

Salt spray testing

DIN
50 021

Sprühnebelprüfungen mit verschiedenen Natriumchlorid-Lösungen

Supersedes May 1975 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

See Explanatory notes for connection with International Standards ISO 1456 — 1974 and ISO 3768 — 1978, published by the International Organization for Standardization (ISO), and ASTM B 117-85 published by the American Society for Testing and Materials (ASTM).

The symbol % as used in this standard means percentage by mass.

1 Scope

This standard specifies the requirements which corrosion testing apparatuses and corrosive agents must meet in salt spray testing, the aim being to enable identical conditions to be reproduced in all cases in which spray tests are carried out on the basis of standards or agreements.

The standard does not deal with the preparation of specimens, the duration of testing, the treatment of specimens after testing, or the evaluation of results.

Which of the three methods listed in clause 3 is to be applied in any individual case shall be the subject of agreement between the parties concerned unless specified in relevant standards (see Explanatory notes).

The tests described in this standard serve both to characterize the effectiveness of corrosion protection systems and to detect defects quickly. They are not suitable for specifically testing for defects in metallic coatings where the coating is made of a baser metal than the substrate (e.g. zinc or aluminium on steel), since the substrate is in such cases cathodically protected by the coating adjoining the defect. The tests are accelerated corrosion tests as specified in DIN 50 900 Part 3, which do not provide any direct information on the behaviour of the tested parts in service. Likewise, due to the fact that the corrosion effects in these tests differ considerably from those which may occur in service, and that consequently different corrosion processes may be involved, a comparison

between the protective value of different corrosion protection systems is only possible where the similarity between them is sufficiently close.

2 Concepts

See DIN 50 900 Parts 1 to 3.

3 Principle

For the purposes of this standard, spray tests are tests in which the corrosive agent is an aqueous sodium chloride solution with a concentration by mass of 5 g/100 ml (main constituent) that is sprayed continuously by means of compressed air.

Note. Other methods of producing a spray may be employed provided that the equivalence of the corrosion effect has been recognized by a committee of experts of the *Normenausschuß Materialprüfung* (Materials Testing Standards Committee).

There are three different spray tests as specified in table 1:

- a) salt spray test (SS test);
- b) acetic acid salt spray test (DIN 50 021 — ASS test);
- c) copper-accelerated acetic acid salt spray test (CASS test) (see Explanatory notes)

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Table 1. Conditions for spray testing

Type of test		Salt spray test	Acetic acid salt spray test	Copper-accelerated acetic acid salt spray test
Standard designation		Test DIN 50 021 – SS	Test DIN 50 021 – ASS	Test DIN 50 021 – CASS
Test solution	Concentration by mass of sodium chloride, in g/l	(50 ± 5)		
	Other additives	None (see subclause 5.1).	Acetic acid (see subclause 5.2).	Acetic acid and copper(II) chloride (see subclause 5.3).
pH value		6,5 to 7,2	3,1 to 3,3	
Temperature in spray cabinet, in °C		(35 ± 2)		(50 ± 2)

4 Apparatus

The test apparatus, illustrated in the figure below, shall essentially comprise the components described in sub-clauses 4.1 to 4.5. All parts of the test apparatus which come into contact with the spray or the test solutions shall be made of a material that is resistant to the test solutions and does not influence the corrosive action of the test solution or of the spray. If the test solution is changed from CASS to ASS or SS, or from ASS to SS, the apparatus shall be cleaned to ensure that copper salt or acetic acid cannot influence the results.

4.1 Spray cabinet

A cabinet that can be heated and in which the pressure can be equalized is required, equipped with the measuring and control devices needed for setting and maintaining a test temperature of (35 ± 2) °C for the SS and ASS tests, and of (50 ± 2) °C for the CASS test in the closed cabinet. The test chamber shall have a minimum capacity of 400 l (see Explanatory notes) and be designed to ensure that drops of spray do not fall from the top cover, side walls and baffles on the specimens. After being sprayed, the test solution shall not return to the reservoir.

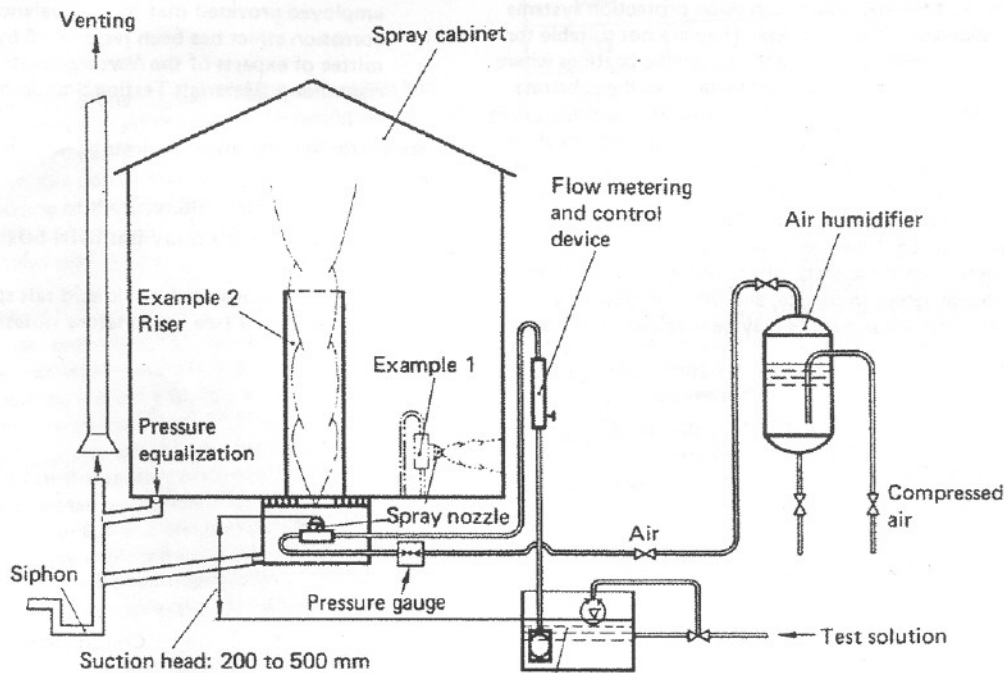


Figure. Illustration of a test apparatus with two examples of nozzle arrangement

Test solution reservoir with level controller

The useful space for test purposes is limited to that part of the cabinet which lies outside the spray jet and in which a uniform dispersion of the spray can be verified as described in subclause 7.2, third paragraph.

4.2 Spray nozzle(s)

To produce the spray, nozzles of polyacrylate glass or stainless austenitic chromium-nickel-molybdenum steel shall be used; the use of other materials is permitted if they enable the conditions specified in subclause 7.2 and 8.6 to be met. Spray nozzles with an aperture diameter of 1 mm and an angle of dispersion of about 30°, operating at a gauge pressure of about 0,7 to 1,4 bar and a suction head of 200 to 500 mm, have proved effective. It is expedient to fit a metering and control device for monitoring the flow rate (see figure). Such devices allow the amount of test solution to be sprayed to be set and monitored, so as to ensure that the amount of spray collected in the cabinet each hour lies within the limits specified in subclause 7.2.

The operation of the spray nozzles can be monitored by means of the flow metering device. If more than one nozzle is used, each nozzle shall be assigned its own flow metering and control device. The spray jet shall not be aimed directly at the specimens. That may require the spray jet to be directed against a baffle or a wall of the apparatus (see figure, example 1). If the nozzle is located on the bottom of the chamber, a riser may be used (see figure, example 2). The spraying arrangement shown in example 1 should only be used in apparatus of large capacity, to ensure that none of the specimens are mounted above the nozzles.

The number and arrangement of the spray nozzles shall be chosen so as to ensure that the specifications of subclauses 7.2 and 8.6 for the useful space are met.

4.3 Reservoir with supply pipe

The reservoir for the test solution to be sprayed shall be designed to ensure that the suction head remains virtually constant throughout the test.

4.4 Compressed air supply pipe and air humidifier

The air humidifier shall be designed to ensure that the compressed air is saturated with water at the required temperature (see table 2) throughout the test. The compressed air pipe between the humidifier and the nozzle shall be fitted with a pressure gauge for monitoring the air pressure at the nozzle.

4.5 Devices for supporting the specimen

Racks shall be used that allow the specimens (specimen panels and product parts) to be arranged in the useful space of the spray cabinet so as not to touch one another, thus precluding contact corrosion. The specimens shall be arranged in such a way that drops accumulated on one specimen cannot fall on another.

Specimen panels shall be inclined by about 60° to 75° from the horizontal. The side to be tested shall be the side exposed to the spray. Product parts shall be mounted or suspended in the apparatus as a function of their size, shape and/or the corrosion to which they are exposed in service. This position may be agreed. Care shall be taken to ensure that as little salt solution as possible can collect in any cavities.

5 Test solutions

The water to be used for preparing the test solutions as specified in subclauses 5.1, 5.2 and 5.3 shall be distilled or deionized, the electrical conductivity of the water not exceeding 2 mS/m at a temperature of $(23 \pm 2)^\circ\text{C}$. The sodium chloride used for making up the test solution shall contain no more than 0,3% of additives, the content of sodium iodide shall not exceed 0,1% and the total contents of copper and nickel shall not exceed 0,001%. In the case of NaCl, these requirements are met if it conforms to *DAB 9* (German Pharmacopoeia). If grades of sodium chloride which do not conform to *DAB 9* are used, it may be necessary to filter the finished solution.

5.1 Test solution for SS test

The pH value of the sodium chloride solution shall be adjusted so that the solution collected has a pH value of 6,5 to 7,2, measured at $(23 \pm 2)^\circ\text{C}$. Dilute, chemically pure hydrochloric acid or chemically pure sodium hydroxide solution shall be used for pH adjustment. The pH value shall be determined electrometrically at $(23 \pm 2)^\circ\text{C}$ using a glass electrode (see also Explanatory notes).

The solution collected shall have a concentration by mass of (50 ± 5) g of sodium chloride per litre.

5.2 Test solution for ASS test

The pH value of the sodium chloride solution shall be adjusted using acetic acid complying with the purity requirements specified in *DAB 9* so that both the solution to be sprayed and the solution collected have a pH value of 3,1 to 3,3 at $(23 \pm 2)^\circ\text{C}$, 1 to 3 g of acetic acid per litre being required for this purpose. The pH value shall be measured electrometrically using a glass electrode.

The solution collected shall have a concentration by mass of (50 ± 5) g of sodium chloride per litre.

5.3 Test solution for CASS test

First, $(0,26 \pm 0,02)$ g of analytical grade copper (II) chloride, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, shall be added per litre to the sodium chloride solution. Then, the pH value shall be adjusted using acetic acid as in subclause 5.2 so that both the solution to be sprayed and the solution collected have a pH value of 3,1 to 3,3 at $(23 \pm 2)^\circ\text{C}$. The pH value shall be measured electrometrically using a glass electrode.

The solution collected shall have a concentration by mass of (50 ± 5) g of sodium chloride per litre.

6 Compressed air

The compressed air used for producing the spray at a gauge pressure of about 0,7 to 1,4 bar shall be free from dirt, oil and other contaminants, these being removed by means of oil and liquid separators and a ceramic pressure filter. The residual contamination of the compressed air after cleaning shall be no more than $0,2 \text{ mg/m}^3$, in the form of oil and dust (of less than $5 \mu\text{m}$ particle size).

The clean compressed air shall then be saturated in an air humidifier filled with deionized water at a temperature selected to give a temperature after expansion of $(35 \pm 2)^\circ\text{C}$ in the case of the SS and ASS tests and a

temperature of $(50 \pm 2)^\circ\text{C}$ in the case of the CASS test (see Explanatory notes).

Note. Saturation of the compressed air with water is necessary to prevent an increase in the concentration by mass of sodium chloride in the spray solution during expansion.

7 Procedure

7.1 Test temperature

The temperature in the useful space of the closed spray cabinet shall be $(35 \pm 2)^\circ\text{C}$ during the SS and ASS tests, but $(50 \pm 2)^\circ\text{C}$ during the CASS test, a brief drop in temperature when the cabinet is opened being permitted (see subclause 7.3).

Note. The variation in temperature over time should be registered by a temperature recorder.

7.2 Quantity and distribution of the spray

The quantity of test solution, as specified in subclauses 5.1, 5.2 and 5.3, to be sprayed per unit of time in the spray cabinet shall be adjusted so that the average rate of sprayed solution collected in each of the collector vessels provided in the cabinet, assuming for each device a horizontal collecting area of about 80 cm^2 and a minimum collection period of 16 h, is $(1,5 \pm 0,5)\text{ ml}$ per hour. For tests taking less than 16 h, the minimum period for determining the average shall be 8 h.

When the nozzle described in subclause 4.2 is used, it has proved expedient to set the test solution spraying rate, given a predetermined, constant pressure and a constant head, solely by means of the metering and control device.

To check that the spray is uniformly dispersed, at least two collector vessels shall be provided at representative points in the useful space.

Suitable as collector vessels are, for example, glass or plastic funnels 10 cm in diameter (equivalent to a collecting area of $78,5\text{ cm}^2$), which are passed through a stopper into a glass or plastic measuring cylinder.

On no account shall drops that have formed on the top cover and walls of the spray cabinet, on any baffles provided, on the racks or on the specimens fall into a collector vessel.

7.3 Test interruptions

Spray tests shall be interrupted and the spray cabinet opened only briefly to enable specimens to be removed and introduced and to carry out interim assessments.

8 Functional check on test apparatus

To check the repeatability of the test results obtained with a test apparatus, or the reproducibility of test results from different test apparatuses, functional checks are to be made.

The functional check described in this clause applies to the SS test. Functional checks for the ASS and CASS tests may be made analogously. The type of specimens, duration of tests and the permissible losses in mass per unit area shall be agreed accordingly.

8.1 Specimens

Five specimens are required, each measuring 50 mm in width, 100 mm in length and 0,6 to 1,5 mm in thickness and made of St 14 05 as specified in DIN 1623 Part 1 (bright).

8.2 Preparation of specimens

Prior to the functional check, the specimens as specified in subclause 8.1 shall be degreased with white spirit or another suitable solvent using a soft, non-fibrous cloth or a brush and subsequently weighed to the nearest $\pm 0,1\text{ mg}$. If they cannot be weighed immediately after degreasing, the specimens shall be kept in a desiccator until weighing. After weighing, the specimens shall be coated on one side with a strippable protection (e.g. self-adhesive films or strippable varnishes).

8.3 Exposure

The specimens shall be set up on edge, inclined at an angle of 60° to 75° to the horizontal, in the test apparatus with the test surface upwards and exposed for 96 h under the conditions specified for the SS test.

8.4 Removal of corrosion products

Before the corrosion products are removed, the coatings applied before exposure shall be stripped off. The corrosion products shall be removed from the specimens by pickling at a temperature of 18°C to 28°C . A hydrochloric acid inhibited with 3,5 g of hexamethylene-tetramine per litre, with $\rho = 1,10\text{ g/ml}$, may be used for this purpose, e.g. 500 ml of HCl, with $\rho = 1,19\text{ g/ml}$, chemically pure, made up to 1 litre with deionized water. Solutions as specified in ISO/DIS 8407 — 1987 may also be used.

After the removal of corrosion products, the specimens shall be thoroughly rinsed in water, dried and subsequently kept until weighing in a desiccator at temperatures of 18°C to 28°C .

8.5 Weighing of specimens

The specimens shall be weighed to the nearest $\pm 1\text{ mg}$.

8.6 Evaluation of functional check results

The loss in mass shall be related to the surface area exposed to corrosion and expressed in g/m^2 . The average loss shall be $(140 \pm 20)\text{ g/m}^2$.

9 Test report

The test report shall include a reference to this standard and provide the following information:

- type and marking of the specimens;
- symbol denoting type of test;
- duration of test;
- any interruption of test;
- spray cabinet capacity;
- any deviations from this standard;
- date of test.

Standards and other documents referred to

DIN 1623 Part 1	Steel flat products; cold rolled sheet and strip; technical delivery conditions; mild unalloyed steels for cold forming
DIN 50 900 Part 1	Corrosion of metals; terminology; general concepts
DIN 50 900 Part 2	Corrosion of metals; terminology; electrochemical concepts
DIN 50 900 Part 3	Corrosion of metals; terminology; concepts associated with corrosion testing
ISO/DIS 8407 — 1987 *)	Metals and alloys; procedures for removal of corrosion products from corrosion test specimens
<i>Deutsches Arzneibuch 9 (DAB 9), 1986 edition</i>	

Other relevant standards and documents

DIN 50 942	Phosphating of metals; process principles, methods of test
DIN 53 167	Paints, varnishes and similar coating materials; salt spray testing of coatings
ISO 1456 — 1974 *)	Metallic coatings; electroplated coatings of nickel plus chromium
ASTM B 117-85 *)	Standard methods of salt spray testing
ASTM B 287-74 (1980) *)	Method of acetic acid-salt spray (fog) testing
ASTM B 368-85 *)	Method of copper accelerated acetic acid-salt spray (fog) testing

Previous editions

DIN 50 021: 04.70, 05.75.

Amendments

The following amendments have been made to the May 1975 edition.

- The content has been brought into line with the state of the art.
- A functional check of the test apparatus is now specified.

Explanatory notes

This standard has been drawn up by the ad hoc Working Group *Salzsprühnebelprüfung* of Technical Committee *NMP 171 Korrosion und Korrosionsschutz* of the *Normenausschuß Materialprüfung*.

The SS test specified in clause 3 conforms in some respects to ASTM Standard B 117-85, viz. as regards the test apparatus, the test agent and the conditions during spray testing. Unlike the ASTM Standard, however, no details have been given here on the preparation of specimens, the treatment of specimens after testing to identify any corrosion spots, or on evaluation. These are to be specified in the relevant test standards for the various materials, or are to be the subject of special agreement. With regard to the degree of purity of the sodium chloride required for making up the test solutions, ASTM B 117 specifies that only sodium chloride which is substantially free of nickel and copper and contains no more than 0,1 % of sodium iodide, with a total impurities content not exceeding 0,3 %, shall be used for this purpose. Furthermore, it specifies that sodium chloride from some sources may contain corrosion-inhibiting additives which preclude its being used for preparing test solutions.

For this reason, ASTM B 117 states that upon agreement between the contracting parties analysis may be required and limits established for elements or compounds in the sodium chloride not specified in the standard, but does not indicate the methods to be used for checking the inhibiting effect or demonstrating analytically the presence of such additives.

Conversely, it must be said that so far no instances have been observed where sodium chloride of a purity conforming to *DAB 9*, which is often used for making up the spray solutions, has contained an undue amount of corrosion-inhibiting additives, and no cases have been reported where such a product has not complied with the requirements of ASTM B 117 with respect to substantial freedom from copper and nickel and the presence of less than 0,1 % of sodium iodide.

For reasons of costs, many testing laboratories, particularly those using large-scale equipment, often use other, cheaper grades of salt for salt spray tests than those hitherto specified in this standard. Results from tests conducted by a number of laboratories show that the loss in mass specified in subclause 8.6 can also be achieved with such salts. Therefore, clause 5 has been expanded accordingly.

DIN 53 167, in which the same test apparatus and test conditions as for the SS test are specified, applies for the salt spray testing of varnishes and similar coatings, whilst DIN 50 942 applies to the salt spray testing of phosphate layers.

The SS test is substantially equivalent to the corresponding test described in ISO 3768 — 1976, Metallic coatings; neutral salt spray test (NSS test), the ASS test is substantially equivalent to ASTM B 287 and the corresponding test described in ISO 1456 — 1974, and the CASS test specified in clause 3, to ASTM B 368 and the corresponding test described in ISO 1456 — 1974.

The copper-accelerated acetic acid salt spray (fog) test has been included in the German standard because it has been widely introduced internationally.

*) Obtainable from *Beuth Verlag GmbH, (Auslandsnormenvermittlung), Burggrafenstraße 6, D-1000 Berlin 30.*

The following notes refer to individual aspects of the tests.

Re clause 1

It is extremely difficult to define for which fields of application the different methods of test are best suited. Therefore, clause 1 deliberately does not specify separate fields of application, but requires the parties concerned to agree on the method or methods to be used in each case.

It should, however, be pointed out here that the SS test covers a far wider field of application than the other two methods dealt with in this standard. This test is mainly used for testing metallic materials, as well as metallic and non-metallic inorganic coatings on metals, and is also employed for the investigation of coating systems. On the other hand, the ASS and CASS tests are generally only used for testing metallic coatings and not for testing organic coatings.

Re subclause 4.1

The minimum capacity of the spray cabinet of 400 l corresponds to that specified in ASTM B 117. This has been kept to in this standard although apparatuses having smaller spray cabinets are still in use in Germany. After detailed discussion of the suitability of smaller cabinets, the working group responsible nevertheless came to the conclusion that when such smaller apparatuses are used, reproducibility of test results cannot be ensured. The reproducibility of results is, however, to be ensured by the specifications in a test standard, wherever that is possible and economically reasonable. The type and dimensions of the spray cabinets shall be chosen so as to ensure that, assuming the optimum configuration of the useful space, the conditions specified in clauses 7 and 8 are met.

Re subclause 4.2

Where multi-component spray nozzles are used, it has proved expedient to set the nozzles to maximum suction throughput at an air pressure of 1 bar, and to mark and fix them in this position before installation. This facilitates resetting of the movable nozzle shroud to maximum suction power when the nozzles have to be removed and dismantled for cleaning.

Re subclause 5.1

Where water containing CO_2 is used for the preparation of sodium chloride solutions, it must be borne in mind when adjusting the pH that CO_2 escapes if the solution is sprayed at a temperature of 35°C , so that the collected solution has a higher pH than the solution before spraying. For this reason, sodium chloride solution prepared with water containing CO_2 shall be adjusted to a pH of less than 6,5 at a temperature of $(23 \pm 2)^\circ\text{C}$ to ensure that the collected solution has a pH value of 6,5 to 7,2. To verify correct adjustment of the pH value of the solution before spraying, take 50 ml, boil gently for

about 30 s, and cool to a temperature of $(23 \pm 2)^\circ\text{C}$. Then measure the pH value immediately. If it is between 6,5 and 7,2, experience shows that the pH value of the collected solution will also be in this range.

Re clause 6

When it emerges from the spray nozzle, the compressed air is decompressed to the ambient atmospheric pressure and cools in the process. In order to ensure a temperature of the spray jet of 35°C to 50°C , the compressed air saturated with water shall be at a higher temperature. Table 2 gives empirical values for the temperature which the compressed air saturated with water (i.e. the air humidifier temperature) must have, as a function of the pressure, for its temperature after decompression to be around 35°C (for the SS and ASS tests) and 50°C (for the CASS test).

Table 2. Empirical air humidifier temperature values

Compressed air pressure, in bar	Air humidifier temperature, in $^\circ\text{C}$, to give a temperature after decompression of	
	35°C	50°C
\approx	SS test and ASS test	CASS test
0,7	45	—
0,84	46	61
0,98	47	65
1,12	48	70
1,26	49	74
1,4	50	—

Re clause 8

The functional check introduced in this standard provides a further possibility, in addition to the checks specified in clause 7, of ensuring correct operation of the test apparatus while maintaining the values given in table 1, and of comparing various test apparatuses with one another in this respect.

If the desired value for the losses in mass per unit area on the bare specimens of $(140 \pm 20) \text{ g/m}^2$ is not met or is exceeded, most apparatuses can be adjusted as follows. Adjust the angle of impact and/or the distance from the nozzle to the wall or the baffle, fit metering pumps for each nozzle and/or alter the counterpressure in the apparatus by reducing the venting cross sections.

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