

- g) For the sprayed quantity of solution, 1.0 ml to 2.0 ml of the salt solution shall be collected per hour into each container throughout the period of spraying.
- h) The temperature in test vessel shall be kept at  $50 \pm 2$  °C, that in salt solution tank at  $50 \pm 2$  °C, and that in air saturator at  $63 \pm 2$  °C.

**7.3.4 Holding of test piece** During the test, the location of test piece in the test vessel shall conform to the following conditions<sup>(11)</sup>.

- a) Hold the test piece so that the surface forms at an angle of 20 degrees (allowable limit: from 15 to 30 degrees) to the vertical, and place it at the position or the direction where it is exposed only to the free fall of spray of salt solution.
- b) The test pieces shall be placed so that they do not disturb the free fall of salt solution on other test pieces.
- c) The test pieces shall not come into contact with other objects than the frame.
- d) The drops of salt solution from the test pieces do not fall on other test pieces.
- e) The pressed stamp for recognition or mounting hole shall be faced downwards.

**7.3.5 Procedures** After conditioning the temperature in test vessel at 50 °C, that in salt solution tank at 50 °C, and that in air saturator at 63 °C, keep the pressure of compressed air with which salt solution is sent to the spraying nozzle at 70 kPa to 167 kPa, and then begin to spray.

- a) **Test conditions** Test conditions shall be as shown in Table 8.
- b) **Duration of test** The duration of test shall be subjected to the agreement between the parties concerned with delivery.

Recommended periods are 2 h, 4 h, 8 h, 16 h, 24 h, 48 h, 96 h, and spraying shall not be interrupted during the prescribed test period.

- c) **Treatment after test** At the end of the test period, open the cover of the test vessel lest the drops of salt solution should fall on the test piece, take out the test piece lest the target surface for evaluation should be damaged, immediately rinse its surface to remove salt stack on the surface of the test piece with water, and then take away the corrosion product at the area except the corroded portion using a brush or sponge. To remove the corrosion product, employ such mechanical measures as brushing, ultrasonic radiation, water spraying, or chemical measures as shown in Attached Table 1.

**Table 3 Test conditions for CASS test method**

Items	While preparing	While testing
Concentration of sodium chloride <i>g/l</i>	$50 \pm 5$	$50 \pm 5$
Concentration of copper (II) chloride ( $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ ) <i>g/l</i>	$0.26 \pm 0.02$	-
pH	3.0	3.0 to 3.2
Amount of spray <i>ml/80 cm<sup>2</sup>/h</i>	-	$1.5 \pm 0.5$
Temperature in test vessel <i>°C</i>	-	$50 \pm 2$
Temperature in salt water tank <i>°C</i>	-	$50 \pm 2$
Temperature in air saturator <i>°C</i>	-	$63 \pm 2$
Pressure of compressed air <i>kPa</i>	-	70 to 167

**7.3.6 Judgement method** Judgement method shall follow 11.

**7.3.7 Report** The test report shall contain the following particulars.

- a) Name and type of test apparatus
- b) Sampling method, shape, quantity, dimensions, symbol of test piece
- c) Test conditions
  - 1) Concentration of sodium chloride
  - 2) Concentration of copper (II) chloride
  - 3) pH
  - 4) Amount of spray
  - 5) Temperature (test vessel, salt water tank, air saturator)
  - 6) Pressure of compressed air
- d) Duration of test
- e) Result of judgement

## 8 Cyclic test method

### 8.1 Cyclic neutral salt spray test method

**8.1.1 Summary** Employ a cyclic neutral salt spray tester, carry out repeatedly the sequential exposure of a test piece to the atmosphere of spraying of neutral sodium chloride solution, drying, and wetting, and check the corrosion resistance of metallic coatings.

**8.1.2 Preparation procedures of test solution** Test solution shall be prepared in the following sequence.

- a) Put suitable amount of pure water<sup>(3)</sup> into a container made of synthetic resin or glass.

- b) Use sodium chloride of guaranteed grade specified in **JIS K 8150** or of the grade equal or superior to this, and dissolve it in water to make a concentration of  $50 \pm 5$  g per liter of test solution.
- c) Control its pH to 6.5 by adding the solution of either sodium hydroxide specified in **JIS K 8576** or hydrochloric acid specified in **JIS K 8180**.
- d) Stir it sufficiently, control it to 25 °C, and adjust its specific gravity to 1.029 to 1.036<sup>(9)</sup> measuring with a hydrometer.
- e) Put a cover on the prepared solution to prevent dust.

**8.1.3 Apparatus** The apparatus required for this test shall be composed of the test vessel equipped with spraying tower or spraying nozzle, tank for salt solution, holder of test piece, container for sprayed solution, temperature controlling device and so on, and a reservoir for salt solution, supplier of compressed air, humidifying device, supplying device for dried air, exhaust system, and so on, all of which must set up the specified test conditions and must satisfy the following requirements.

- a) The test vessel shall have at least 0.2 m<sup>3</sup> capacity, and preferably 0.4 m<sup>3</sup> or larger, and its shape and dimensions are optional.
- b) The ceiling or cover of the test vessel shall be so constructed that the drops of the salt solution formed on it do not fall on the test piece.
- c) The corrosive material shall not be used for the apparatus.
- d) The apparatus shall be so constructed that the temperature in test vessel and spraying of salt solution are not influenced from outside atmosphere, and that the salt solution which fell from a test piece is not used again for the test.
- e) The test piece holder shall be capable of holding the test piece at the specified angle.
- f) The container for sprayed solution shall be clean one with 80 cm<sup>2</sup> of horizontal area for solution collecting, and be placed at least at 2 locations to confirm the uniformity of spraying. For instance, in the vicinity of test piece, one is placed near the spray tower or spray nozzle, and the other remote from it.
- g) Humidifying device shall be capable of setting the specified humid condition.
- h) The supplying device for dried air shall be capable of setting the specified drying condition.
- i) Exhaust system shall be such that the spraying of salt solution is not influenced by outside atmospheric pressure.
- j) The maintenance of test apparatus shall be carried out to achieve the specified condition.

**8.1.4 Holding of test piece** During the test, the location of test piece in the test vessel shall conform to the following conditions<sup>(11)</sup>.

- a) Principally, hold the test piece so that the surface to be evaluated forms at an angle of 20 degrees (allowable limit: from 15 degrees to 30 degrees) to the vertical, and place it at the position or the direction where it is exposed only to the free fall of spray of salt solution.

- b) The test pieces shall be placed so that they do not disturb the free fall of salt solution on other test pieces.
- c) The test pieces shall not come into contact with other objects than the frame.
- d) The drops of salt solution from the test pieces do not fall on other test pieces.
- e) The pressed stamp for recognition or mounting hole shall be faced downwards.

**8.1.5 Procedures** After confirming that the spraying conditions have been obtained in advance, stop the spraying temporarily, then put the test piece into the test vessel, and start the test.

- a) **Test conditions** Test conditions shall be as shown in Table 4.
- b) **Duration of test** The duration of test shall be subjected to the agreement between the parties concerned with delivery.

Recommended periods are 3 cycles (24 h), 6 cycles (48 h), 10 cycles (80 h), 30 cycles (240 h), 60 cycles (480 h), and 120 cycles (960 h), and principally the test shall be continued without interruption throughout the test duration.

- c) **Treatment after test** At the end of the test period, open the cover of the test vessel lest the drops of salt solution should fall on the test piece, take out the test piece lest the target surface for evaluation should be damaged, immediately rinse its surface to remove salt stack on the surface of the test piece with water, and then take away the corrosion product at the area except the corroded portion using a brush or sponge. To remove the corrosion product, employ such mechanical measures as brushing, ultrasonic radiation, water spraying, or chemical measures as shown in Attached Table 1.

**Table 4 Test conditions for cyclic neutral salt spray test method**

Items	Conditions
1 Spray of salt solution a) Temperature °C b) Concentration of sodium chloride g/l	35 ± 1 50 ± 5
2 Drying a) Temperature °C b) Relative humidity %RH	60 ± 1 20 to 30
3 Wetting a) Temperature °C b) Relative humidity %RH	50 ± 1 95 min.
4 Time and content of one cycle h	8 ( Salt solution spraying 2 ) ( Drying 4 ) ( Wetting 2 )  (These times include the time for reaching the specified temperature for each condition)

**Table 4 Test conditions for cyclic neutral salt spray test method (concluded)**

Items	Conditions
5 Time to reach the specified condition min (This means period taken for temperature and humidity to reach the specified values once the test condition has begun.)	30 or less from spraying to drying 15 or less from drying to wetting 30 or less from wetting to spraying humidity (Principally, mist conditions are attained almost instantaneously once this condition begins.)
6 Angle at which test piece is hold.	Principally, hold a test piece so that the surface to be evaluated forms at an angle of 20 degrees (allowable limit: from 15 degrees to 30 degrees) to the vertical.

**8.1.6 Judgement method** Judgement method shall follow 11.

In case of zinc and cadmium coatings, the corrosion defects shall be judged on the generation of red rust or of white corrosion products with the naked eyes.

**8.1.7 Report** The test report shall contain the following particulars.

- a) Name and type of test apparatus
- b) Sampling method, shape, quantity, dimensions, symbol of test piece
- c) Test conditions
  - 1) Conditions for spray of salt solution (temperature, concentration of sodium chloride)
  - 2) Conditions for drying (temperature, relative humidity)
  - 3) Conditions for wetting (temperature, relative humidity)
- d) Duration of cyclic test (h)
- e) Result of judgement

**8.2 Cyclic artificial acid rain test method**

**8.2.1 Summary** Employ a cyclic spray tester, carry out repeatedly the sequential exposure of a test piece to the atmosphere of spraying of artificial acid rain prepared by adding nitric acid and sulfuric acid into neutral sodium chloride solution, drying, and wetting, and check the corrosion resistance of metallic coatings.

**8.2.2 Preparation procedures of test solution** Test solution shall be prepared in the following sequence.

- a) Put suitable amount of pure water<sup>(8)</sup> into a container made of synthetic resin or glass.
- b) Use sodium chloride of guaranteed grade specified in JIS K 8150 or of the grade equal or superior to this, and dissolve it in water to make a concentration of  $50 \pm 5$  g per liter of test solution.

- c) Control its pH to 6.5 by adding the solution of either sodium hydroxide specified in JIS K 8576 or hydrochloric acid specified in JIS K 8180.
- d) Stir it sufficiently, control it to 25 °C, and adjust its specific gravity to 1.029 to 1.036(°) measuring with a hydrometer.
- e) Add 12 ml of nitric acid specified in JIS K 8541 and 17.3 ml of sulfuric acid specified in JIS K 8951 into 10 l of the above prepared solution, agitate it well, and further add about 317 ml of 10 % sodium hydroxide solution, and control its pH to 3.5 at  $35 \pm 2$  °C.
- f) Put a cover on the prepared solution to prevent dust.

**8.2.3 Apparatus** The apparatus required for this test shall be composed of the test vessel equipped with spraying tower or spraying nozzle, tank of solution for test, holder of test piece, container for sprayed solution, temperature controlling device and so on, and a reservoir for solution, supplier of compressed air, humidifying device, supplying device of dried air, exhaust system, and so on, all of which must set up the specified test conditions and must satisfy the following requirements.

- a) The test vessel have at least 0.2 m<sup>3</sup> capacity, and preferably 0.4 m<sup>3</sup> or larger, and its shape and dimensions are optional.
- b) The ceiling and cover of the test vessel shall be so constructed that the drops of the salt solution formed on them do not fall on the test piece.
- c) The corrosive material shall not be used for the apparatus.
- d) The apparatus shall be so constructed that the temperature in test vessel and spraying of salt solution are not influenced from outside atmosphere, and that the salt solution which fell from a test piece is not used again for the test.
- e) The test piece holder shall hold the test piece at the specified angle.
- f) The container for sprayed solution shall be clean one with 80 cm<sup>2</sup> of horizontal area for solution collecting, and be placed at least at 2 locations to confirm the uniformity of spraying. For instance, in the vicinity of test piece, one is placed near the spray tower or spray nozzle, and the other remote from it.
- g) Humidifying device shall be capable of setting the specified humid condition.
- h) The supplying device for dried air shall be capable of setting the specified drying condition.
- i) Exhaust system shall be such that the spraying is not influenced by outside atmospheric pressure.
- j) The maintenance of test apparatus shall be carried out to achieve the specified condition.

**8.2.4 Holding of test piece** During the test, the location of test piece in the test vessel shall conform to the following conditions<sup>(1)</sup>.

- a) Principally, hold the test piece so that the surface to be evaluated forms at an angle of 20 degrees (allowable limit: from 15 to 30 degrees) to the vertical, and place it at the position or the direction where it is exposed only to the free fall of spray of salt solution.

- b) The test pieces shall be placed so that they do not disturb the free fall of salt solution on other test pieces.
- c) The test pieces shall not come into contact with other objects than the frame.
- d) The drops of salt solution from the test pieces do not fall on other test pieces.
- e) The pressed stamp for recognition or mounting hole shall be faced downwards.

**8.2.5 Procedures** After confirming that the spraying conditions have been obtained in advance, stop the spraying temporarily, then put the test piece in the test vessel, and start the test.

- a) **Test conditions** Test conditions shall be as shown in Table 5.
- b) **Duration of test** The duration of test shall be subjected to the agreement between the parties concerned with delivery.

Recommended periods are 3 cycles (24 h), 6 cycles (48 h), 10 cycles (80 h), 30 cycles (240 h), 60 cycles (480 h), and 120 cycles (960 h), and principally the test shall be continued without interruption throughout the test duration.

- c) **Treatment after test** At the end of test period, open the cover of the test vessel lest the drops of salt solution should fall on the test piece, take out the test piece lest the target surface for evaluation should be damaged, immediately rinse its surface to remove salt stack on the surface of the test piece with water, and then take away the corrosion product at the area except the corroded portion using a brush or sponge. To remove the corrosion product, employ such mechanical measures as brushing, ultrasonic radiation, water spraying, or chemical measures as shown in Attached Table 1.

**Table 5 Test conditions for cyclic artificial acid rain test method**

Items	Conditions
1 Spray	
a) Temperature °C	35 ± 2
b) Composition of spray solution	
5 % neutral sodium chloride solution (pH 6.5) l	10
Nitric acid ml	12
Sulfuric acid ml	17.3
c) pH	3.5
(The value of pH is controlled with adding about 317 ml of 10 % sodium hydroxide solution.)	
2 Drying	
a) Temperature °C	60 ± 1
b) Relative humidity %RH	20 to 30

**Table 5 Test conditions for cyclic artificial acid rain test method (concluded)**

Items	Conditions
3 Wetting a) Temperature °C b) Relative humidity %RH	50 ± 1 95 min.
4 Time and content of one cycle h	8 <div style="display: flex; justify-content: center; align-items: center; gap: 10px;"> <span style="font-size: 2em;">{</span> <div style="text-align: center;">                     Artificial acid rain    2                      Drying                            4                      Wetting                            2                 </div> <span style="font-size: 2em;">}</span> </div> (These times include the time for reaching the specified temperature for each condition.)
5 Time to reach the specified condition min (This means period taken for temperature and humidity to reach the specified values once the test condition has begun.)	30 or less from spraying to drying 15 or less from drying to wetting 30 or less from wetting to spraying (Principally, mist conditions are attained almost instantaneously once this condition begins.)
6 Angle at which test piece is hold.	Principally, hold a test piece so that the surface to be evaluated forms at an angle of 20 degrees (allowable limit: from 15 to 30 degrees) to the vertical.

**8.2.6 Judgement method** Judgement method shall follow 11.

**8.2.7 Report** The test report shall contain the following particulars.

- a) Name and type of test apparatus
- b) Sampling method, shape, quantity, dimensions, symbol, of test piece
- c) Test conditions
  - 1) Conditions for spray of acid rain (temperature, pH)
  - 2) Conditions for drying (temperature, relative humidity)
  - 3) Conditions for wetting (temperature, relative humidity)
- d) Duration of cyclic test (h)
- e) Result of judgement

## 9 Corrodkote corrosion test method

**9.1 Summary** Apply corrodkote slurry to the one side surface of a test piece, dry it, allow it to stand in a humidity chamber, and check the corrosion resistance of metallic coatings.

### 9.2 Employed chemicals and its preparation

- a) **Copper nitrate solution** Dissolve 2.5 g of copper nitrate in pure water, and dilute it to 500 ml.