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**Methods of corrosion resistance test
for metallic coatings**

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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 H 8502:1988** is replaced with **JIS H 8502:1999**.

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Methods of corrosion resistance test for metallic coatings

Introduction This Japanese Industrial Standard has been prepared based on the corresponding International Standards listed in Remarks to 1 Scope for the corresponding parts, without any modification of technical contents, and added the items not specified in the corresponding International Standards and further the contents specified in the corresponding International Standards (test method of sulfur dioxide, test method of hydrogen sulfide, and test method of mixed gas) with partial modification.

1 Scope This Standard specifies the methods of corrosion resistance test for the metallic coatings and the products coated with metal. Metallic coating contains such plating as electroplating, electroless plating, vapor deposition⁽¹⁾, and hot-dip plating.

Note ⁽¹⁾ Vapor deposition means vacuum evaporation, sputtering, ion plating, chemical vapor deposition, and so on.

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

- | | |
|----------------------------|--|
| ISO 4540:1980 | <i>Metallic coatings — Coatings cathodic to the substrate — Rating of electroplated test specimens subjected to corrosion tests</i> |
| ISO 4541:1978 | <i>Metallic and other non-organic coatings — Corrodokote corrosion test (CORR test)</i> |
| ISO 8407:1991 | <i>Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens</i> |
| ISO 8565:1992 | <i>Metals and alloys — Atmospheric corrosion testing — General requirements for field tests</i> |
| ISO 9227:1990 | <i>Corrosion tests in artificial atmospheres — Salt spray tests</i> |
| ISO 10062:1991 | <i>Corrosion tests in artificial atmosphere at very low concentrations of polluting gas(es)</i> |
| ISO/DIS 14993:1998 | <i>Corrosion of metals and alloys — Accelerated corrosion testing involving cyclic exposure to salt mist, dry and wet conditions</i> |
| IEC 60068-2-42:1982 | <i>Basic environmental testing procedure — Part 2: Tests. Test Kc : Sulfur dioxide test for contacts and connections</i> |
| IEC 60068-2-43:1976 | <i>Basic environmental testing procedure — Part 2: Tests. Test Kd : Hydrogen-sulphide test for contacts and connections</i> |

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

- JIS B 7952 *Continuous analyzers for sulfur dioxide in ambient air*
- JIS H 0211 *Glossary of terms used in surface treatments by dry processing*
- JIS H 0400 *Glossary of terms used in electroplating*
- JIS K 0101 *Testing methods for industrial water*
- JIS K 0103 *Methods for determination of sulfur oxides in flue gas*
- JIS K 0104 *Methods for determination of oxides of nitrogen in flue gases*
- JIS K 8116 *Ammonium chloride*
- JIS K 8142 *Iron (III) chloride hexahydrate*
- JIS K 8145 *Copper (II) chloride dihydrate*
- JIS K 8150 *Sodium chloride*
- JIS K 8180 *Hydrochloric acid*
- JIS K 8355 *Acetic acid*
- JIS K 8541 *Nitric acid*
- JIS K 8576 *Sodium hydroxide*
- JIS K 8951 *Sulfuric acid*
- JIS P 3801 *Filter paper (for chemical analysis)*
- JIS Z 2371 *Methods of neutral salt spray testing*
- JIS Z 8401 *Guide to the rounding of numbers*

3 Definitions For the purpose of this Standard, the definitions in **JIS H 0211** and **JIS H 0400** and the following definitions apply.

- a) **outdoor exposure test** The test which a test piece is placed on an exposure frame and then is exposed under atmospheric condition.
- b) **direct outdoor exposure test** The outdoor exposure test which is carried out outdoors by direct exposure under atmospheric condition.
- c) **sheltered exposure test** The outdoor exposure test which is carried out outdoors under the atmospheric condition but sheltered from snow, rain and sunshine.
- d) **continuous spray test** The test which a test piece is exposed to the atmosphere of continuously spraying corrosive liquid.
- e) **neutral salt spray test** Continuous spray test with spraying neutral sodium chloride solution.
- f) **acetic acid salt spray test, ASS test** Continuous spray test with spraying sodium chloride solution acidified by acetic acid.
- g) **CASS test (copper-accelerated acetic acid salt spray test)** Continuous spray test with spraying sodium chloride solution acidified by acetic acid in which copper (II) chloride dihydrate was added.
- h) **cyclic test** The test in which spraying of corrosive liquid, drying and wetting are repeatedly carried out in order to make the atmosphere similar to natural condition and to accelerate the test.

- i) **cyclic neutral salt spray test** Cyclic test carried out in the atmosphere of spraying of neutral sodium chloride solution, drying, and wetting.
- j) **cyclic artificial acid rain test** Cyclic test carried out in the atmosphere of spraying of artificial acid rain prepared by adding nitric acid, sulfuric acid, etc. into neutral sodium chloride solution, drying, and wetting.
- k) **corrodkote corrosion test** The test which a test piece is applied with corrodkote slurry and is allowed to stand in a humidity chamber after being dried.
- l) **pollutioning gas corrosion test** The test carried out by means of exposing a test piece in the atmosphere of pollutioning gas.
- m) **sulfur dioxide gas test** Pollutioning gas corrosion test carried out in the atmosphere of sulfur dioxide gas.
- n) **hydrogen sulfide gas test** Pollutioning gas corrosion test carried out in the atmosphere of hydrogen sulfide gas.
- o) **chlorine gas test** Pollutioning gas corrosion test carried out in the atmosphere of chlorine gas.
- p) **mixed pollution gas test** Pollutioning gas corrosion test carried out in the atmosphere of mixed gas of sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and chlorine gas.

4 Classification of test methods Test methods are classified as follows.

- a) Outdoor exposure test method
 - 1) Direct outdoor exposure test method
 - 2) Sheltered exposure test method
- b) Continuous spray test method
 - 1) Neutral salt spray test method
 - 2) Acetic acid salt spray test method, ASS test method
 - 3) CASS test method, Copper-accelerated acetic acid salt spray test method
- c) Cyclic test method
 - 1) Cyclic neutral salt spray test method
 - 2) Cyclic artificial acid rain test method
- d) Corrodkote corrosion test method
- e) Pollutioning gas corrosion test method
 - 1) Sulfur dioxide gas test method
 - 2) Hydrogen sulfide gas test method
 - 3) Chlorine gas test method
 - 4) Mixed pollution gas test method

5 Test piece Test pieces shall be as follows.

5.1 Handling of test piece When handling a test piece, use gloves instead of handling with the bare hands.

5.2 Sampling of test piece Test pieces shall be either sampled from the significant surface of the product or the product itself. When it is difficult to test or judge on the product, a test piece replacing it may be used.

The test piece shall be the one capable of representing⁽²⁾⁽³⁾ the products.

5.3 Size of test piece The size of a test piece is preferably 150 mm × 70 mm or 100 mm × 100 mm. The agreement between the parties concerned with delivery, however, can choose other size of test piece.

5.4 Treatment before test

- a) Wipe well the test piece with a solvent⁽⁴⁾ adequate for dirt, or rub⁽⁵⁾ fully the surface to be tested with fine powder of magnesium oxide or precipitated calcium carbonate stuck on water-moistened absorbent cotton, then rinse it with water, and take off water on it with a clean cloth or blotting paper.
- b) The exposed substrate such as cut end or end surface of a test piece where is not to be tested shall be protected with applying a coating⁽⁶⁾ stable enough under the test condition.
- c) When cross cut test is necessitated, follow Note (7).

Notes (2) The composition of material, condition for manufacturing, and the finishing condition before metallic coating are preferably the same as those for products.

(3) Carry out the pretreatment and metallic coating in the same bath and under the same condition as those for products, and further it is recommendable to carry out the procedures simultaneously with the products in order that the working conditions can similarly influence on the test piece.

(4) Ethanol, benzine, or gasoline is recommendable.

(5) In case of applying conversion treatment (for instance, chromate treatment on galvanized sheet) or of coating with paint after metallic coating, it is preferable to avoid this procedure.

(6) Insulating tape may be used.

(7) On about half surface of a test piece, as shown in Fig. 1, cut two X-shaped flaws crossing each other by about 70 degrees and measuring 50 mm length using a bite or diamond cutter. It is preferable to hold its edge at a definite angle of 35 to 45 degrees to the test surface, and to keep constant the depth and dimension of the cut.

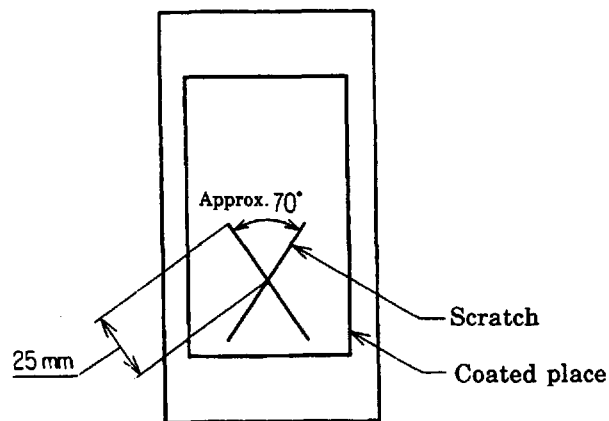


Fig. 1 Way to cut the scratch

6 Outdoor exposure test method

6.1 Direct outdoor exposure test method

6.1.1 Summary Place a test piece on a exposure frame, expose it directly to atmospheric condition, and check the corrosion resistance of metallic coatings.

6.1.2 Conditions of site for exposure Exposure site shall satisfy the following conditions.

- a) Principally, the testing area shall be exposed to the full effects of the weather.
- b) The plants or shrubs growing in the vicinity of exposure frame shall be 0.2 m or less.
- c) The place where chemicals are used for plant growth in the vicinity of the exposure frame shall be avoided.

6.1.3 Exposure site Exposure site shall satisfy the following conditions.

- a) The site where test pieces can be periodically observed and environmental factors are measured.
- b) The site where the safety countermeasures against theft, damage, or other obstructions are completely furnished.

6.1.4 Exposure frame Exposure frame shall be as follows.

- a) The main material of exposure frame is aluminum alloy, wood, or steel applied adequate rust prevention, and the frame must be firmly constructed.
- b) The exposure surface faces southwards at an angle of 30 to 45 degrees from horizontal, and depending on its purpose, other orientations and angles, for instance vertically and northwards, are permissible.
- c) The earth's surface shall be suitably covered to avoid influences radiated from the earth.
- d) The lowest end of exposure surface shall be at least 0.5 m above the earth's surface.

6.1.5 Attaching of test pieces The test pieces shall be attached so as not to allow them to touch each other nor to give influences to the others.

6.1.6 Duration of exposure The duration of exposure is at least one month, and it is recommended to take 3 months, 6 months, 1 year, 2 years, 5 years, 10 years, or 20 years. In any case, the time when exposure was started shall be noted in the record.

6.1.7 Measurement of weather factors The measurements of environmental factors are as follows.

a) **Items to be measured** Environmental factors necessary for analysis of the results obtained from outdoor exposure test shall be as follows, and they are principally measured and recorded every day during test period. For factors considered to be unimportant depending on its purpose, the measurement of the factor can be omitted. For the items from 1) to 5), the records provided by the neighbouring meteorological weather station can be used.

- 1) The maximum air temperature (°C), the minimum air temperature (°C), averaged air temperature (°C)
- 2) The maximum relative humidity (%) the minimum relative humidity (%), averaged relative humidity (%)
- 3) Wind direction
- 4) Wind speed (m/s)
- 5) Amount of precipitation (mm/d)
- 6) Duration of precipitation (h)
- 7) Number of precipitations (times/d)
- 8) Time of wetness (h)
- 9) Particles of sea salt [mgNaCl/(100 cm²·d)]
- 10) Concentration of sulfur dioxide (ppm) or concentration of sulfur trioxide [mg/(m²·d)]
- 11) Concentration of nitrogen dioxide (ppm or [mg/(m²·d)])

b) **Measuring method** The measuring methods of environmental factors are as follows.

- 1) **Measurement of air temperature** Attach a maximum and minimum thermometer or automatically recording thermometer to the instrument screen placed on or near the exposure frame to measure the temperature.
- 2) **Measurement of humidity** At the same place as mentioned at 1), use an automatically recording hygrometer, and measure the humidity.
- 3) **Measurement of wind direction** Use an anemoscope.
- 4) **Measurement of wind speed** Use an anemometer.
- 5) **Measurement of amount of precipitation** Use a pluviometer.
- 6) **Measurement of duration of precipitation** Record the start time of raining and stop time of raining, and calculate the duration of precipitation.

- 7) **Measurement of number of precipitations** Measure the number of precipitations per day.
- 8) **Measurement of the time of wetness** Measure the time of wetness per day.
- 9) **Measurement of particles of sea salt** For the measurement of sea-salt particles, employ the method in Annex 1 or other methods recognized effectiveness.
- 10) **Measurement of concentration of sulfur dioxide and sulfur trioxide** For the measurement of concentration of sulfur dioxide, employ the turbidimetry specified in **JIS K 0103**. For the measurement of concentration of sulfur trioxide, follow Annex 2 or Annex 3.
- 11) **Measurement of concentration of nitrogen dioxide** For the measurement of concentration of nitrogen dioxide, follow Salzman method specified in **JIS K 0104** or follow Annex 3.

6.1.8 Judgement Judgement shall follow 11.

6.1.9 Report The test report shall contain the following particulars.

- a) Conditions of exposure site (such as angle of exposure)
- b) Sampling method, shape, quantity, dimensions, and symbol of test piece
- c) Environmental factors observed during exposure
- d) Duration of exposure (start time of exposure, and so on)
- e) Results of judgement

6.2 Sheltered exposure test method

6.2.1 Summary Place a test piece on a exposure frame, expose it under the atmospheric condition but being sheltered from snow, rain and sunshine, and check the corrosion resistance of metallic coatings.

6.2.2 Conditions of site for exposure Exposure site shall satisfy the following conditions.

- a) The testing area shall be exposed to the full effects of the weather except of snow, rain, and sunshine.
- b) The plants or shrubs growing in the vicinity of exposure frame shall be 0.2 m or less.
- c) The place where chemicals are used for plant growth in the vicinity of the exposure frame shall be avoided.

6.2.3 Exposure site Exposure site shall satisfy the following conditions.

- a) The site where test pieces can be periodically observed and environmental factors are measured.
- b) The site where the safety countermeasures against theft, damage, or other obstructions are completely furnished.

6.2.4 Exposure frame Exposure frame shall be as follows.

- a) The main material of exposure frame is aluminum alloy, wood, or steel applied adequate rust prevention, and the frame must be firmly constructed.
- b) The exposure surface is inclined by any one of 0°, 30°, 45°, 60°, and 90° to the vertical.
- c) The earth's surface shall be suitably covered to avoid influences radiated from the earth.
- d) The lowest end of exposure surface shall be at least 0.5 m above the earth's surface.
- e) The roof or cover is inclined and its height is 3 m or less.

6.2.5 Attaching of test pieces The test pieces shall be attached so as not to allow them to touch each other nor to give influences to the others.

6.2.6 Duration of exposure The duration of exposure is at least one month, and it is recommended to take 3 months, 6 months, 1 year, 2 years, 5 years, 10 years, or 20 years. In any case, the time when exposure was started shall be noted in the record.

6.2.7 Measurement of environmental factors The measurements of environmental factors are as follows.

- a) **Items to be measured** Environmental factors necessary for analysis of the results obtained from outdoor exposure test shall be as follows, and they are principally measured and recorded every day during test period. For factors considered to be unimportant depending on its purpose, the measurement of the factor can be omitted. For the items from 1) to 5) the records provided by the neighbouring meteorological weather station can be used.
 - 1) The maximum air temperature (°C), the minimum air temperature (°C), averaged air temperature (°C)
 - 2) The maximum relative humidity (%), the minimum relative humidity (%), averaged relative humidity (%)
 - 3) Wind direction
 - 4) Wind speed (m/s)
 - 5) Amount of precipitation (mm/d)
 - 6) Duration of precipitation (h)
 - 7) Number of precipitations (times/d)
 - 8) Time of wetness (h)
 - 9) Particles of sea salt [mgNaCl/(100 cm²·d)]
 - 10) Concentration of sulfur dioxide (ppm) or concentration of sulfur trioxide [mg/(m²·d)]
 - 11) Concentration of nitrogen dioxide (ppm or [mg/(m²·d)])
- b) **Measuring method** The measuring methods of environmental factors are as follows.

- 1) **Measurement of atmospheric temperature** Attach a maximum and minimum thermometer or automatically recording thermometer to the instrument screen placed on or near the exposure frame to measure the temperature.
- 2) **Measurement of humidity** At the same place as mentioned at 1), use an automatically recording hygrometer, and measure the humidity.
- 3) **Measurement of wind direction** Use an anemoscope.
- 4) **Measurement of wind speed** Use an anemometer.
- 5) **Measurement of amount of precipitation** Use a pluviometer.
- 6) **Measurement of duration of precipitation** Record the start time of raining and stop time of raining, and calculate the duration of precipitation.
- 7) **Measurement of number of precipitations** Measure the number of precipitations per day.
- 8) **Measurement of the time of wetness** Measure the time of wetness per day.
- 9) **Measurement of particles of sea salt** For the measurement of sea-salt particles, employ the method in Annex 1 or other methods recognized effectiveness.
- 10) **Measurement of concentration of sulfur dioxide and sulfur trioxide** For the measurement of concentration of sulfur dioxide, employ the turbidimetry specified in **JIS K 0103** or the like. For the measurement of concentration of sulfur trioxide, follow Annex 2 or Annex 3.
- 11) **Measurement of concentration of nitrogen dioxide** For the measurement of concentration of nitrogen dioxide, follow Salzmann method specified in **JIS K 0104** or follow Annex 3.

6.2.8 Judgement Judgement shall follow 11.

6.2.9 Report The test report shall contain the following particulars.

- a) Conditions of exposure site (such as angle of exposure)
- b) Sampling method, shape, quantity, dimensions, and symbol of test piece
- c) Environmental factors observed during exposure
- d) Duration of exposure (start time of exposure, and so on)
- e) Results of judgement

7 Continuous spray test method

7.1 Neutral salt spray test method

7.1.1 Summary Employ a salt spray tester, spray neutral sodium chloride solution, and check the corrosion resistance of metallic coatings under the sprayed condition.

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

- a) Put suitable amount of pure water⁽⁸⁾ 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 the water to make a concentration of 50 ± 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⁽⁹⁾ measuring with a hydrometer.
- e) Put a cover on the prepared solution to prevent dust.

Notes ⁽⁸⁾ This pure water shall have a conductivity of 20 μ S/cm (or 2 mS/m) or less at 25 ± 2 °C.

1 μ S/cm or less is preferable.

- ⁽⁹⁾ Measure the concentration of sodium chloride solution by either **d)** of **7.1.2** or the following method: Dilute 5 ml of taken solution with 100 ml of pure water, mix them well, take 10 ml aliquot using a pipet, add 40 ml of pure water and 1 ml of potassium chromate solution (1 w/v %) (chloride free), and agitate well. Then, titrate it with 0.1 mol silver nitrate solution, and confirm the required amount of the titrant is from 3.4 ml to 5.1 ml.

7.1.3 Apparatus The apparatus required for this test shall be in accordance with **JIS Z 2371**, and composed of a thermostatic and humidistatic test vessel equipped with spraying tower or spraying nozzle, tank for salt solution, holder of test piece, container for sprayed solution and so on, and reservoir for salt solution, air saturator, supplier of compressed air, exhaust system and so on, all of which must satisfy the following requirements.

- a) The material of the apparatus shall not give any influences on the corrosiveness of salt solution, and not be easily corroded itself.
- b) The test vessel shall have at least 0.2 m³ capacity.
- c) The salt solution shall not be directly sprayed on the test piece, and the drops of the salt solution formed on the ceiling of the vessel shall not fall on the test piece.
- d) Don't reuse the salt solution which fell from the test piece.
- e) The compressed air used for spraying salt solution shall be free from oil or dirties, and its pressure be in the range from 70 kPa to 167 kPa⁽¹⁰⁾.
- f) The container for sprayed solution shall be clean one with 80 cm² 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) 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 35 ± 2 °C, that in salt solution tank at 35 ± 2 °C, and that in air saturator at 47 ± 2 °C.

Note ⁽¹⁰⁾ Apply any pressure within this range, and it is preferable to keep the pressure constant during the test.

7.1.4 Holding of test piece During the test, the location of test piece in the test vessel shall conform to the following conditions⁽¹¹⁾.

- 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 spray 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.

Note ⁽¹¹⁾ When the products are tested, the items not satisfying shall conform to the agreement between the parties concerned with delivery.

7.1.5 Procedures After conditioning the temperature in test vessel at 35 °C, that in salt solution tank at 35 °C, and that in air saturator at 47 °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 1.
- b) **Duration of test** The duration of test shall be subjected to the agreement between the parties concerned with delivery.

Recommended periods are 8 h, 16 h, 24 h, 48 h, 96 h, 240 h, 480 h, and 720 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 1 Test conditions for neutral salt spray test method

Items	While preparing	While testing
Concentration of sodium chloride g/l	50 ± 5	50 ± 5
pH	6.5	6.5 to 7.2
Amount of spray ml/80 cm ² /h	—	1.5 ± 0.5
Temperature in test vessel °C	—	35 ± 2
Temperature in salt water tank °C	—	35 ± 2
Temperature in air saturator °C	—	47 ± 2
Pressure of compressed air kPa	—	70 to 167

7.1.6 Judgement method Judgement method shall follow 11.

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

7.1.7 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) Concentration of sodium chloride
 - 2) pH
 - 3) Amount of spray
 - 4) Temperature (test vessel, salt water tank, air saturator)
 - 5) Pressure of compressed air
- d) Duration of test
- e) Result of judgement

7.2 Acetic acid salt spray test method, ASS test method

7.2.1 Summary Employ a salt spray tester, spray sodium chloride solution acidified by acetic acid, and check the corrosion resistance of metallic coatings under the spraying condition.

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

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

- c) Stir it sufficiently, control it to 25 °C, and adjust its specific gravity to 1.029 to 1.036⁽⁹⁾ measuring with a hydrometer.
- d) Use acetic acid of guaranteed grade specified in **JIS K 8355** or equal or superior to this, and dissolve it by adding 1 ml per liter of sodium chloride solution, agitate it well, and measure its pH. If the pH is 3.1 or higher at 25 °C, add acetic acid more, agitate it well, and measure its pH again. Repeat these procedures until its pH reaches 3.0 at 25 °C .
- e) Put a cover on the prepared solution to prevent dust.

7.2.3 Apparatus The apparatus required for this test shall be in accordance with **JIS Z 2371**, and composed of a thermostatic and humidistatic test vessel equipped with spraying tower or spraying nozzle, tank for salt solution, holder of test piece, container for sprayed solution and so on, and reservoir for salt solution, air saturator, supplier of compressed air, exhaust system, and so on, all of which must satisfy the following requirements.

- a) The material of the apparatus shall not give any influences on the corrosiveness of salt solution, and not be easily corroded itself.
- b) The test vessel shall have at least 0.2 m³ capacity.
- c) The salt solution shall not be sprayed directly on the test piece, and the drops of the salt solution formed on the ceiling of the vessel shall not fall on the test piece.
- d) Don't reuse the salt solution which fell from the test piece.
- e) The compressed air used for spraying salt solution shall be free from oil or dirties, and its pressure be in the range from 70 kPa to 167 kPa⁽¹⁰⁾.
- f) The container for sprayed solution shall be clean one with 80 cm² 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) 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 35 ± 2 °C, that in salt solution tank at 35 ± 2 °C, and that in air saturator at 47 ± 2 °C.

7.2.4 Holding of test piece During the test, the location of test piece in the test vessel shall conform to the following conditions⁽¹¹⁾.

- 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.

7.2.5 Procedures After conditioning the temperature in test vessel at 35 °C, that in salt solution tank at 35 °C, and that in air saturator at 47 °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 2.
- b) **Duration of test** The duration of test shall be subjected to the agreement between the parties concerned with delivery.

Recommended periods are 8 h, 16 h, 24 h, 48 h, 96 h, 240 h, 480 h, and 720 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 2 Test conditions for acetic acid salt spray test method

Items	While preparing	While testing
Concentration of sodium chloride g/l	50 ± 5	50 ± 5
pH	3.0	3.1 to 3.3
Amount of spray ml/80 cm ² /h	—	1.5 ± 0.5
Temperature in test vessel °C	—	35 ± 2
Temperature in salt water tank °C	—	35 ± 2
Temperature in air saturator °C	—	47 ± 2
Pressure of compressed air kPa	—	70 to 167

7.2.6 Judgement method Judgement method shall follow 11.

7.2.7 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) Concentration of sodium chloride
 - 2) pH
 - 3) Amount of spray
 - 4) Temperature (test vessel, salt water tank, air saturator)
 - 5) Pressure of compressed air
- d) Duration of test
- e) Result of judgement

7.3 CASS test method

7.3.1 Summary Employ a CASS tester, spray the acetic acid-acidified sodium chloride solution added copper (II) chloride dihydrate, and check the corrosion resistance of metallic coatings under the spraying condition.

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

- a) Put suitable amount of pure water⁽⁸⁾ 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 ± 5 g per liter of test solution.
- c) Stir it sufficiently, control it to 25 °C, and adjust its specific gravity to 1.029 to 1.036⁽⁹⁾ measuring with a hydrometer.
- d) Use copper (II) chloride dihydrate of guaranteed grade specified in **JIS K 8145** or of the grade equal or superior to this, and dissolve it by adding 0.26 ± 0.02 g per liter of sodium chloride solution. This solution is equivalent, when prepared, to 0.205 ± 0.015 g of copper (II) chloride per liter.
- e) Use acetic acid of guaranteed grade specified in **JIS K 8355** or of the grade equal or superior to this, and dissolve it by adding 1 ml per liter of the solution mentioned above, agitate it well, and measure its pH. If the pH is 3.1 or higher at 25 °C, add acetic acid more, agitate it, and measure its pH again. Repeat these procedures until its pH reaches 3.0 at 25 °C.
- f) Put a cover on the prepared solution to prevent dust.

7.3.3 Apparatus The apparatus required for this test shall be in accordance with **JIS Z 2371**, and composed of a thermostatic and humidistatic test vessel equipped with spraying tower or spraying nozzle, tank for salt solution, holder of test piece, container for sprayed solution and so on, and reservoir for salt solution, air saturator, supplier of compressed air, exhaust system, and so on, all of which must satisfy the following requirements.

- a) The material of the apparatus shall not give any influences on the corrosiveness of salt solution, and not be easily corroded itself.
- b) The test vessel shall have at least 0.2 m³ capacity.
- c) The salt solution shall not be directly sprayed on the test piece, and the drops of the salt solution formed on the ceiling of the vessel shall not fall on the test piece.
- d) Don't reuse the salt solution which fell from the test piece.
- e) The compressed air used for spraying salt solution shall be free from oil or dirties, and its pressure be in the range from 70 kPa to 167 kPa⁽¹⁰⁾.
- f) The container for sprayed solution shall be clean one with 80 cm² 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) 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 ± 2 °C, that in salt solution tank at 50 ± 2 °C, and that in air saturator at 63 ± 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⁽¹⁾.

- 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 3.
- 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 g/l	50 ± 5	50 ± 5
Concentration of copper (II) chloride ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$) g/l	0.26 ± 0.02	—
pH	3.0	3.0 to 3.2
Amount of spray ml/80 cm ² /h	—	1.5 ± 0.5
Temperature in test vessel °C	—	50 ± 2
Temperature in salt water tank °C	—	50 ± 2
Temperature in air saturator °C	—	63 ± 2
Pressure of compressed air kPa	—	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⁽⁸⁾ 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 ± 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⁽⁹⁾ 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 m³ capacity, and preferably 0.4 m³ 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 cm² 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⁽¹¹⁾.

- 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.