INTERNATIONAL STANDARD

ISO 10289

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Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests

Méthodes d'essai de corrosion des revêtements métalliques et inorganiques sur substrats métalliques — Cotation des éprouvettes et des articles manufacturés soumis aux essais de corrosion

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10289 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 7, *Corrosion tests*.

This first edition cancels and replaces ISO 1462:1973, ISO 4540:1980 and ISO 8403:1991.

Annexes A and B of this International Standard are for information only.

Introduction

The rating method described in this International Standard recognizes that decorative and protective metallic and inorganic coatings on metallic substrates can be either anodic or cathodic to the substrate. In rating these coatings for the effects of corrosion, two evaluations shall be made:

— the ability of the coating to protect the substrate from corrosion and thus prevent degradation of the base metal;

— the ability of the coating to retain its integrity and thus maintain a satisfactory appearance.

Although these functions overlap, they can be evaluated separately in terms of:

— a protection rating (R_p) relating to the corrosion of the base metal;

— an appearance rating (R_A) relating to the deterioration of the coating.

The protection rating (R_p) assigns a number representing the ability of the coating to protect the base metal from corrosion.

The appearance rating (R_A) assigns a sequence of letters and numbers to the overall appearance of the specimen which includes all deterioration caused by the corrosion test or environment.

NOTE 1 Imperfections on a panel or article before exposure testing should be noted and given due consideration when evaluating the results of the examination. Deliberate imperfections may also be introduced as part of a test programme.

The coating system has to be known and reported if this rating system is applied. It is especially important to know, if possible, whether the coating is anodic or cathodic to the base metal.

NOTE 2 Determination of the anodic and cathodic corrosive mechanisms can be extremely difficult in some cases (chromated zinc on steel or multiple coatings). For the purposes of this document knowledge of these mechanisms is not necessary.

Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests

1 Scope

This International Standard gives a method of evaluating the condition of decorative and protective metallic and inorganic coated panels or articles which have been exposed to corrosive environments for test or for other purposes.

It is applicable to test panels or components exposed to natural atmospheres, in mobile or static conditions, or subjected to accelerated tests.

NOTE 1 Examples of such tests are given in the Bibliography.

This International Standard recognizes that the protection rating can be assessed objectively in accordance with clause 6. However, the assessment of appearance depends on many subjective factors (see 6.2).

NOTE 2 The edges of test panels or components may be protected, e.g. by tape or wax (paraffin), if this is an agreed part of the test and is recorded in the test report. This is essential if the specimens are cut from larger pieces and have exposed uncoated edges.

2 Terms and definitions

2.1
protection rating
R_p
rating number (see Table 1) assigned to the ability of the coating to protect the base metal from corrosion

2.2
protection defect
defect used to assess the protection rating, including crater corrosion, pin-hole corrosion, corrosion stain due to corrosion from the substrate, blisters and other defects that involve base metal corrosion

NOTE Blisters on electroplated aluminium and zinc alloy die castings usually signify base metal corrosion, but the inspector's judgement may be required to decide whether a blister does or does not arise at the substrate–coating interface.

2.3
appearance rating
R_A
rating number and symbols (see Table 2) assigned to describe the overall appearance of the specimen, including all defects caused by exposure

2.4
appearance defect
defect that detracts from the appearance of the specimen (see Table 2)

2.5
performance rating
combination of the protection rating number (R_p) followed by a slash mark followed by the appearance rating number (R_A), i.e. R_p/R_A

2.6
coating system
particular series of deposits including the thickness and type of layers in multilayer deposits and treatments which have been applied to the base metal

2.7
significant surface
part of the surface which is essential in the appearance or serviceability of the article and which is to be covered or is covered by the coating (see clause 5)

3 Principle

This International Standard establishes a rating system for evaluating the deterioration of the coating and the base metal due to corrosion. The rating method described in this International Standard is applied to evaluate the appearance of the coating, as well the extent of the corrosion on test panels or the significant surfaces of components which have been subjected to performance tests.

The result of inspecting a surface, called the performance rating, is recorded as two separate ratings, the protection rating (R_p) and the appearance rating (R_A).

When recording the rating of a surface, the type(s) and severity of defect(s) contributing to the rating shall be noted if this information is required. This information is recorded using agreed symbols for the defects and the extent of these defects.

When only the protection rating (R_p) is required, it is permitted to omit the appearance rating (R_A). However, in such a case, a written dash should follow the protection rating in order to indicate deliberate omission of the appearance rating.

4 Types of defect

It is possible for defects to affect both the protection rating (R_p) and the appearance rating (R_A). In this rating system, the protection rating is a simple numerical rating while the appearance rating is permitted to include specific defects along with a numerical rating designating the intensity.

A list of defects is given in Table 2. Additions may also be made to the list, as appropriate, when recording specific defects.

Defects include crater corrosion, pin-hole corrosion, general corrosion of the coating, corrosion products, blisters, and any other defect that involves the coating. Some defects, such as blisters, can be associated with the coating, the base metal, the interface between the coating and the base metal, or between layers in the coating.

Other defects can have a small corrosion content but an appreciable affect on the appearance, e.g., staining, tarnishing, cracks, etc.

Defects on the surface of the basis metal such as scratches, porosity, non-conducting inclusions, roll and die marks, cold shuts and cracks can adversely affect the performance of coatings applied thereto, despite the observance of the best finishing practices. Such defects shall be reported and rated separately.

Ensure that the coating system is reported, because the significance of certain defects can be dependent on whether the coating is anodic or cathodic to the base metal.

Note defects that develop on exposure, e.g. peeling or spalling of the coating, since this indicates possible improper preparation of the base metal or improper application of the coating.

5 Method of inspection

Use drawings or suitably marked samples to indicate the significant surface.

It may sometimes be necessary or appropriate to expose material which is defective in certain respects before carrying out environmental testing. In such cases, make an inspection and record the findings before the specimens are tested.

If deliberate damage is applied to a surface, record the damage before the specimens are tested and so reported. If the specimen is purposely deformed, rate the deformed areas separately.

Material may be inspected either on the exposure racks or in a more suitable location. Ensure that lighting during inspection is as uniform as possible; avoid direct reflection from sun or clouds, and use various angles of inspection to ensure that all defects are revealed.

At the conclusion of the test, if the condition of the specimens allows, inspect them in the uncleaned condition. If dirt, salt deposits, etc., mask the defects and create difficulties with inspection, the surface may be sponged with a mild soap solution and then rinsed with water. However, exert no pressure during such cleaning in order to avoid accidentally upgrading the rating by, for example, cleaning off the corrosion products. Cleaning solutions should be compatible with the coatings and not cause any degradation of the coating. In the case of intermediate, periodic inspections do not clean or otherwise disturb the specimens.

Allow surfaces to dry before they are inspected.

Defects to be noted and taken into account when rating surfaces include only those which can be seen by normal or corrected vision.

NOTE 1 Optical aids may be used subsequently to characterize defects, after initial detection.

Edge defects, occurring within 5 mm of the edge of a specimen or tape/wax, may be noted in the report, but should not normally influence the numerical rating. Similarly, disregard contact and rack marks, mounting holes, etc.

NOTE 2 Edge defects may be difficult to assess on deeply worked manufactured specimens, such as threads, bores etc. In these cases it may be necessary to obtain agreement between purchaser and supplier regarding the exact defective area to be reported.

When the coating is anodic to the base metal, white corrosion product developed from the edges of the specimen shall not constitute failure.

Rubbing, polishing, chemical cleaning, etc., of the surface of the specimen may be used to facilitate study of the surface but confine it to the minimum practicable area, preferably not more than 100 mm^2 on a surface of 100 mm $\times$ 150 mm. Note this area for subsequent ratings.

6 Assignment of ratings

6.1 Assignment of protection rating (R_p)

The numerical rating system is based on the area of the substrate that exhibits corrosion, by the following formula:

$$R_p = 3\,(2 - \log A) \qquad (1)$$

where A is the percentage of the total area which shows base metal corrosion. R_p is rounded off to the nearest whole number, leading to the tabulation given in Table 1.

NOTE 1 In some cases, calculating the exact area may be difficult, especially on deeply worked specimens such as thread, bores, etc. In these cases, it may be necessary for the inspector to estimate the area as closely as possible.

Strict application of equation (1) would lead to ratings greater than 10 for specimens with extremely small defective areas. Therefore, equation (1) is only defined for areas where $A > 0{,}046\,416$ %. A rating of 10, accordingly, is arbitrarily assigned to a surface showing no corrosion of the base metal.

If desired, fractional ratings may be assigned between the ratings listed in Table 1.

NOTE 2 When coating systems anodic to the base metal are used, it may be impossible to assess a legitimate protection rating number due to the extreme voluminous corrosion products formed by the coating. Because of the highly absorbable nature of these corrosion products, they would tend to obliterate the true area of substrate corrosion. An example would be a zinc coating on steel exposed in a saline atmosphere. Although this International Standard may be used to rate the performance of zinc on steel, it may be difficult in some environments to define the protection rating.

If the defects are very localized, standards in the form of dot charts or photographs, such as those given in annexes A and B, may be used. Flexible graticules having 1 mm, 2 mm, or 5 mm squares could also be used to assess the corroded area.

If a large group of specimens is being inspected at one time, it is recommended that they be assessed individually by use of equation (1). When the entire group has been rated, the individual ratings should then be reviewed to ensure that each of the ratings assigned actually reflects the extent of the defects relating to those of the other specimens. The review acts as a check on individual ratings and helps to ensure that the inspector's judgement or frame of reference has not changed during the course of the inspection because of such factors as changes in lighting conditions or fatigue.

Inspection is improved by:

a) removing individual items from their racks and grouping then with other specimens for comparison;

b) arranging all of the specimens in order of merit.

Table 1 — Protection (R_p) and appearance (R_A) ratings

Area of defects A (%)	**Rating** R_p or R_A
No defects	10
$0 < A \leqslant 0{,}1$	9
$0{,}1 < A \leqslant 0{,}25$	8
$0{,}25 < A \leqslant 0{,}5$	7
$0{,}5 < A \leqslant 1{,}0$	6
$1{,}0 < A \leqslant 2{,}5$	5
$2{,}5 < A \leqslant 5{,}0$	4
$5{,}0 < A \leqslant 10$	3
$10 < A \leqslant 25$	2
$25 < A \leqslant 50$	1
$50 < A$	0

Examples of assessing the protection rating R_p by this method are:

a) slight rusting over 1 % of the surface 5/–;

b) no visible defects 10/–.

6.2 Assignment of appearance rating (R_A)

The appearance rating is assessed in terms of:

a) the type of defect, as given in Table 2;

b) the area affected by a particular defect using the scale 10 to 0 as described in Table 1;

c) The subjective assessment of the degree of deterioration, e.g.:

vs = very slight amount
s= slight amount
m = moderate amount
x= excessive amount.

Table 2 — Classification of types of coating deterioration

A	Staining and/or colour change due to deterioration of the coating (other than that of obvious base metal corrosion products)
B	Dulling with little or no visible corrosion of coating
C	Corrosion products from anodic coatings
D	Corrosion products from cathodic coatings
E	Surface pitting (corrosion pits probably not extending through to the base metal)
F	Flaking, peeling, spalling
G	Blistering
H	Cracking
I	Crazing
J	Crow's feet or star-shaped defects

Examples of assessing appearance ratings (R_A) by this method are:

a) moderate staining over 20 % of the area: –/2 m A;

b) slight corrosion of coating (anodic) over 1 % of area: –/5 s C;

c) slight dulling over complete area due to very slight (small) surface pits: –/0 s B, vs E.

NOTE The appearance rating (R_A) may include more than one defect, in which case each one shall be reported separately [see example in 6.3 c)].

6.3 Assignment of the performance rating

As stated in 2.5, the performance rating is the combination of the protection rating (R_p) followed by a slash mark, followed by the appearance rating (R_A). Examples of reporting the performance rating are:

a) Specimens showing base metal corrosion over 0,1 % of the total area and the remaining surface of the specimen showing moderate staining over 20 % of the area: 9/2 m A.

b) Specimens showing no base metal corrosion but showing slight corrosion of the anodic coating less than 1,0 % of the area: 10/6 s C.

c) Specimens showing 0,3 % area of base metal corrosion (R_p = 7), also showing corrosion products from an anodic coating covering 0,15 % of total area, and very slight blistering of the top electroplated layer over 0,75 % of the total area (but not extending to the base metal): 7/8 vs C, 6 m G.

7 Test report

Unless otherwise specified, the test report shall contain the following information.

a) the test conditions, e.g. those of an International Standard;

b) the exposure period, known or estimated;

c) the description of the coating system and base metal or the product tested;

d) a report of any difficulty in appraising R_p;

e) the dimensions and shape of the specimen or article tested;

f) the method of preparation of the surface evaluated, including any cleaning treatment applied, any protection given to edges or other special areas and any deliberate damage prior to test;

g) the number of specimens or articles subjected to the test, representing each coating or product;

h) the method, if any, used to clean the test specimen or article after the test but before evaluation;

i) the results of evaluation of protective rating (R_p) as expressed in 6.1 and of appearance rating (R_A) as expressed in 6.2 for each test specimen or article (performance rating, 2.5).

Annex A
(informative)

Dot charts and colour photographs for coatings cathodic to the base metal[1)]

A.1 General

These charts and photographs represent the maximum amount of corrosion of the base metal permissible for a given rating; there is a chart or photograph for each rating from 1 to 9. A specimen worse than the chart or photograph for rating 1 is assigned a rating of 0 unless a fractional rating is assigned between 1 and 0.

A.2 Using dot charts

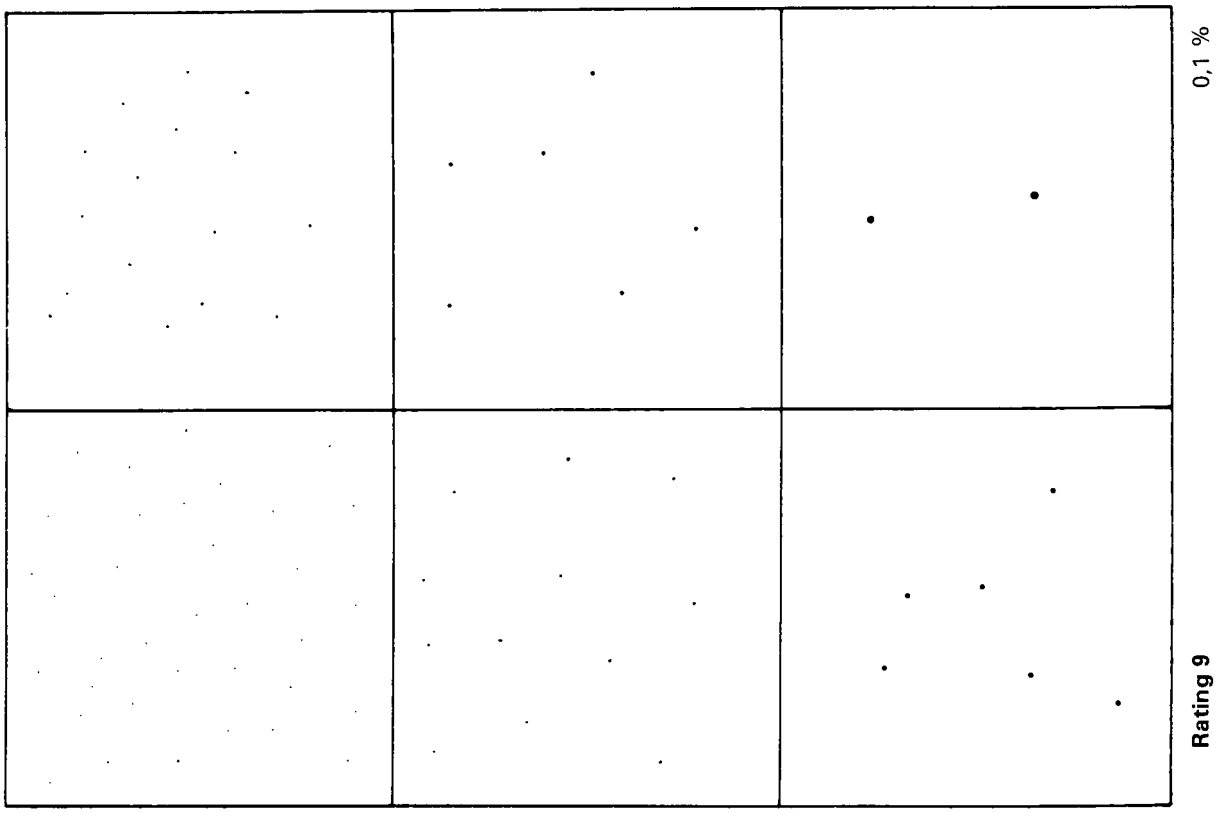
When using the dot charts or photographs, it is recommended that the appropriate charts or photographs be placed alongside the surface to be examined, and defects then matched as nearly as possible with one of the ratings. If the surface to be examined is somewhat better than rating (X), but not as good as rating ($X + 1$), it is rated (X); if the surface is somewhat worse than rating (X) but not as bad as rating ($X - 1$), it is rated ($X - 1$).

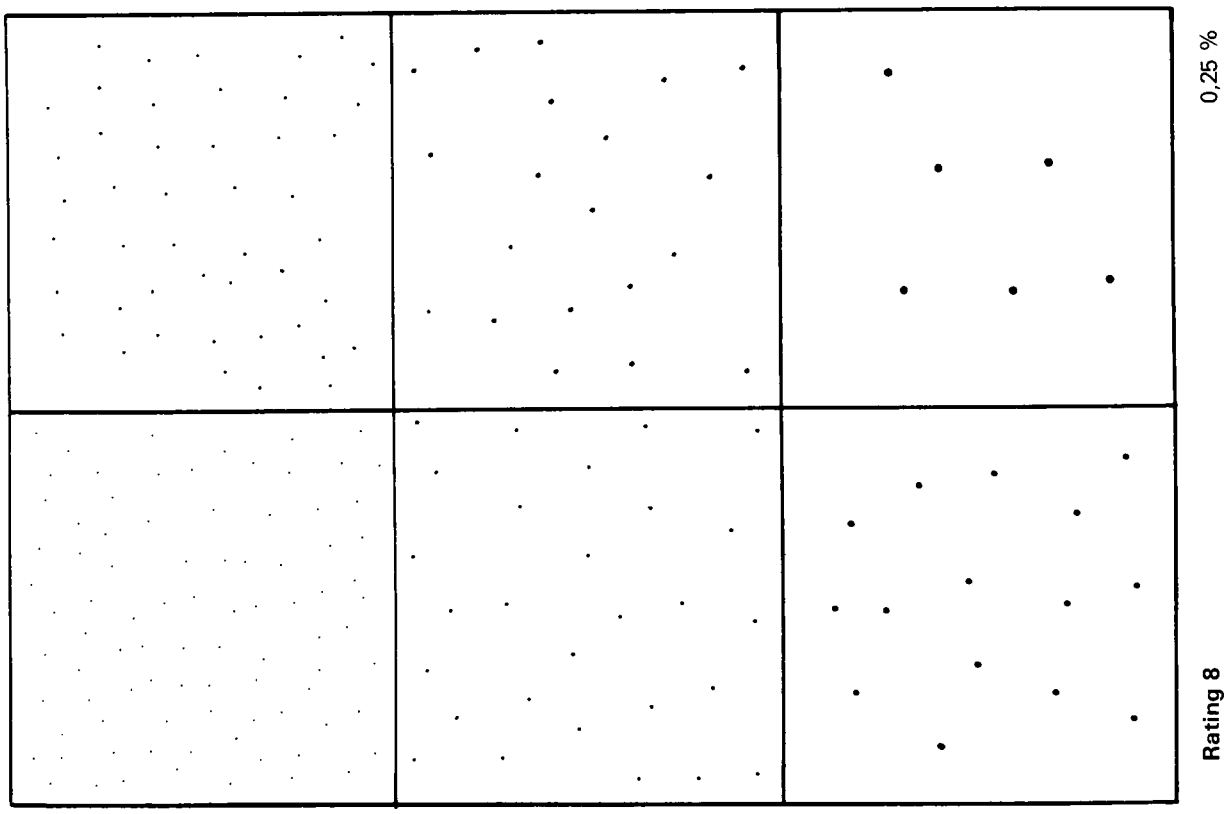
The type of corrosion defects encountered may differ according to the type of atmospheric exposure and to the type of coating under test. Hence, in some cases, the use of dot charts is preferable but, for other applications, colour photographs would be more suitable. However, under certain circumstances, it may be beneficial to assess the affected area by direct measurement.

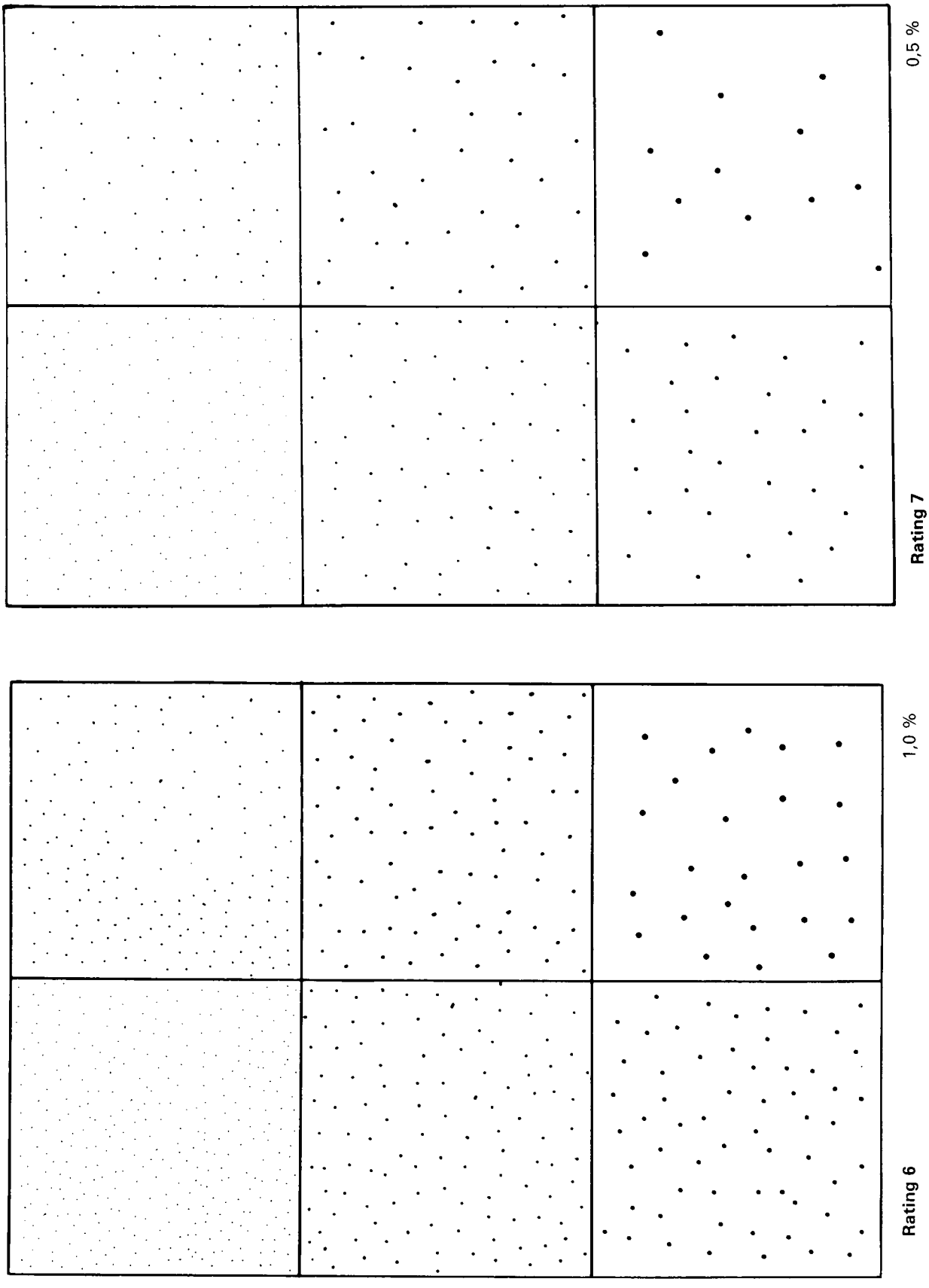
In general, the dot charts are appropriate when assessing the extent of corrosion in industrial atmospheres; photographs are preferable when assessing the extent of corrosion in marine atmospheres.

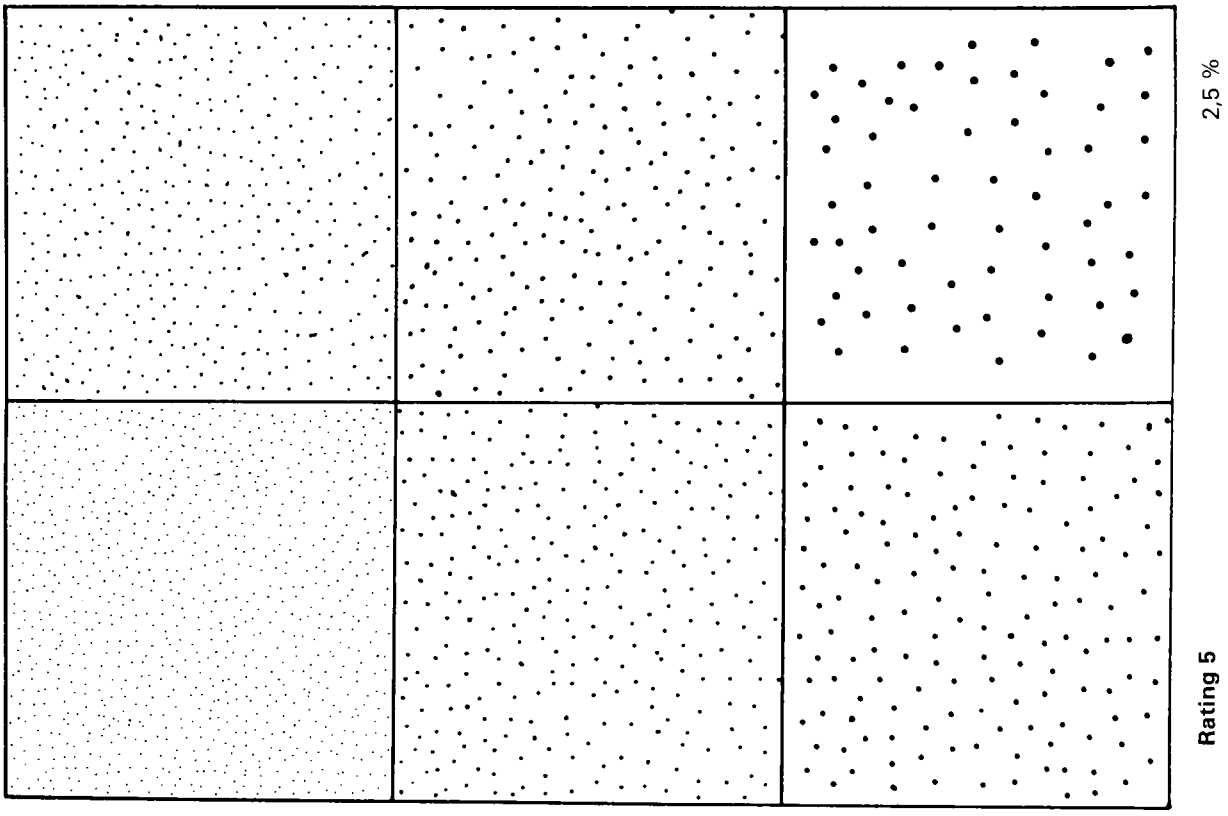
The six squares representing each of the 10 ratings or corroded areas pictorially describes the number of corrosion spots dependent upon their respective sizes.

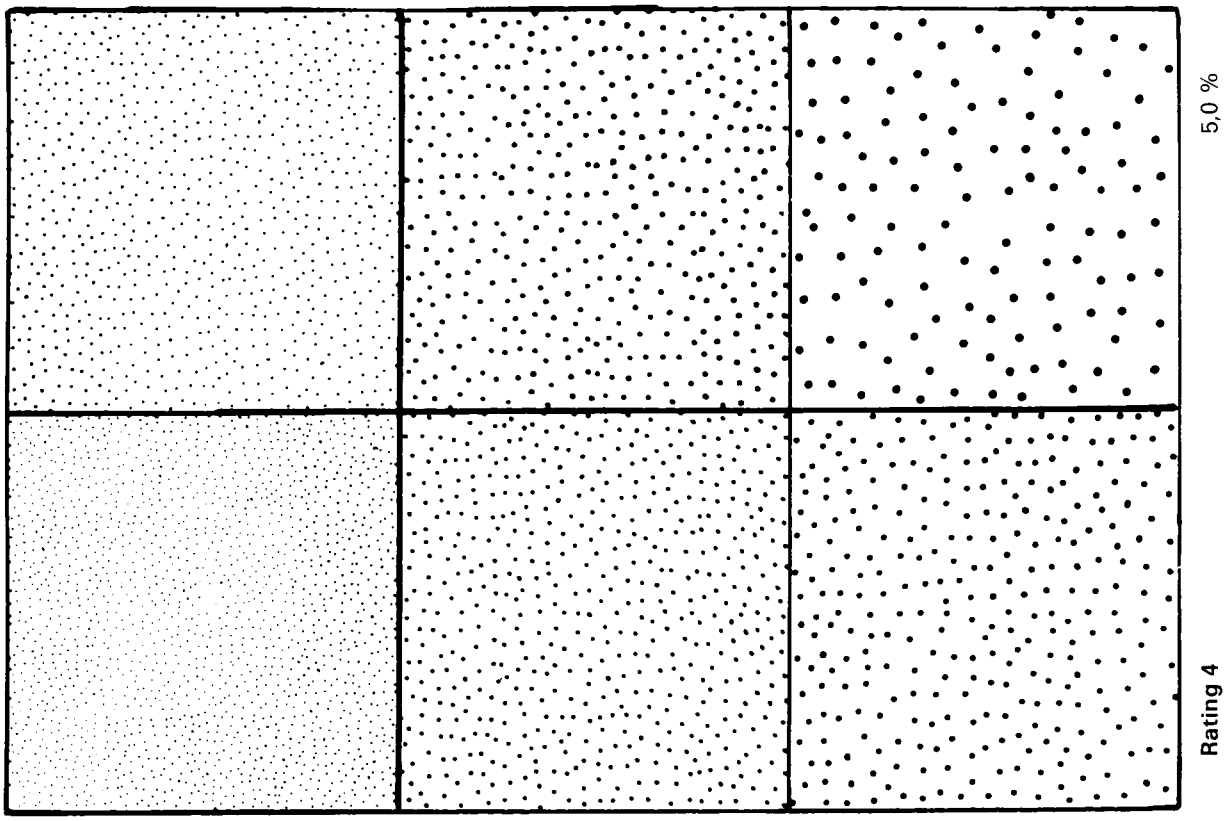
[1)] The dot charts and photographs were supplied by the American society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, Pennysylvania 19428-2951.

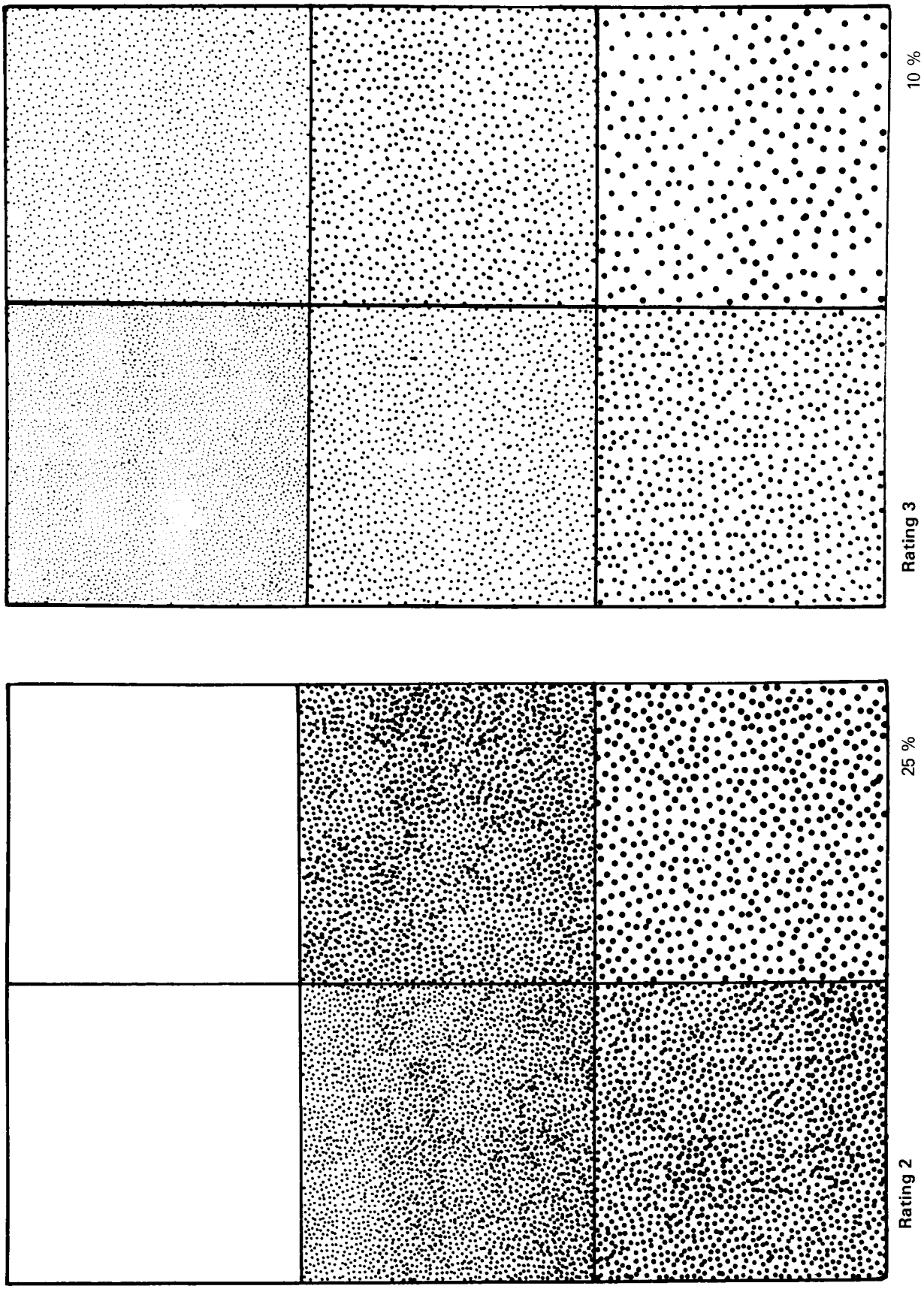


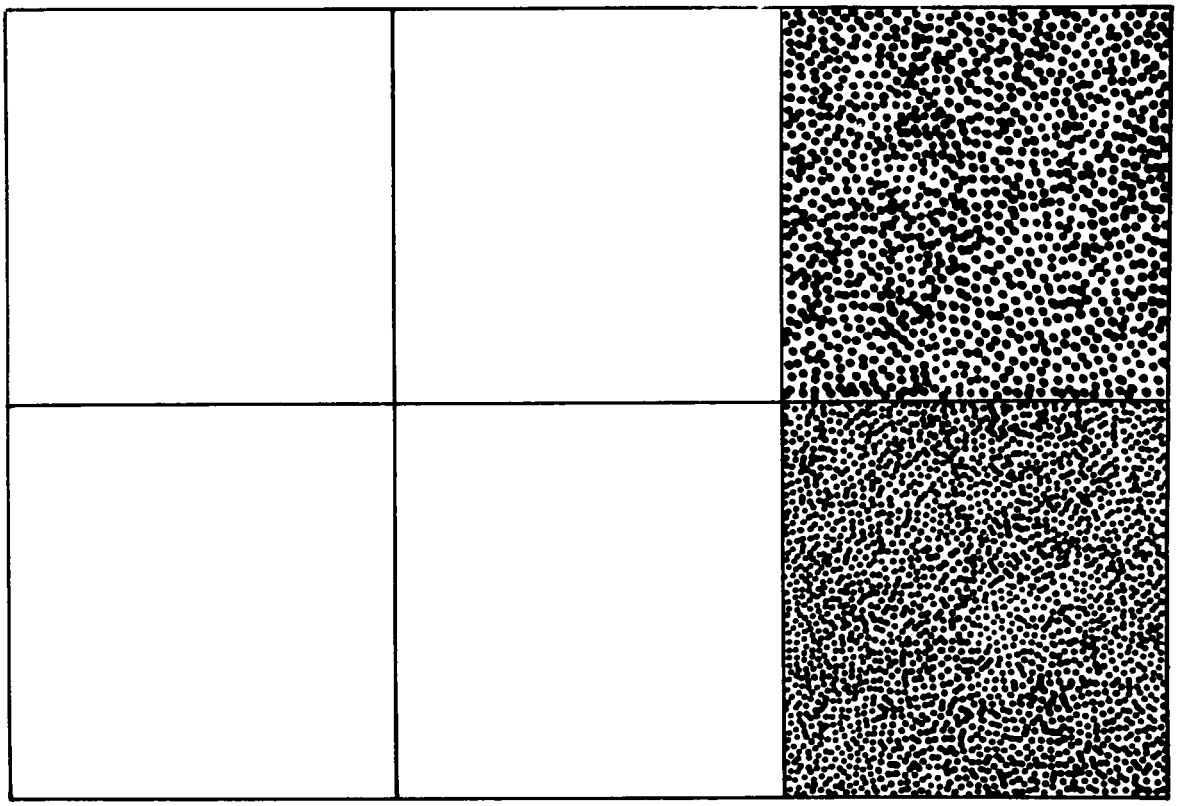






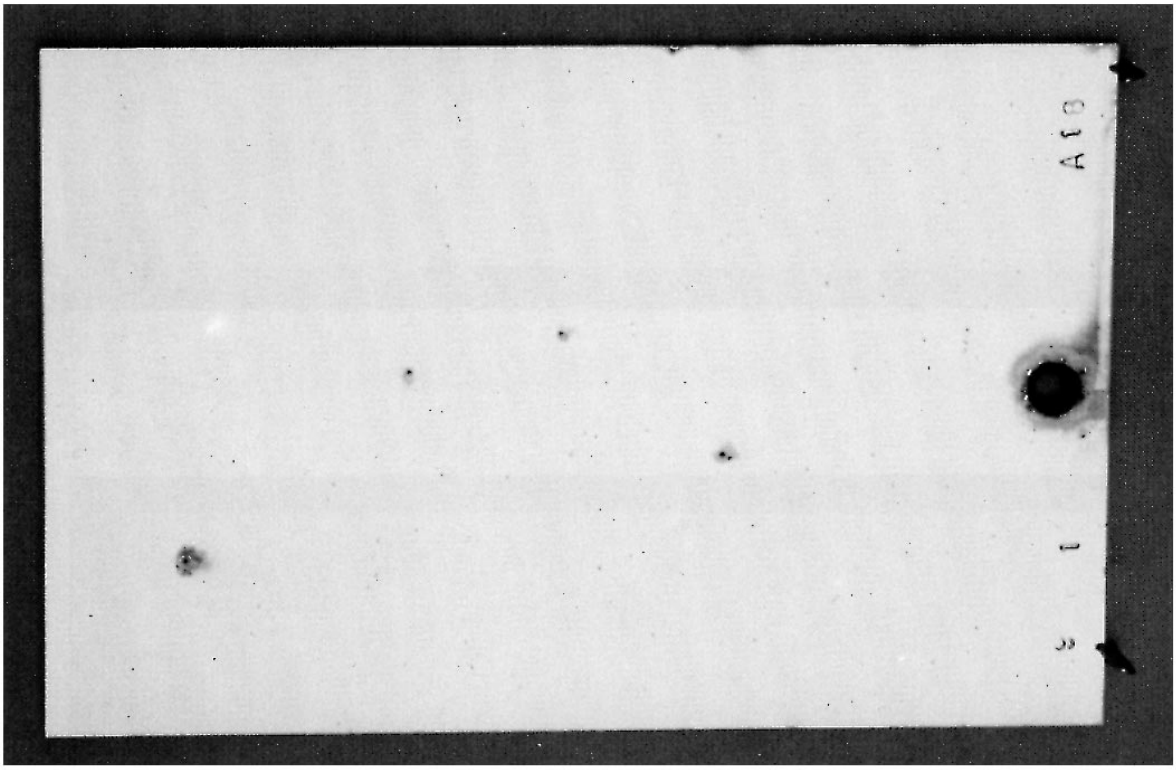




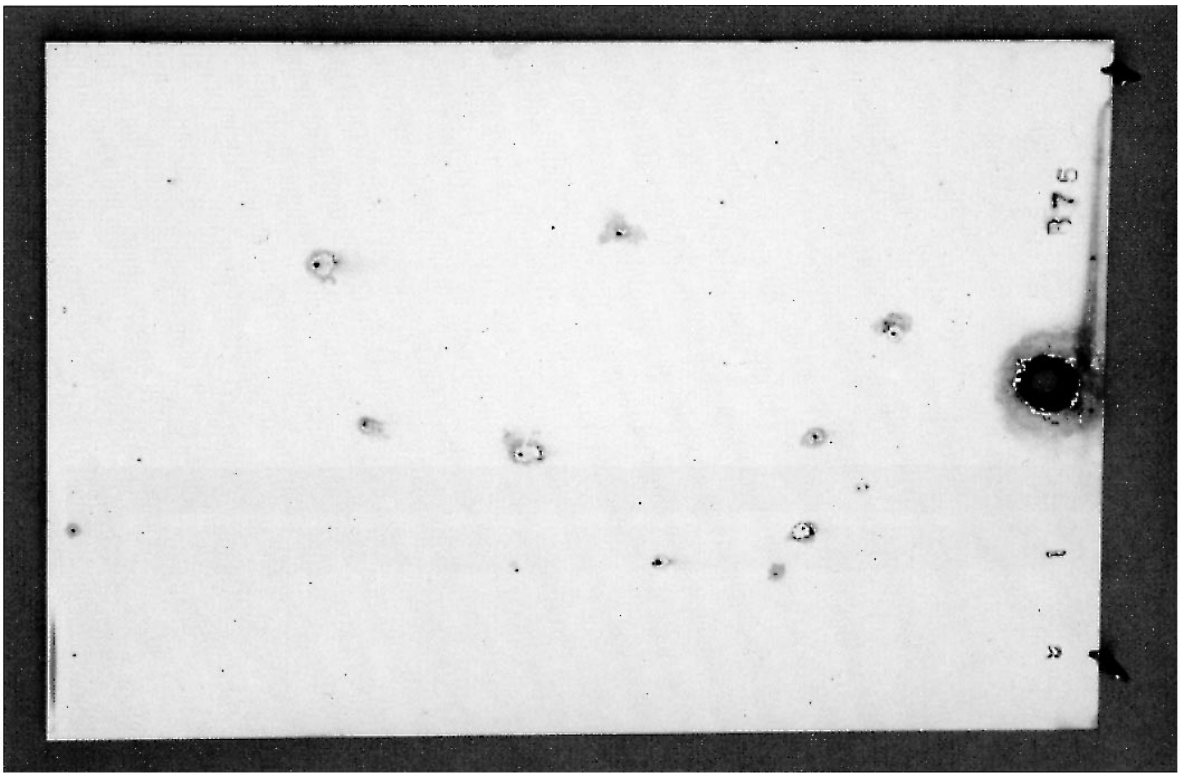


50 %

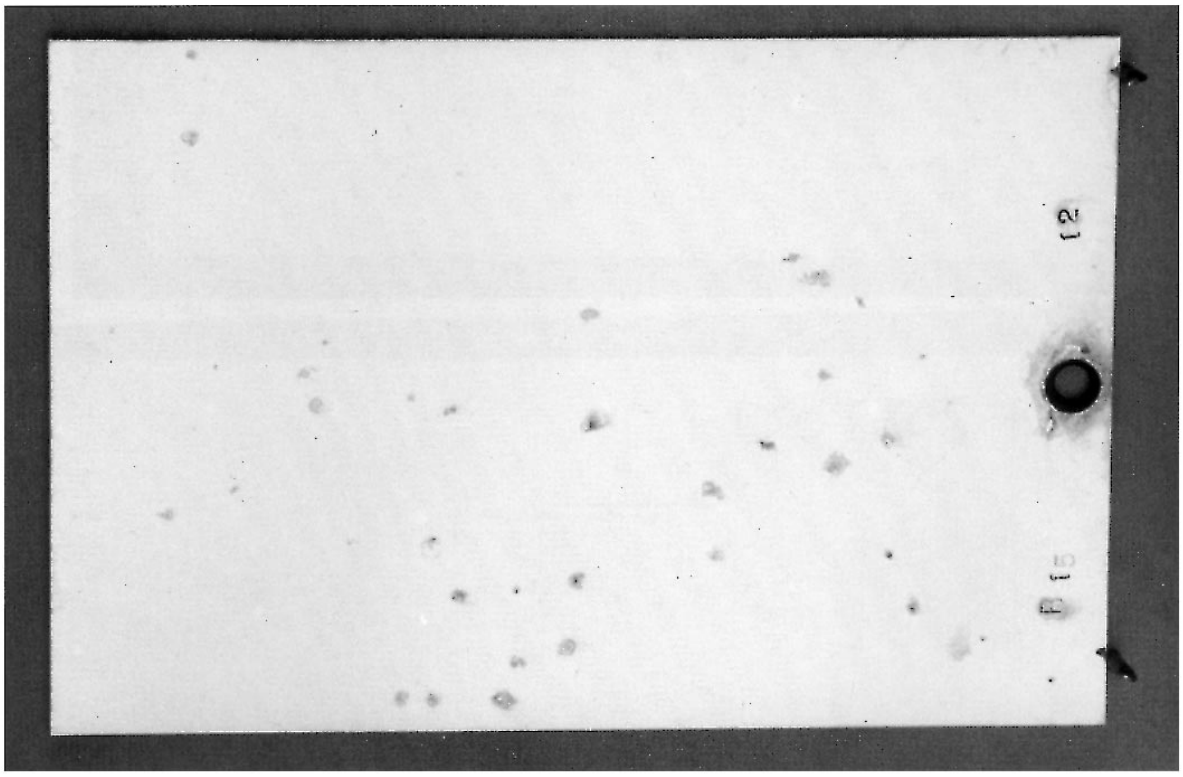
Rating 1



Protection rating 9



Protection rating 8



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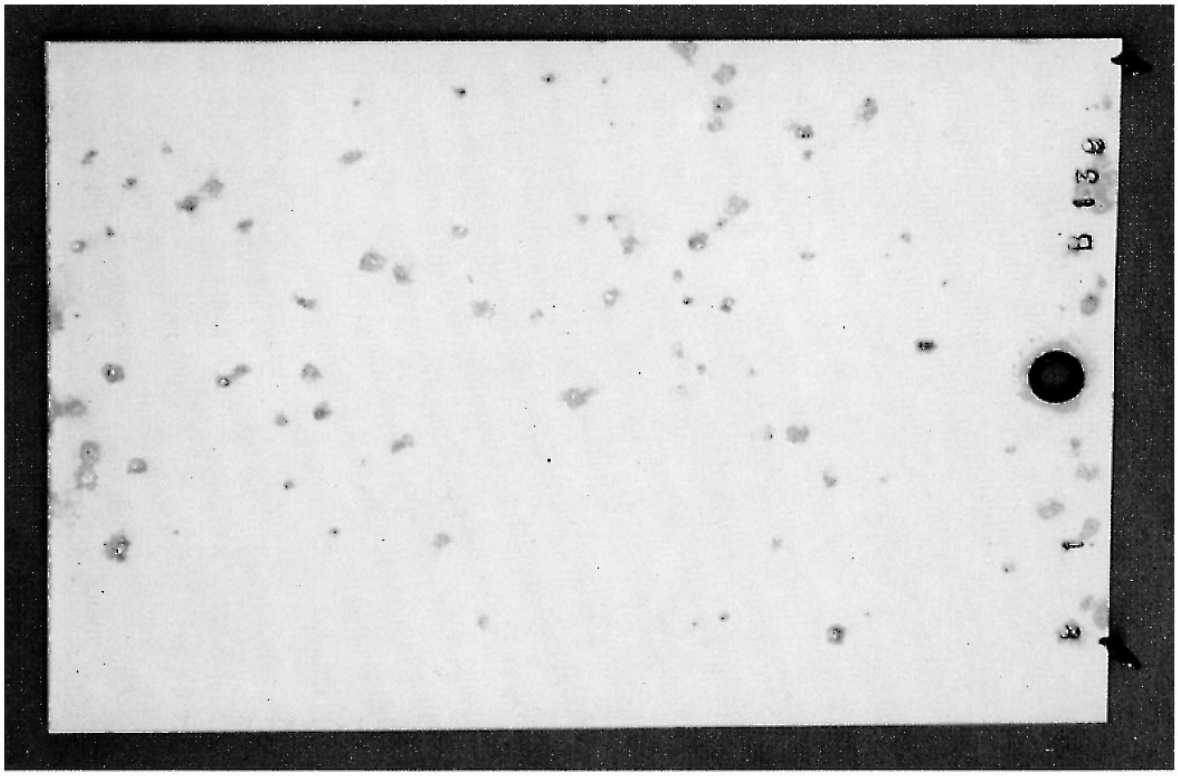
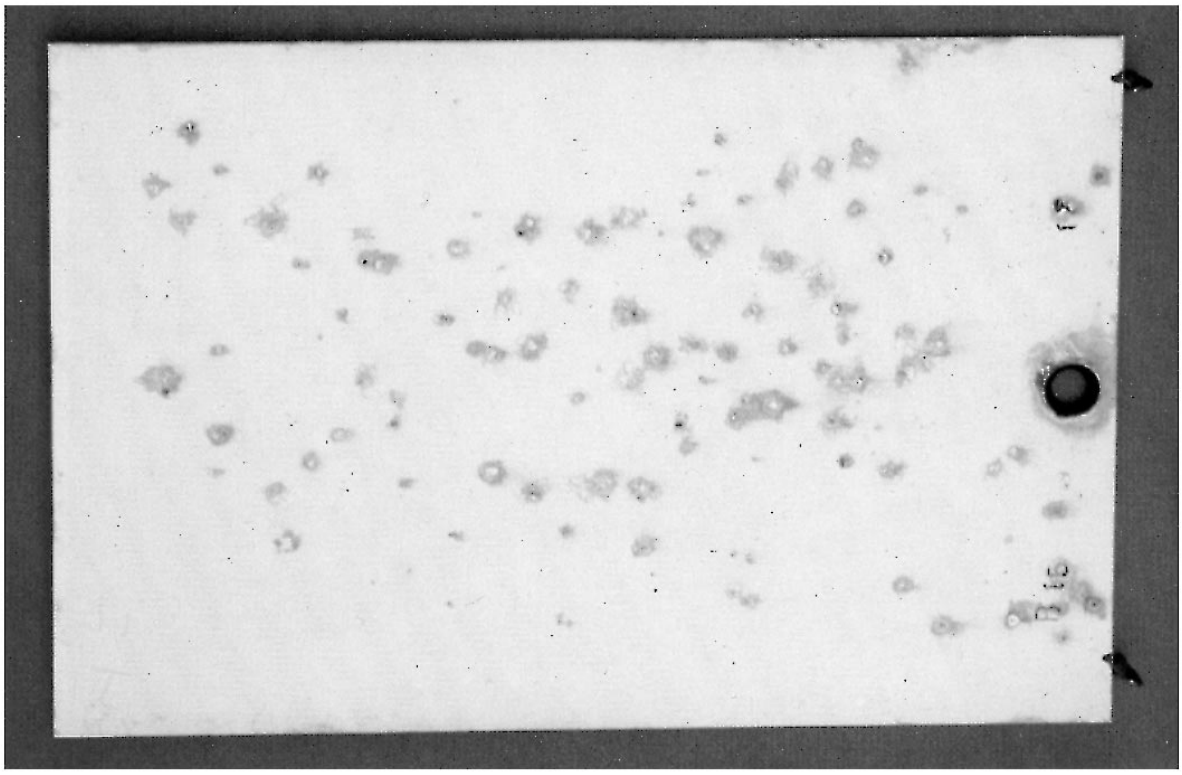
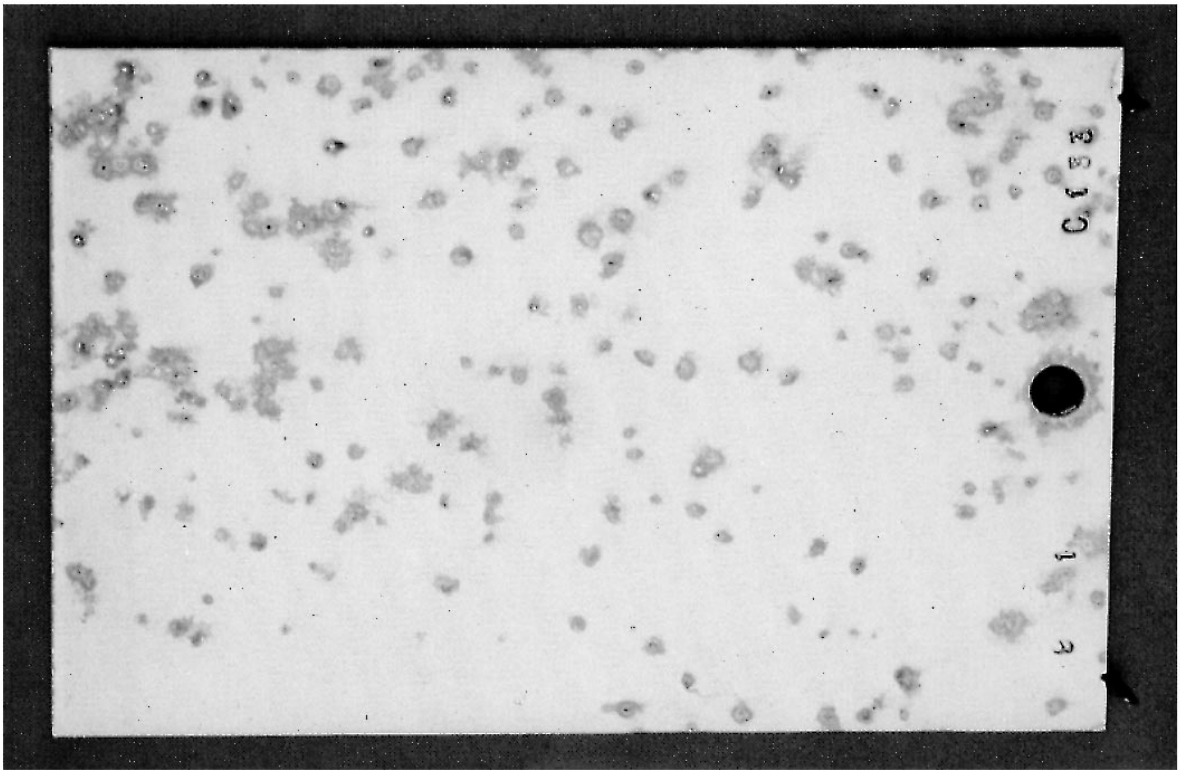


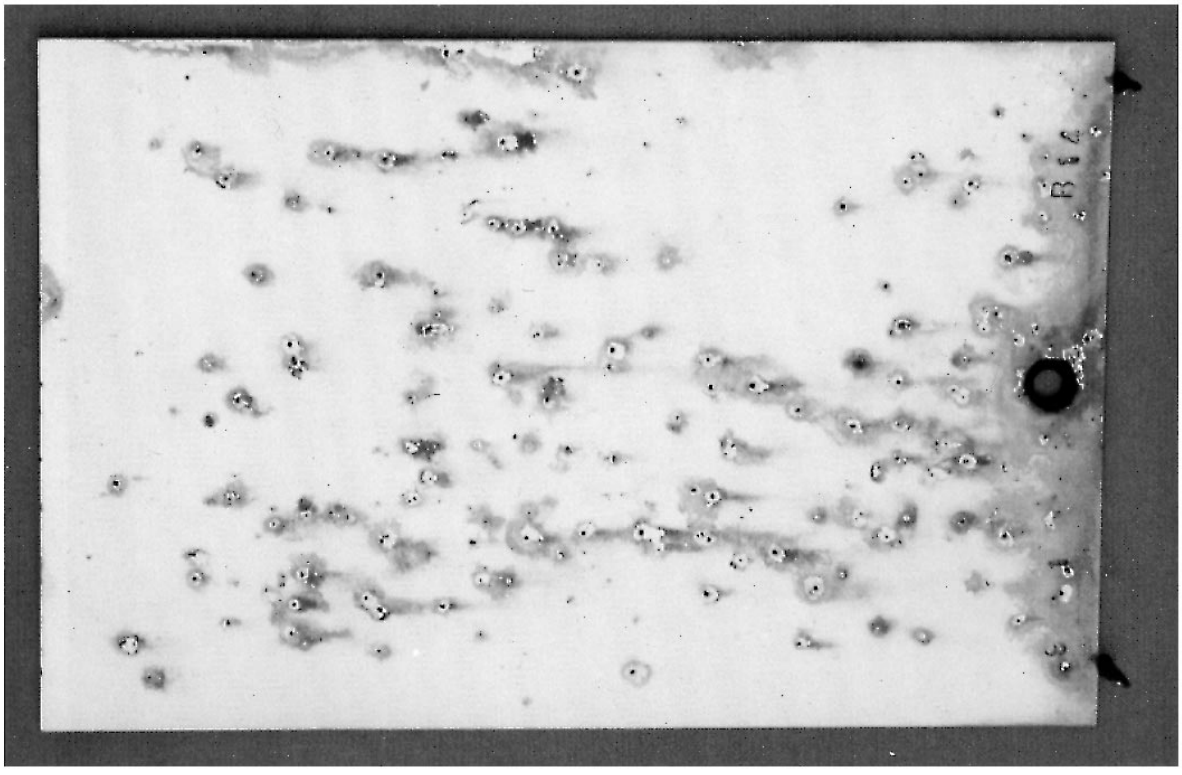
Protection rating 6



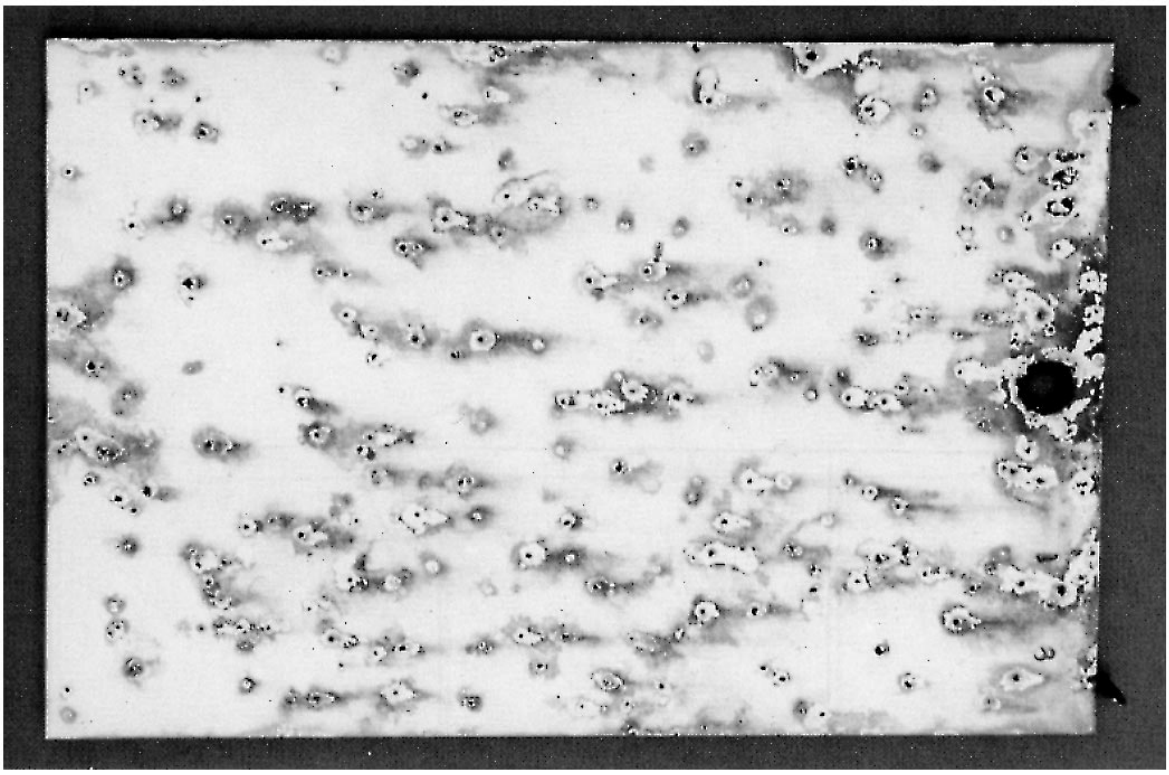
Protection rating 5



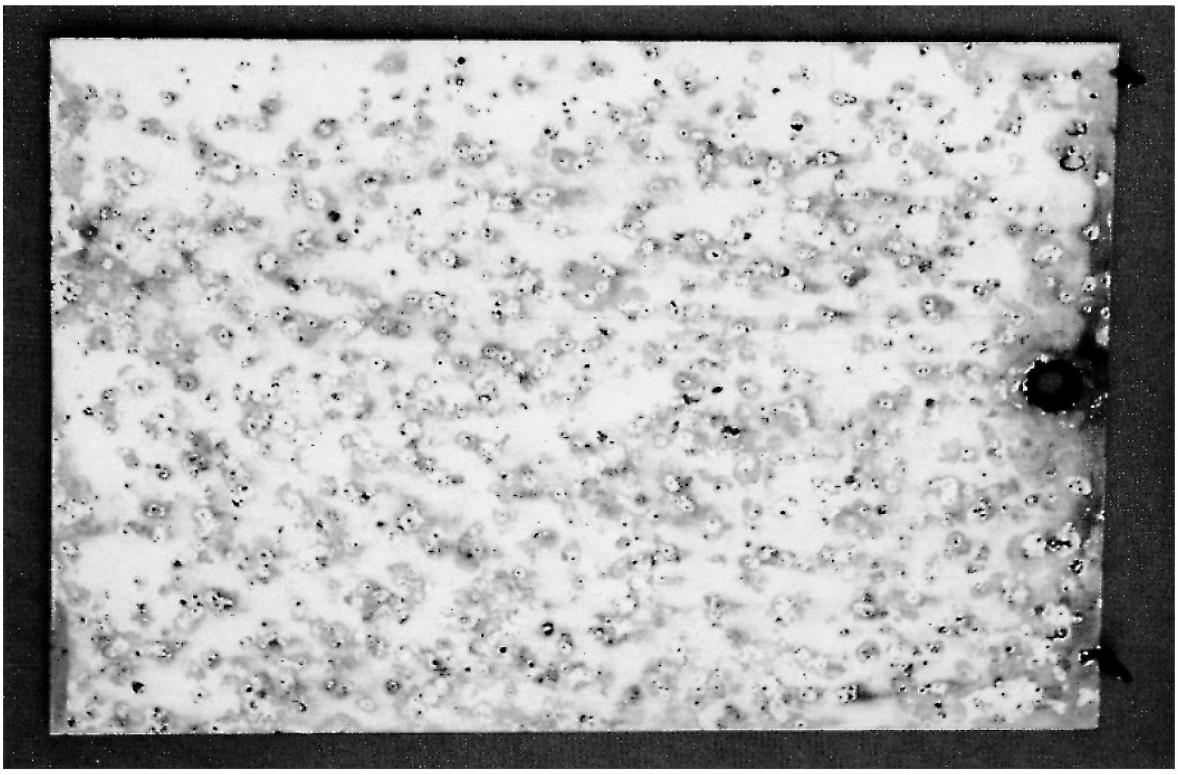
Protection rating 4



Protection rating 3



Protection rating 2



Protection rating 1

Annex B
(informative)

Dot charts for coatings anodic to the base metal

B.1 General

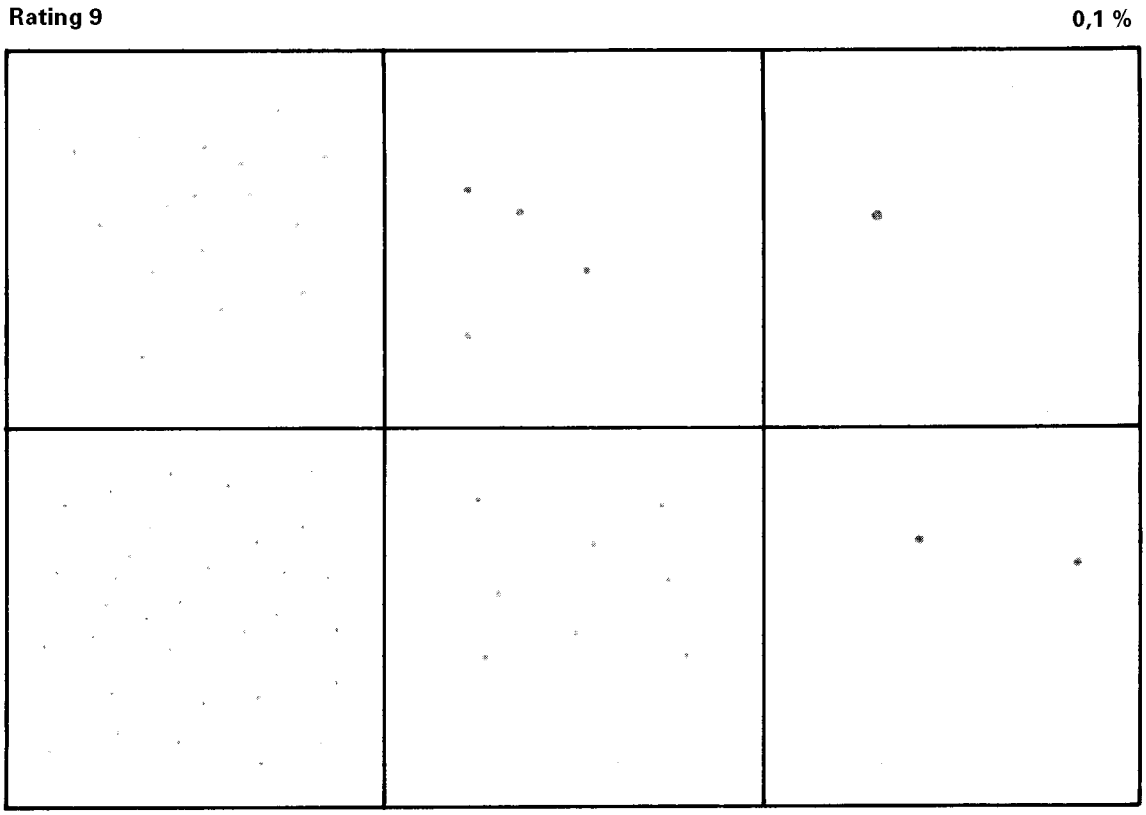
These charts represent the maximum amount of corrosion of the coating and base metal permissible for a given rating; there is a chart for each rating from 1 to 9. A specimen worse than the chart or photograph for rating 1 is assigned a rating of 0 unless a fractional rating is assigned between 1 and 0.

B.2 Using dot charts

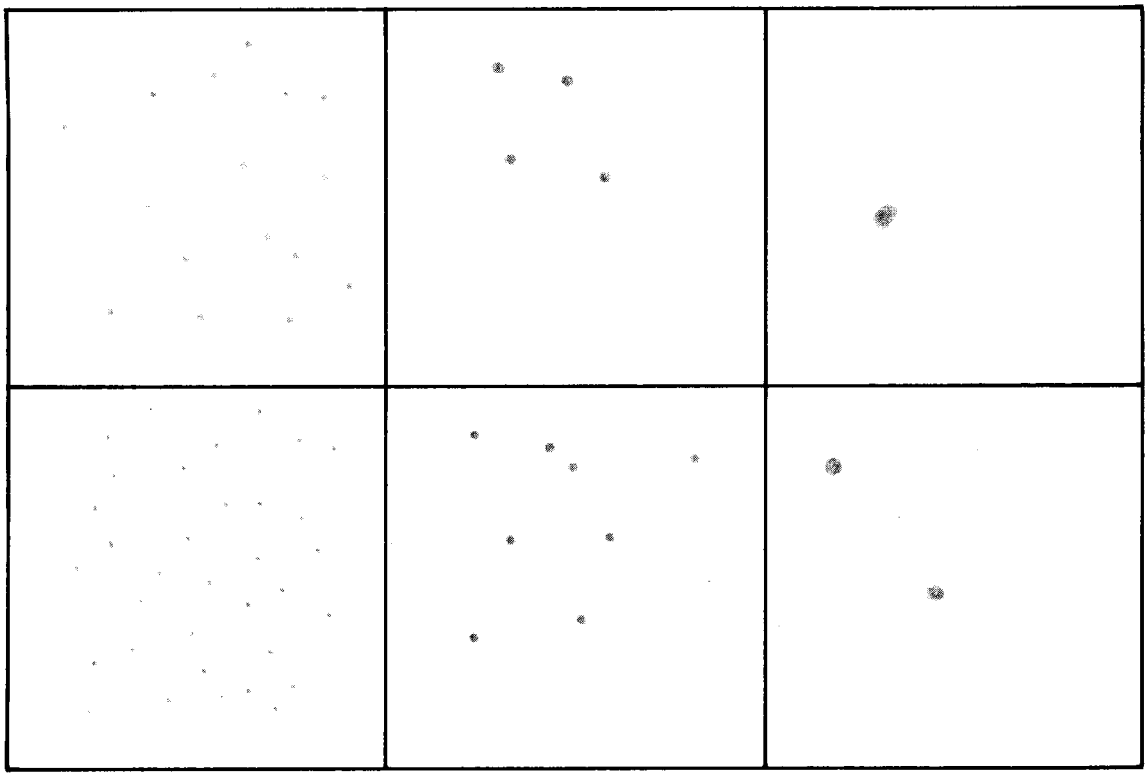
When using the dot charts, it is recommended that the appropriate charts be placed alongside the surface to be examined, and defects then matched as nearly as possible with one of the ratings. If the surface to be examined is somewhat better than rating (X), but not as good as rating ($X + 1$), it is rated (X); if the surface is somewhat worse than rating (X) but not as bad as rating ($X - 1$), it is rated ($X - 1$).

The type of corrosion defects encountered may differ according to the type of atmospheric exposure and to the type of coating under test. Hence, in some cases, the use of dot charts is preferable but, for other applications, colour photographs would be more suitable. However, under certain circumstances, it may be beneficial to assess the affected area by direct measurement.

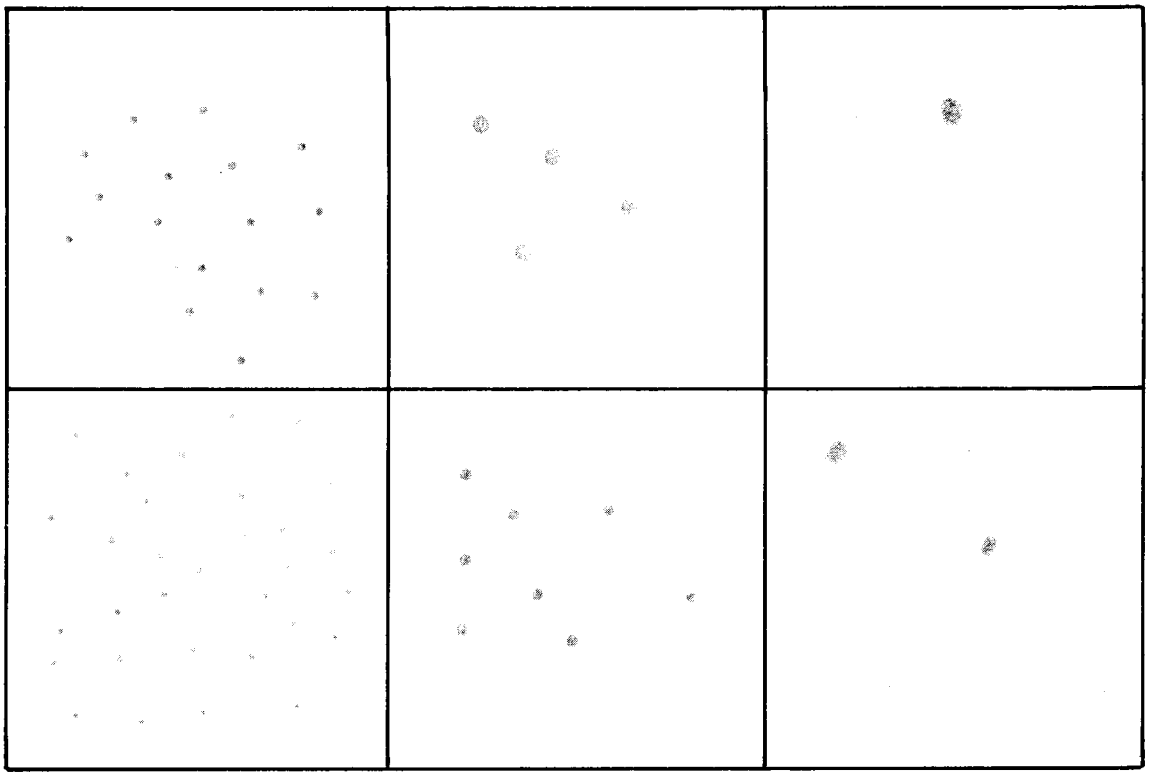
The six squares representing each of the 10 ratings or corroded areas pictorially describes the number of corrosion spots dependent upon their respective sizes.



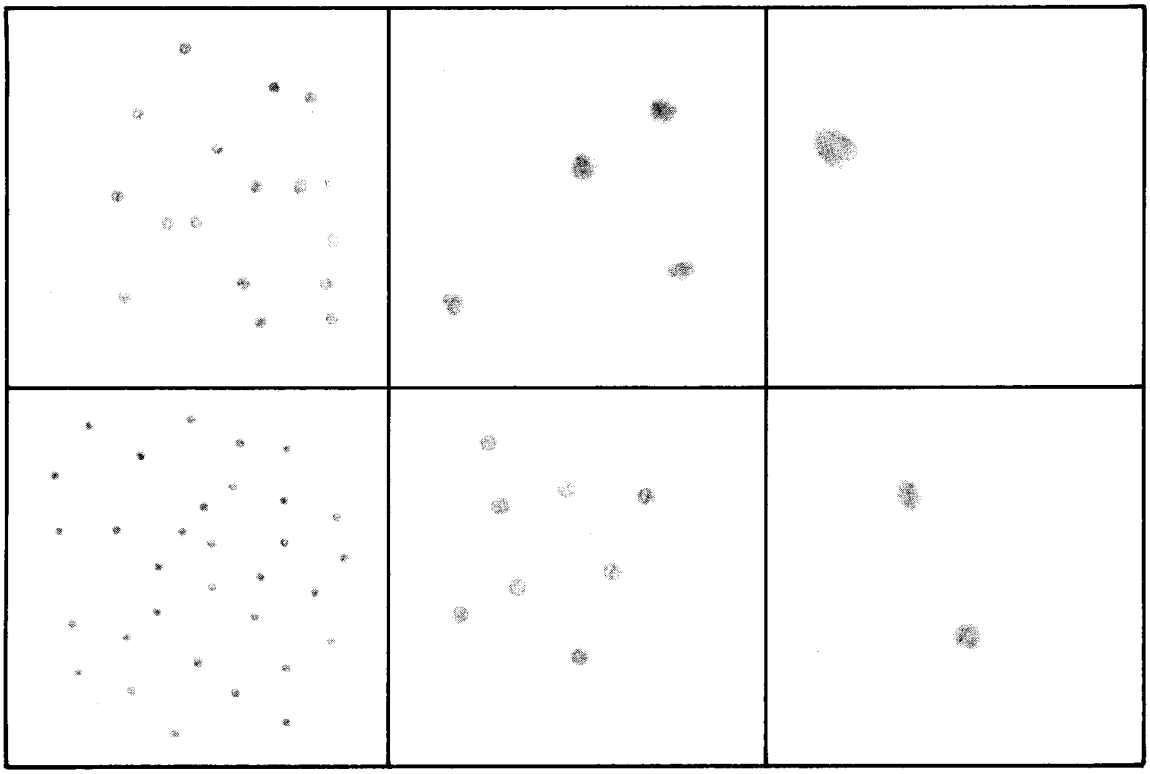
Rating 8 **0,25 %**



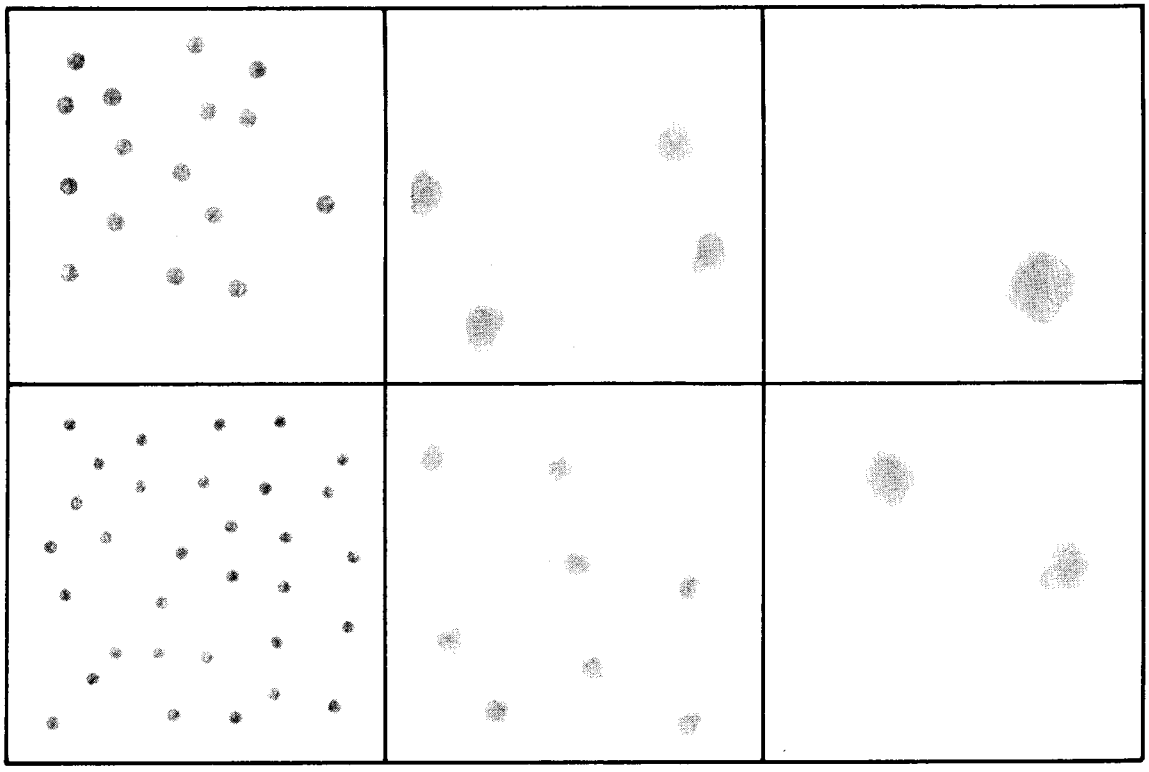
Rating 7 **0,5 %**



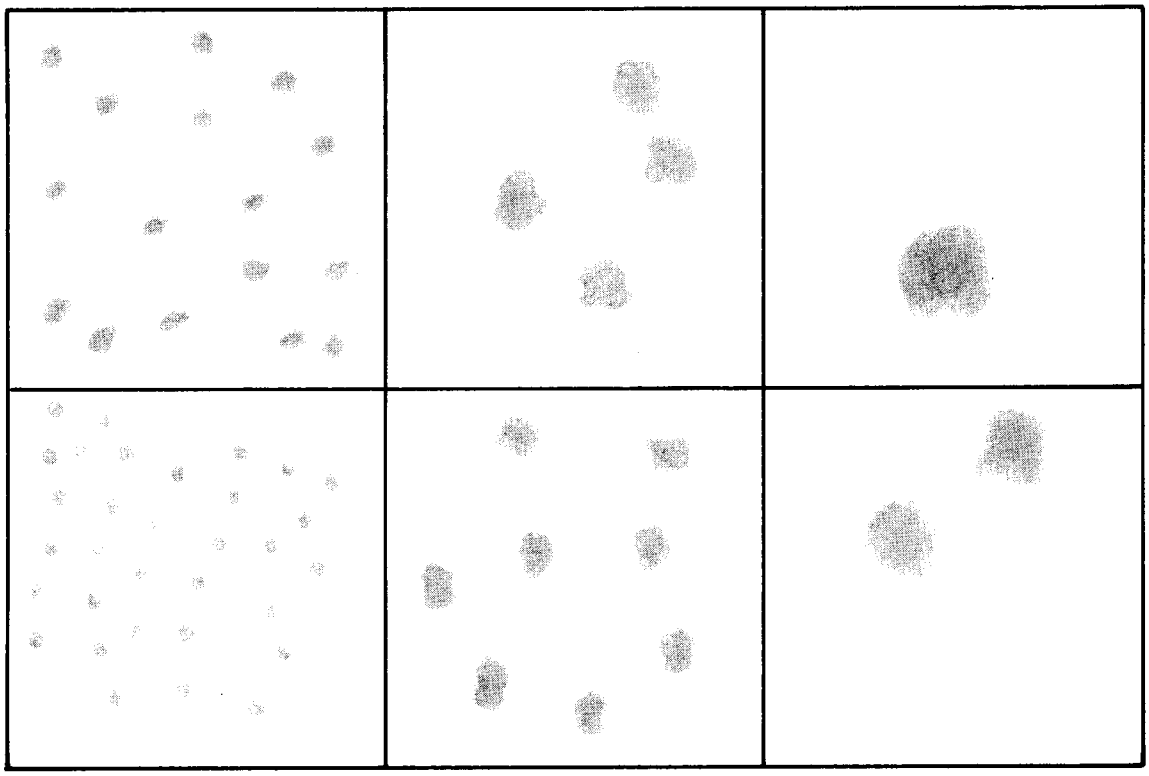
Rating 6 **1 %**



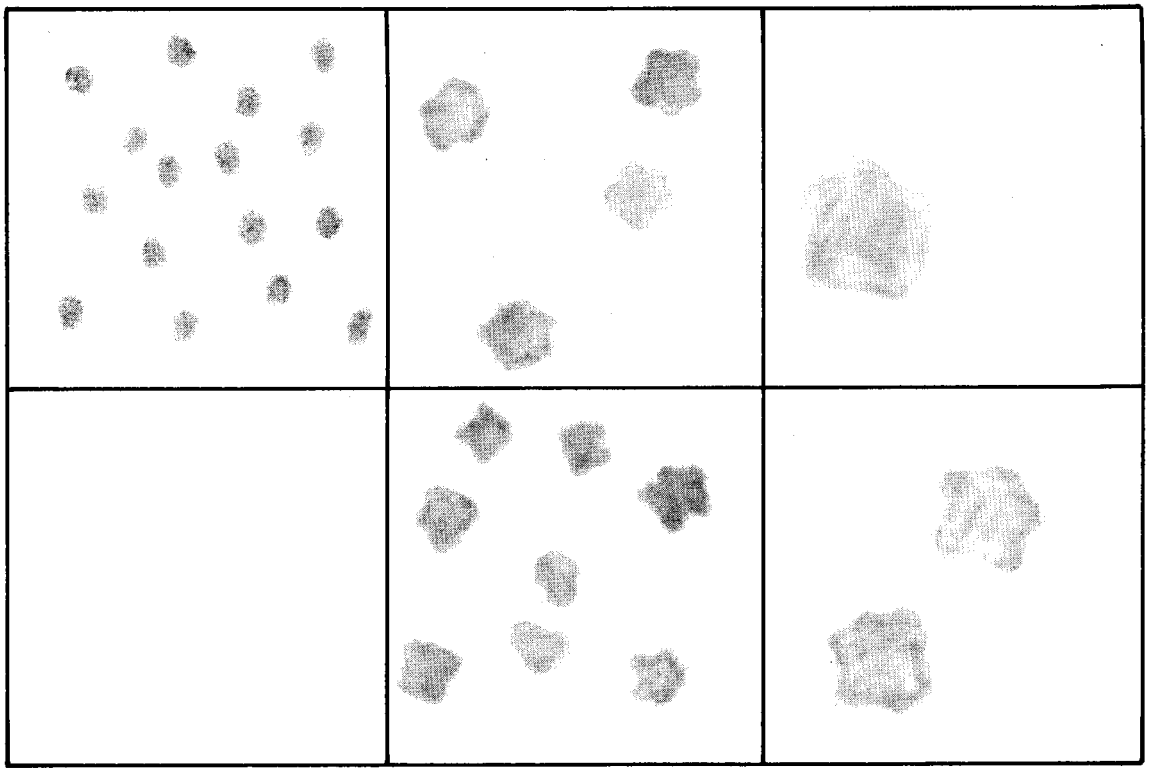
Rating 5 **2,5 %**



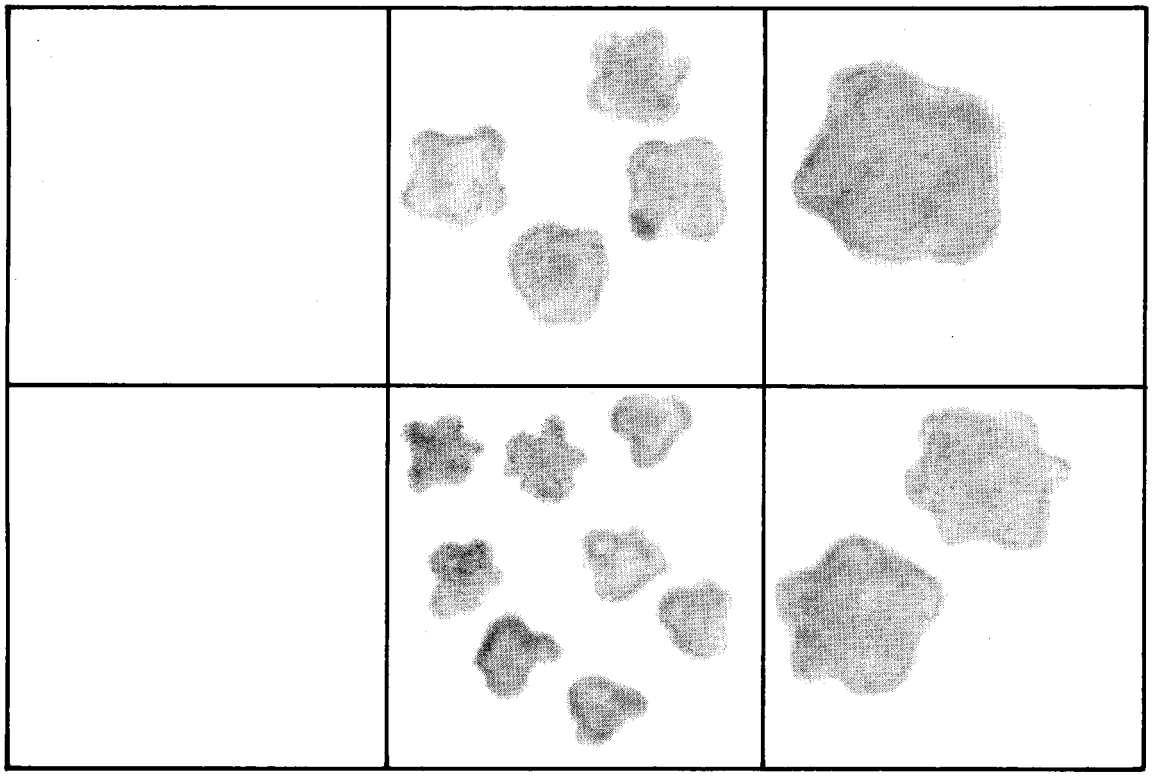
Rating 4 **5 %**



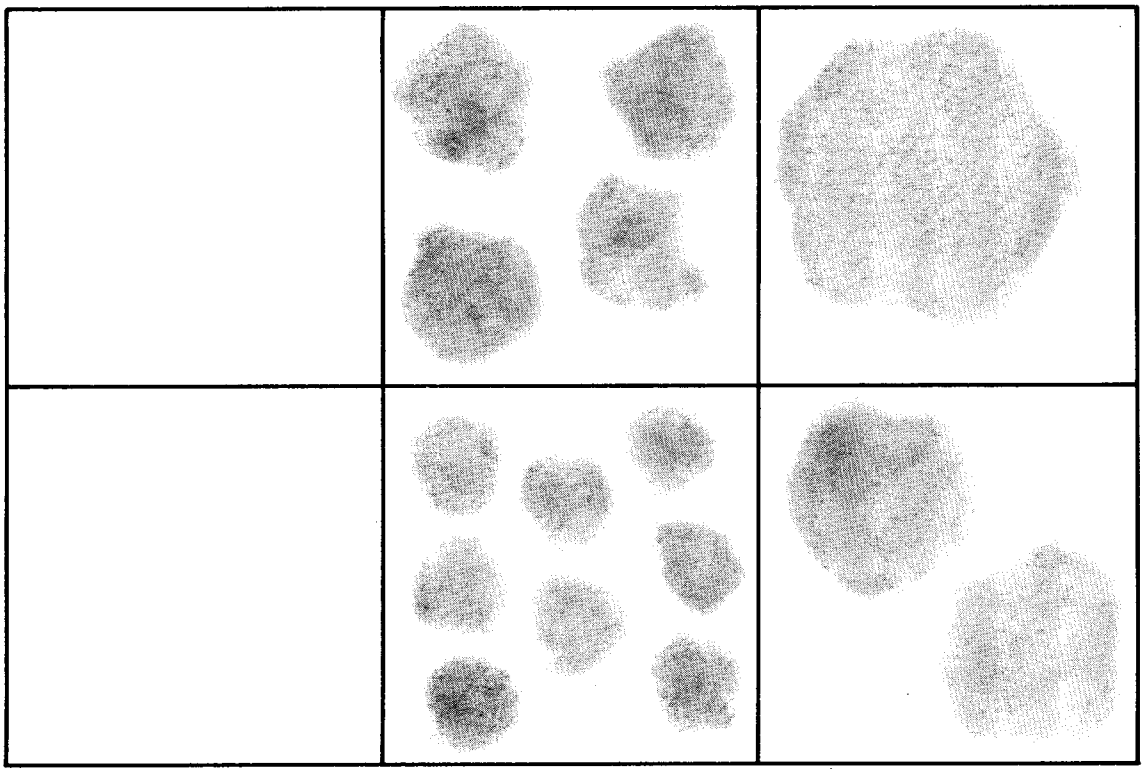
Rating 3 **10 %**



Rating 2 **25 %**



Rating 1 **50 %**



Bibliography

[1] ISO 4536, *Metallic and non-organic coatings on metallic substrates — Saline droplets corrosion test (SD test).*

[2] ISO 4538, *Metallic coatings — Thioacetamide corrosion test (TAA test).*

[3] ISO 4541, *Metallic and other non-organic coatings — Corrodkote corrosion test (CORR test).*

[4] ISO 4543, *Metallic and other non-organic coatings — General rules for corrosion tests applicable for storage conditions.*

[5] ISO 6988, *Metallic and other non-organic coatings — Sulfur dioxide test with general condensation of moisture*.

[6] ISO 7384, *Corrosion tests in artificial atmosphere — General requirements.*

[7] ISO 8565, *Metals and alloys — Atmospheric corrosion testing — General requirements for field tests*.

[8] ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*.

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