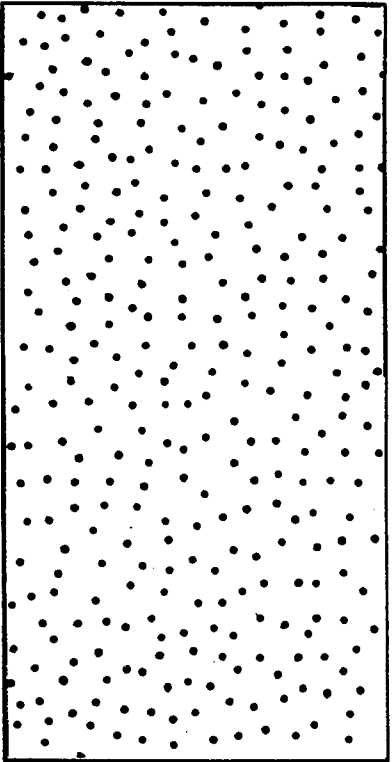
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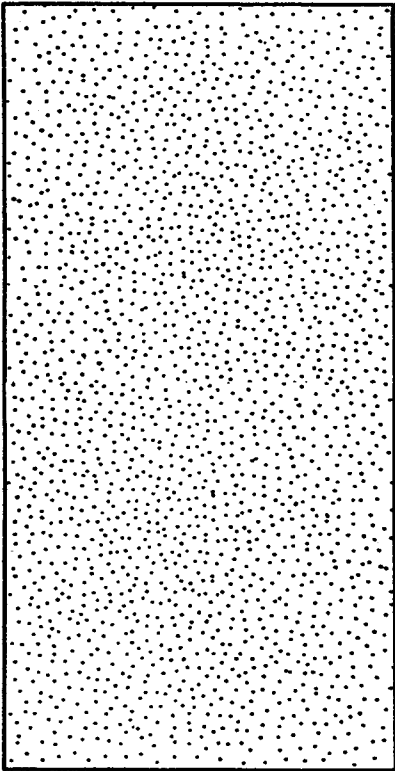
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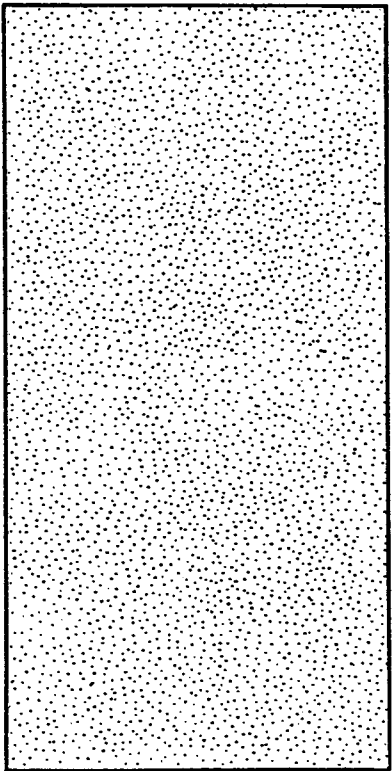
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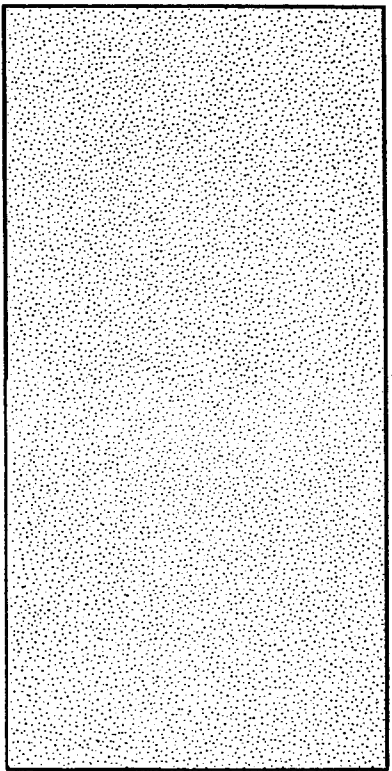
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4-5

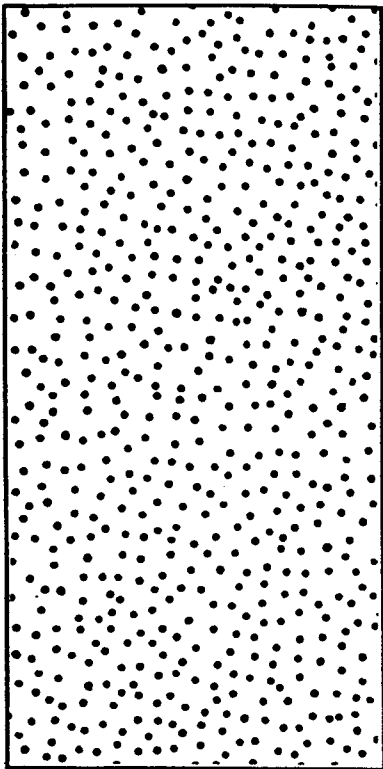


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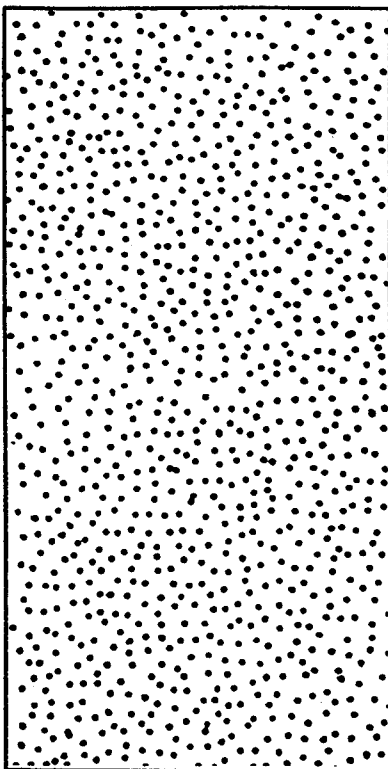


Annex 1 Attached Fig. 9 Standard drawings for rating number 4

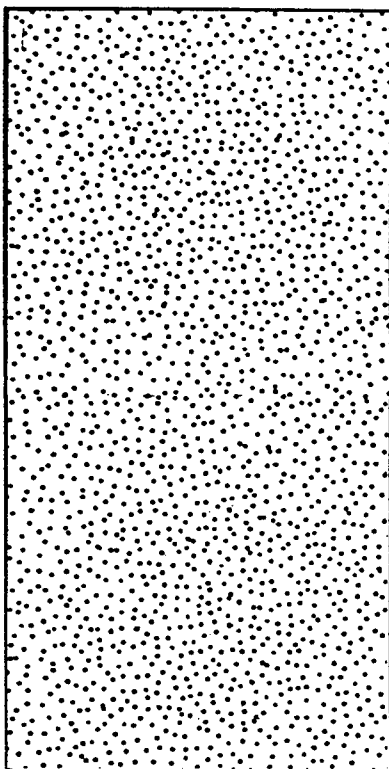
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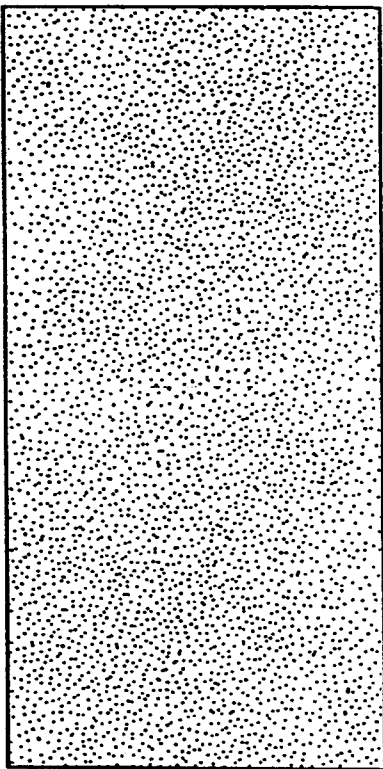
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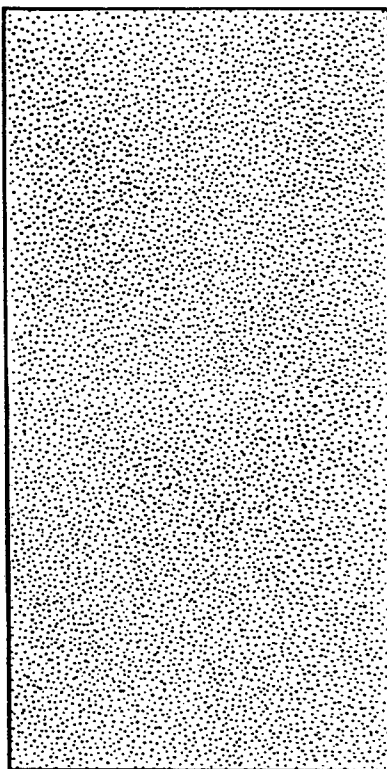
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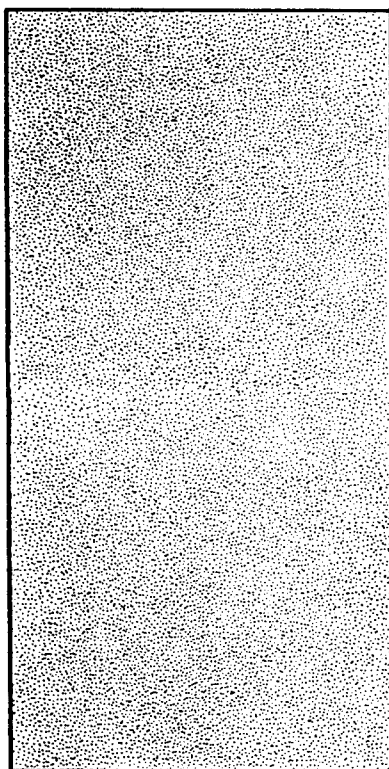
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3-5

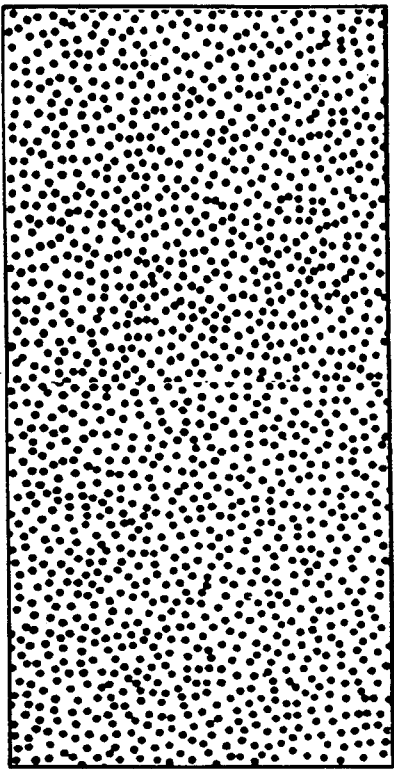


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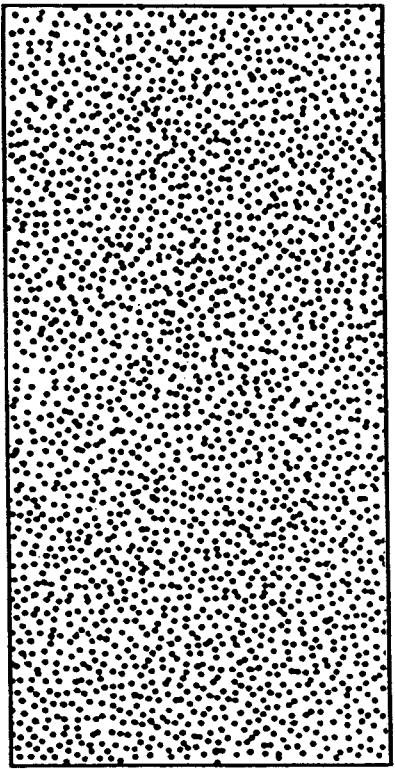


Annex 1 Attached Fig. 10 Standard drawings for rating number 3

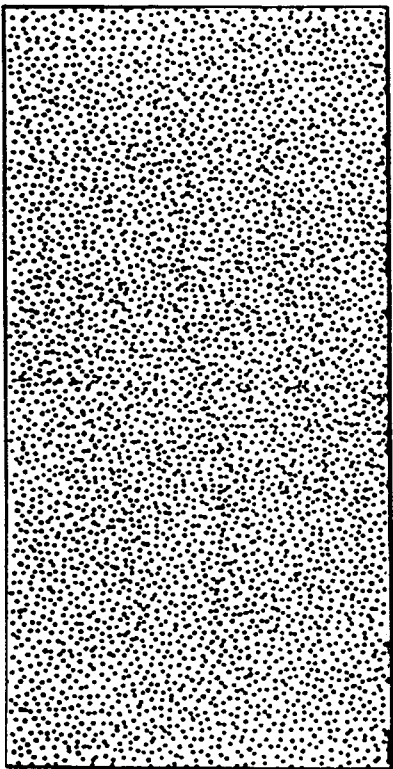
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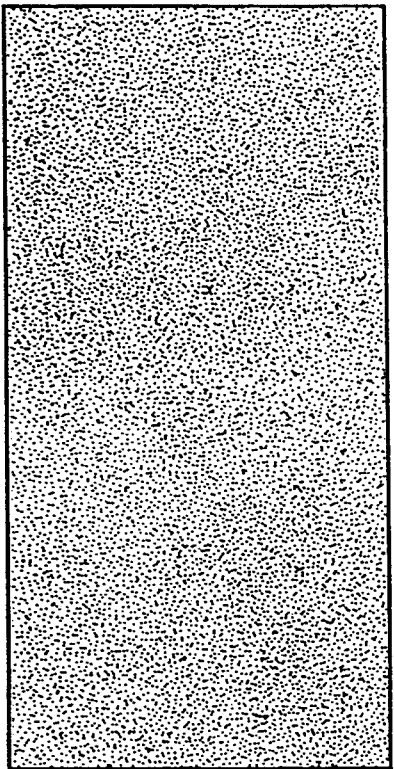
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2-3

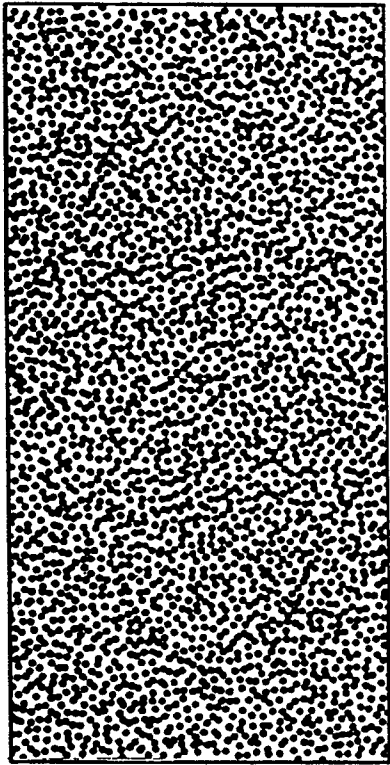


2-4

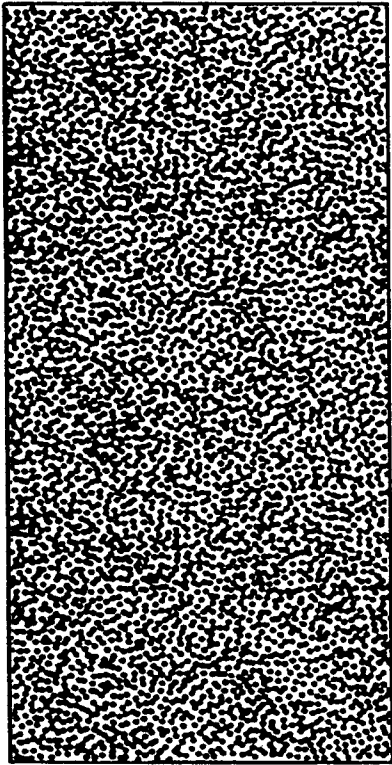


Annex 1 Attached Fig. 11 Standard drawings for rating number 2

1-1



1-2



Annex 1 Attached Fig. 12 Standard drawings for rating number 1

Annex 2 (informative) Structure of apparatus

This Annex supplements the matters related to the requirements of the text of this Standard and Annex, and does not constitute a part of this Standard.

The structures of apparatus conforming to the requirements specified in this Standard are given in this Annex.

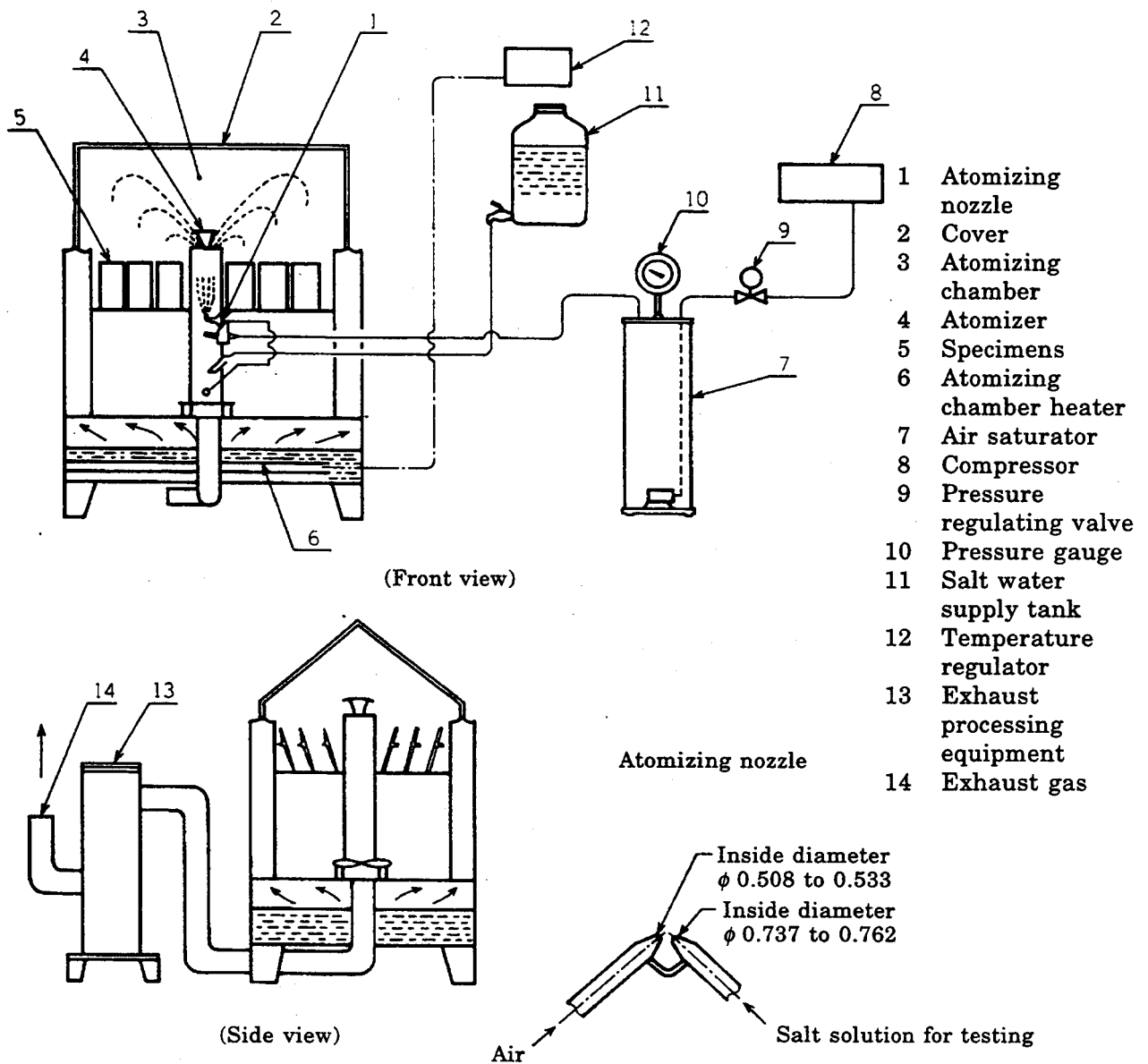
In order to eliminate the fluctuation of the salt concentration of salt spray, supplied air shall have a relative humidity of 95 % to 98 % when spray is emitted. For this purpose, the temperature of air saturator is kept at $47\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ when the pressure of supplied air is 0.098 MPa in neutral salt spray test. The water in the air saturator shall be replaced every specified period so that it may remove the impurities in the air.

Further, A2 or A3 of water specified in **JIS K 0557** shall be used.

The apparatus shall have a structure taking heat insulation into consideration so that the atomizing chamber and the specimen are not influenced by the changing temperature of the open air. Sensors for regulating temperature, and indicating temperature and humidity shall be positioned in a place at least 100 mm from the wall of the atomizing chamber, and shall be so arranged as to facilitate reading the temperature and humidity from the outside. Exhaust gas, not to be forced out, should preferably be discharged through an exhaust processing equipment which is not influenced by the wind pressure of the open air.

Drainage should preferably be discharged through a drainage processing equipment. A salt water supply tank is preferably equipped with an automatic salt water supplier to ensure a long operation.

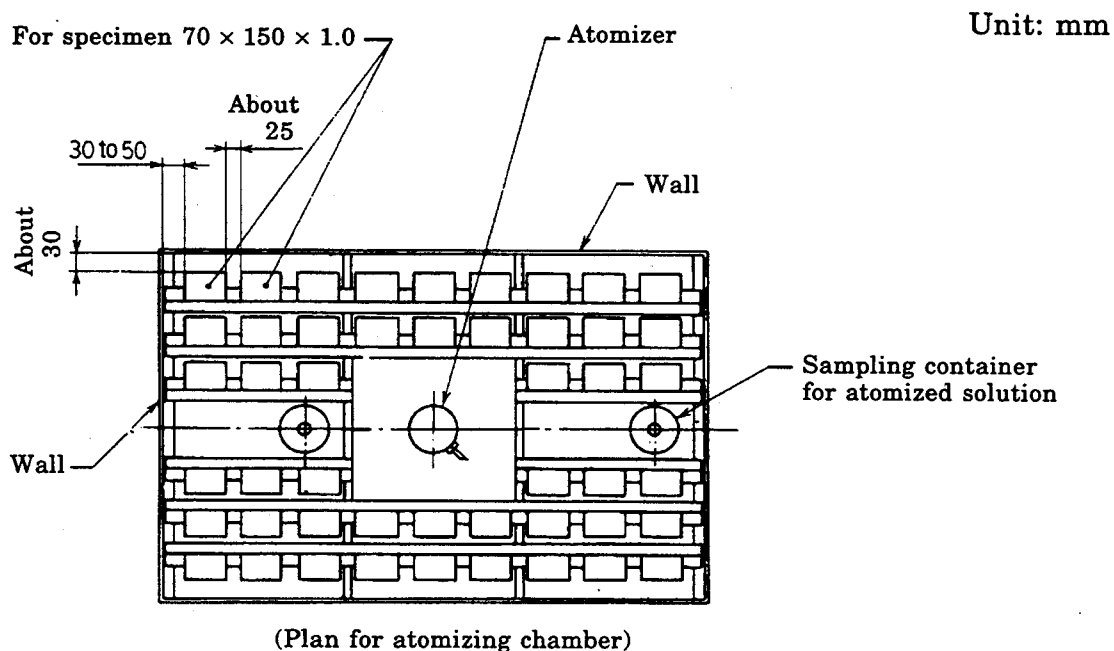
Unit: mm



Annex 2 Attached Fig. 1 An example of salt spray testing apparatus

Annex 3 (informative) Placing and positioning of specimens

This Annex supplements the matters related to the requirements of the text of this Standard and Annex, and does not constitute a part of this Standard.



Annex 3 Attached Fig. 1 Placing and positioning of specimens

Related standards:

- JIS C 0023 *Basic environmental testing procedures Part 2: Tests — Test Ka: Salt mist*
- JIS H 8502 *Methods of corrosion resistance test for metallic coatings*
- JIS H 8681-1 *Test methods for corrosion resistance of anodic oxide coatings on aluminium and aluminium alloys Part 1: Alkali resistance test*
- JIS H 8681-2 *Test methods for corrosion resistance of anodic oxide coatings on aluminium and aluminium alloys Part 2: CASS test*
- JIS K 2246 *Rust preventive oils*
- JIS K 5400 *Testing methods for paints*
- JIS Z 0304 *Outdoor exposure test for protected metals*
- ISO 4611 *Plastics — Determination of the effects of exposure to damp heat, water spray and salt mist*
- ISO 7253 *Paints and varnishes — Determination of resistance to neutral salt spray (fog)*
- ISO 8407 *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*
- ISO 8993 *Anodized aluminium and aluminium alloys — Rating system for the evaluation of pitting corrosion — Chart method*
- IEC 60068-2-11 *Environmental testing — Part 2: Tests. Test Ka: Salt mist*
- IEC 60068-2-52 *Environmental testing — Part 2: Tests. Test Kb: Salt mist, cyclic (sodium, chloride solution)*

Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

Errata will be provided upon request, please contact:

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