
International Standard



4540

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Metallic coatings — Coatings cathodic to the substrate — Rating of electroplated test specimens subjected to corrosion tests

Revêtements métalliques — Dépôts électrolytiques cathodiques par rapport au métal de base — Cotation des éprouvettes ayant reçu un dépôt électrolytique, soumises aux essais de corrosion

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Descriptors : metal coatings, corrosion tests, classification, defects.

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4540 was developed by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*, and was circulated to the member bodies in March 1977.

It has been approved by the member bodies of the following countries :

Australia	India	South Africa, Rep. of
Austria	Ireland	Spain
Bulgaria	Israel	Sweden
Canada	Italy	Switzerland
Czechoslovakia	Japan	Turkey
France	Korea, Rep. of	United Kingdom
Germany, F. R.	Poland	USA
Hungary	Romania	USSR

The member body of the following country expressed disapproval of the document on technical grounds :

Netherlands

Metallic coatings — Coatings cathodic to the substrate — Rating of electroplated test specimens subjected to corrosion tests

1 Scope and field of application

1.1 This International Standard specifies a method of evaluating the condition of electroplated test specimens that have been exposed to corrosive environments for test purposes.

It is based on experience of the method with standard 10 cm × 15 cm test panels, exposed on racks at outdoor test sites in natural atmospheres. It has also been used for rating similar panels that have been subjected to accelerated tests, such as those specified in ISO 3768, *Metallic coatings — Neutral salt spray test (NSS test)*, ISO 3769, *Metallic coatings — Acetic acid salt spray test (ASS test)*, ISO 3770, *Metallic coatings — Copper-accelerated acetic acid salt spray test (CASS test)* and ISO 4541, *Metallic and other non-organic coatings — Corrodokote corrosion test (CORR test)*. Any modifications needed to adapt the method to rating actual production parts are not considered in this International Standard.

1.2 This method is applicable only to decorative and protective coatings that are cathodic to the substrate, for example nickel plus chromium or copper plus nickel plus chromium on steel or zinc die castings. It is not intended for use with anodic sacrificial coatings such as zinc and cadmium on steel.

2 Principle

2.1 The rating method described in this International Standard recognizes that typical decorative and protective deposits such as nickel plus chromium, with or without a copper undercoat, have two functions :

- a) to protect the substrate from corrosion and thus prevent degradation of appearance caused by basis metal corrosion products, such as rust and rust stains;
- b) to itself maintain a satisfactory appearance.

Although these functions overlap, they can be evaluated separately and it is frequently desirable to do so. Accordingly, this International Standard assigns separate ratings to

- a) the appearance as affected by corrosion of the substrate;
- b) the appearance as affected by deterioration of the coating itself.

2.2 The rating number assigned to the ability of the coating to protect the substrate from corrosion is called the "protection" rating.

2.3 The rating number assigned by the inspector's judgment of the overall appearance of the specimen, including all defects caused by exposure (see the note), is called the "appearance" rating.

NOTE — Specimens that are not "perfect" even before being exposed should normally be rejected (see the note to clause 4).

2.4 The result of inspecting a specimen is recorded as two numbers separated by an oblique stroke (/), the protection number being given first.

2.5 In addition to recording the numerical rating of a specimen, the inspector should note the type(s) and severity of defect(s) contributing to the rating. This may be done by the use of agreed symbols for the most common defects (see annex A) and abbreviations for the degree or severity of these defects.

2.6 For the rating of purely protective (not decorative) cathodic coatings, the "appearance number" may be omitted.

3 Types of defect

3.1 "Protection" defects (see annex A) include crater corrosion, pinhole corrosion, corrosion products, blisters (see the note), and any other defects that involve basis metal corrosion.

NOTE — Blisters on electroplated zinc alloy die castings usually signify basis metal corrosion, but the inspector's judgment may be required to decide whether a blister does or does not arise at the substrate-coating interface.

3.2 "Appearance" defects include, in addition to those caused by basis metal corrosion, all defects that detract from the appearance (i.e. the commercial acceptability) of the specimen. Typical defects are surface pits, "crow's feet", cracks, surface stain, tarnish, etc.

3.3 Defects developing on exposure that indicate improper preparation or electroplating shall be noted, but no attempt should be made to rate test specimens showing major amounts of such defects. Peeling of the coating from the substrate, or of one coating from another, is the principal such defect.

4 Preparation for and manner of inspection

NOTE — It may sometimes be necessary to expose specimens for test, even though they are defective in certain respects before exposure. In that case, an inspection shall be made and the findings recorded before the specimens are exposed.

4.1 Specimens may be inspected on the exposure racks or may be removed to a more suitable location if necessary. Lighting during inspection shall be as nearly uniform as possible; direct reflection from sun or clouds shall be avoided, and various angles of inspection shall be tried to ensure that defects show up.

4.2 If the condition of the specimens allows, they shall be inspected in the uncleaned condition. If dirt, salt deposits, etc., make it impractical to inspect them, specimens may be sponged with a mild soap solution followed by a water rinse, but no pressure should be exerted in this procedure as this would tend to upgrade the rating by, for example, cleaning off the corrosion products. Specimens should be allowed to dry before they are inspected.

4.3 Defects to be noted and taken into account in rating specimens include only those that can be seen by the unaided eye. ("Unaided eye" includes wearing of correctional glasses, if the inspector normally wears them.)

Optical aids may be used to identify or study defects, after they have been detected by the unaided eye.

4.4 Edge defects, occurring within 6 mm of the edges of a specimen, may be noted in the description, but are not normally counted in arriving at the numerical rating. Similarly, contact and rack marks, mounting holes, etc., shall be disregarded.

4.5 Rubbing, polishing, etc., of the surface of the specimen may be desirable to study one or another aspect of its condition. Such a procedure shall be confined to the minimum area absolutely necessary for the purpose, preferably not more than 1 cm² of a 10 cm × 15 cm specimen.

5 Assignment of protection rating

5.1 The numerical rating system is based on the area covered by protection defects and is given by the following equation :

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

where

R is the rating;

A is the percentage of the total area covered by defects.

R is rounded off to the nearest whole number, as indicated in the following table.

TABLE — Protection rating versus area of defect

Area of defect %	Rating
No defect	10
≤ 0,1	9
> 0,1 ≤ 0,25	8
> 0,25 ≤ 0,5	7
> 0,5 ≤ 1,0	6
> 1,0 ≤ 2,5	5
> 2,5 ≤ 5	4
> 5 ≤ 10	3
> 10 ≤ 25	2
> 25 ≤ 50	1
> 50	0

5.1.1 Strict application of the equation given in 5.1 would lead to ratings greater than 10 for specimens with extremely small defective areas. Rating 10, accordingly, is arbitrarily assigned to a specimen with no defects.

5.1.2 If desired, fractional ratings between 9 and 10 may be assigned to panels judged better than 9 but not perfect. Fractional ratings below 9, although normally not especially useful, may be assigned if desired.

5.2 As an aid in judging the defective area, standards of comparison consisting of photographs of panels and dot charts are reproduced in annex B. The standards represent as nearly as possible the maximum amount of corrosion permissible for a given rating; there is a standard for each rating 1 to 9. A specimen worse than the standard for rating 1 is assigned a rating of 0.

The types of corrosion defects normally encountered differ according to the type of atmospheric exposure. Typical decorative deposits exposed to marine atmospheres often tend to fail by crater corrosion, whereas, in industrial atmospheres, they are more likely to exhibit pinhole corrosion. The latter atmosphere also tends to be more severe with regard to degradation of the coating system, but somewhat less severe with regard to basis metal corrosion. For this reason, the same standard comparison photographs or charts are not suitable for use at all types of locations. Photographs are more helpful in assessing specimens exposed to marine atmospheres, whereas dot charts are more suitable for industrial atmospheres. (See annex B.)

5.3 In rating any given specimen, it is recommended that the appropriate series of standards, i.e. photographs or dot charts, be placed beside it, and the basis metal corrosion defects be matched as nearly as possible with one of the standards. If the specimen is somewhat better than standard (*X*), but not as good as standard (*X* + 1), it is rated (*X*); if somewhat worse than standard (*X*) but not as bad as standard (*X* - 1), it is rated (*X* - 1).

5.4 If a large group of specimens is being inspected at one time, it is recommended that they be assessed individually as in 5.3, but when the entire group has been rated, the individual ratings should be reviewed to make sure that the ratings assigned actually reflect their relative merits. This review acts as a check on individual ratings and aids in ensuring that the inspector's judgment or frame of reference has not changed during the course of the inspection, owing to fatigue, change in lighting conditions, haste to finish the job, or other causes. One method of facilitating this comparison is to remove individual specimens from their racks and place them beside other specimens. It may be advisable to arrange all of the specimens in order of merit.

6 Assignment of appearance rating

6.1 The assessment of appearance depends on many subjective factors. Therefore, the appearance rating cannot be assigned with the same degree of precision as the protection rating.

Unlike the protection rating, the appearance rating is based not only on the area of the defects but also on their severity, namely, the degree to which they would detract from the commercial acceptability of an article of appearance similar to that of the specimen.

6.2 The appearance rating is based, in the first instance, on the protection rating. Because corrosion of the substrate also detracts from appearance, the appearance rating cannot be higher than the protection rating.

If basis metal corrosion is the only defect, there being no additional defects affecting only the coating, the appearance rating is the same as the protection rating. If there are surface defects not accounted for in the protection rating, the appearance rating will be one or more units lower than the protection rating. This lowering of the appearance rating is referred to in what follows as the "penalty".

6.3 The inspector has to decide, on the basis of best current practice and opinion, whether a surface coating defect is

- a) very slightly,
- b) slightly,
- c) moderately, or
- d) severely

damaging to the acceptability of the appearance. Guidelines are given below, but judgment factors inevitably enter into any decision.

6.3.1 Defects only slightly damaging may include very slight surface pitting that detracts little from the reflectivity, light tarnish or stain easily removed by mild cleaning (such as would be given, for instance, in normal carwashing practice) superficial crack patterns typical of some kinds of chromium plate, etc. Such defects, in order to be categorized as "slight", must not render the finish commercially unacceptable.

A penalty of 1 or 2 points (rating numbers) is assigned for appearance defects classified as slight. One penalty point is assigned if the defects can be classified as very slight, two if slight.

NOTE — If fractional rating was used for the protection number, this would result in a fractional appearance rating; in that case the fractional appearance rating should be rounded to the next lower whole number.

6.3.2 Defects moderately damaging include the same types as in 6.3.1, but more severe, so as to render the appearance questionably acceptable from a commercial standpoint. Examples are surface pits that begin to detract from reflectivity, and tarnish or stains that, although removable, require more drastic treatment than routine washing.

A penalty of 3 or 4 points (rating numbers) is assigned for appearance defects classified as moderate.

6.3.3 Surface defects that render the specimen definitely unacceptable in appearance are classified as severe.

A penalty of 5 or more points, up to the maximum available, is assigned for severe surface defects.

6.4 The procedure for checking the ratings described in 5.4 is of particular importance in assigning appearance ratings, and is strongly recommended.

7 Low-rated specimens

The system described in clauses 5 and 6 should be satisfactory for assessing relatively good specimens, but difficulties may be encountered in attempting to rate severely corroded specimens. For example, if a specimen rates as low as 4 for protection, it may be difficult to assess any additional appearance defects. At the option of the inspector, this difficulty may be handled as follows.

7.1 A cut-off point may be chosen below which appearance ratings are deemed to be of no significance. For example, it may be agreed that any specimen which has a protection rating of 5 is so unacceptable that an appearance rating has no meaning. Such specimens may arbitrarily be assigned one of two appearance ratings :

- a) if there are no obvious additional surface defects, the appearance rating is equal to the protection rating;
- b) if there are any surface defects at all, no attempt is made to assess their severity, and the appearance rating is 0.

7.2 Alternatively, after setting the cut-off point as in 7.1, the appearance rating may be disregarded and only a protection rating assigned.

8 Test report

8.1 Outdoor exposure tests

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

- a) the description of the coating system or product tested;
- b) the dimensions and shape of the test specimen and the nature of the surface tested;
- c) preparation of the test specimen, including any cleaning treatment applied and any protection given to edges or other special areas;
- d) known characteristics of the coating, with an indication of the surface finish;

e) the number of test specimens subjected to the test representing each coating or product;

f) the method, if any, used to clean the test specimen after test;

g) the rating (number);

h) the location of the exposure site;

j) the exposure period.

8.2 Accelerated corrosion tests

Unless otherwise specified, the test report shall contain, in addition to the rating, the information required in the International Standard in which the accelerated corrosion test is specified.

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Annex A

Symbols describing defects

A.1 Types of failure

- R : Corrosion of the basis metal. (Permanent or massive type of basis metal corrosion such as that from pinholes, bare or flaked areas, or in craters of broken blisters.)
- Rs : Stain due to basis metal corrosion products, such as rust stain, which can be removed readily with a damp cloth or chamois leather and mild abrasive, to reveal a sound bright surface.
- S : Stains or spots other than those of obvious basis metal corrosion products.
- Sp : Surface pits. Absence of obvious basis metal corrosion products bleeding from corrosion pits probably not extending through to the basis metal.
- F : Flaking or peeling of deposit.
- B : Blistering.
- C : Cracking.
- Z : Crazeing (network of cracks).
- W : Crow's feet (or star-shaped defects).

A.2 Degree or extent of pinhole corrosion, staining, surface pitting, flaking, etc.

- vs : Very slight.
- s : Slight.
- m : Moderate or intermediate.
- x : Substantial.

A.3 Description of blisters

- a : Less than about 0,5 mm in diameter.
- b : About 0,5 to 2,0 mm in diameter.
- c : Greater than about 2,0 mm in diameter.
- d : ≤ 5 .
- e : > 5 to 10.
- f : > 10 to 25.
- g : > 25 to 50.
- h : > 50 .

A.4 Description of location of defects

- y : Edge.
- z : General.

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Annex B

Dot charts and colour photographs¹⁾

B.1 Dot charts

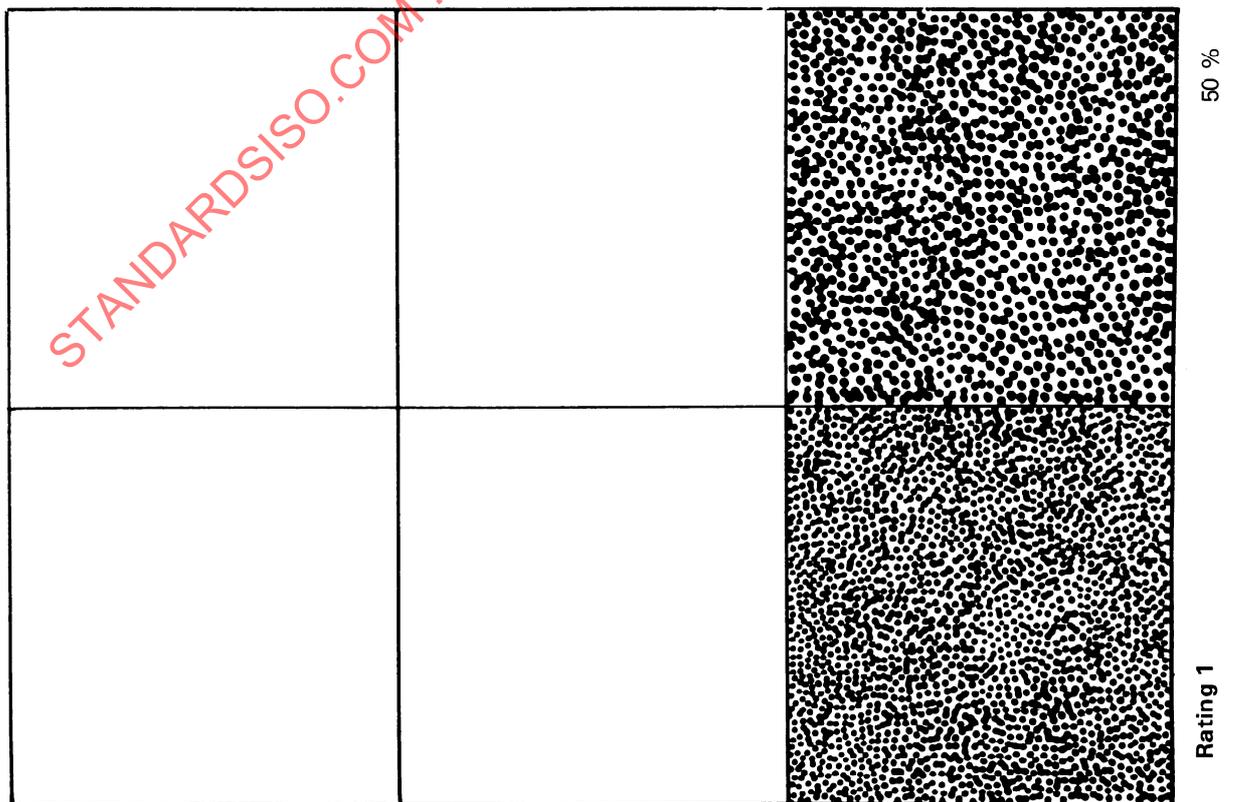
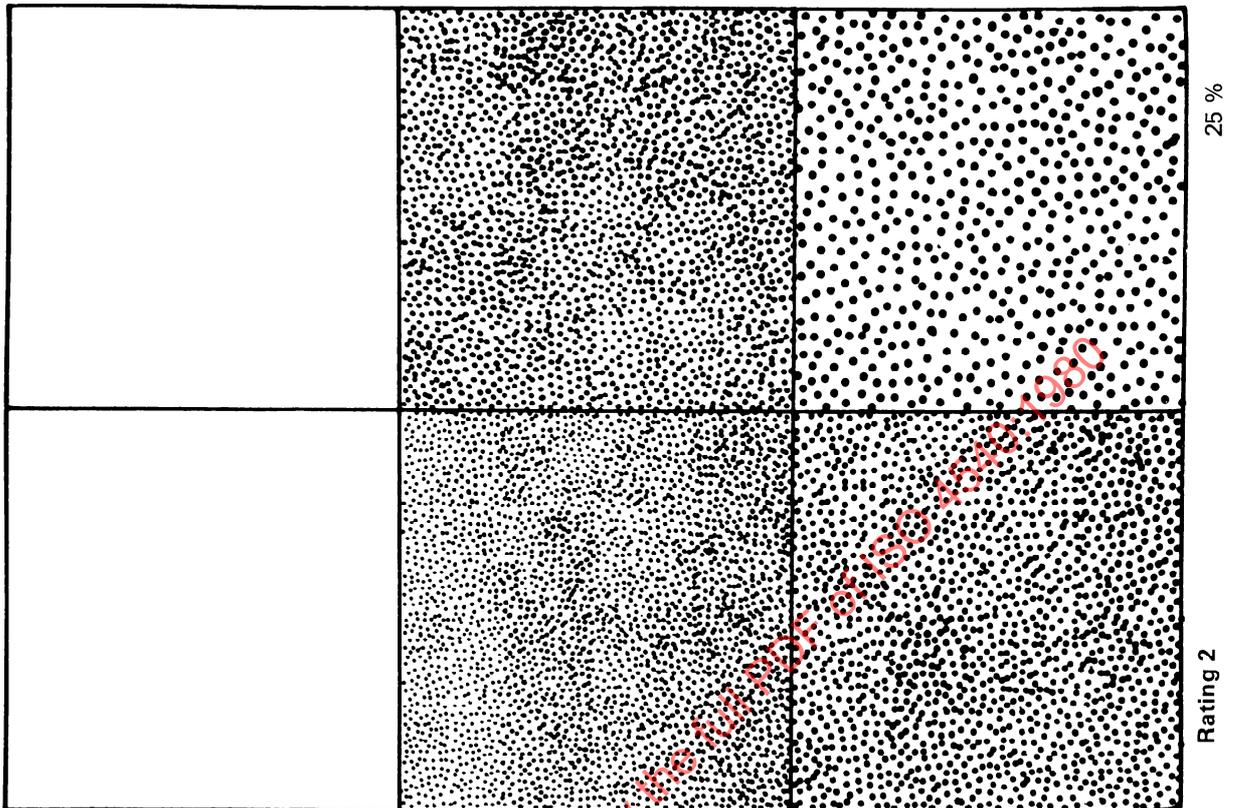
The standard dot charts are most useful when assessing the degree of corrosion in industrial atmospheres.

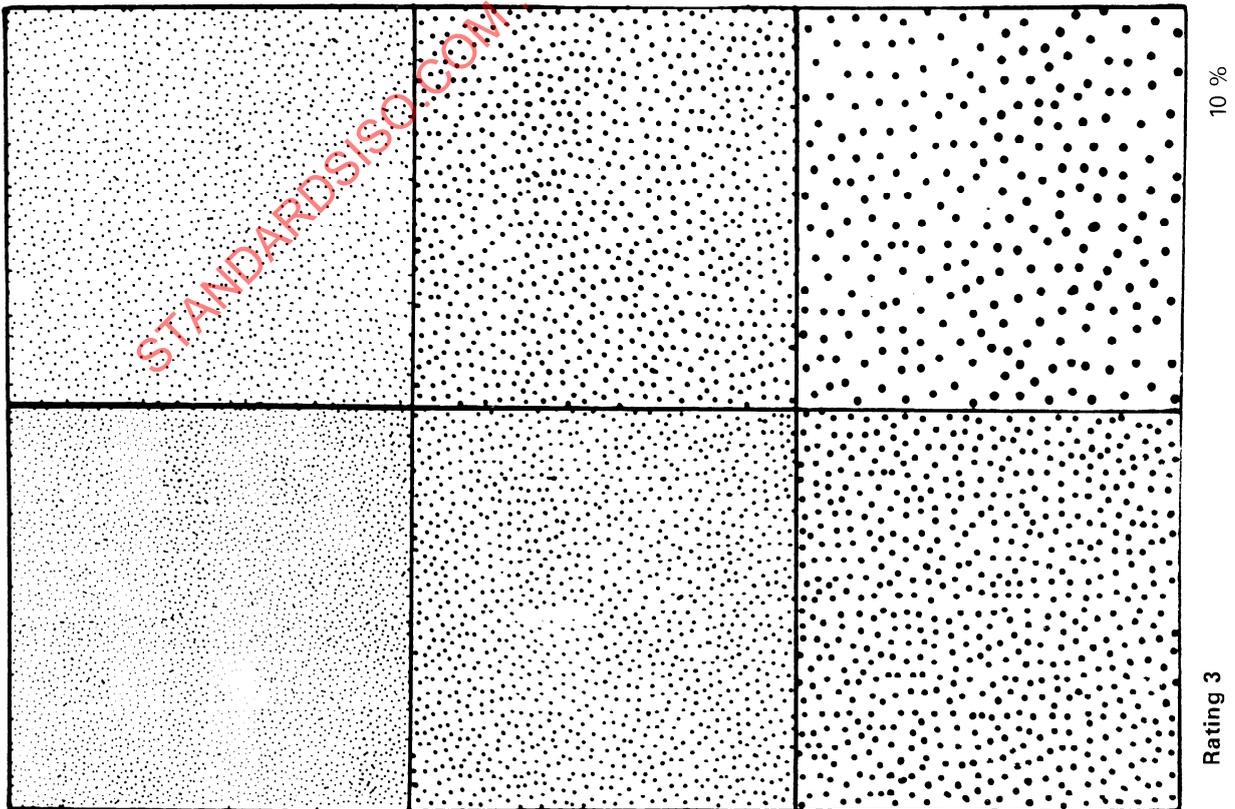
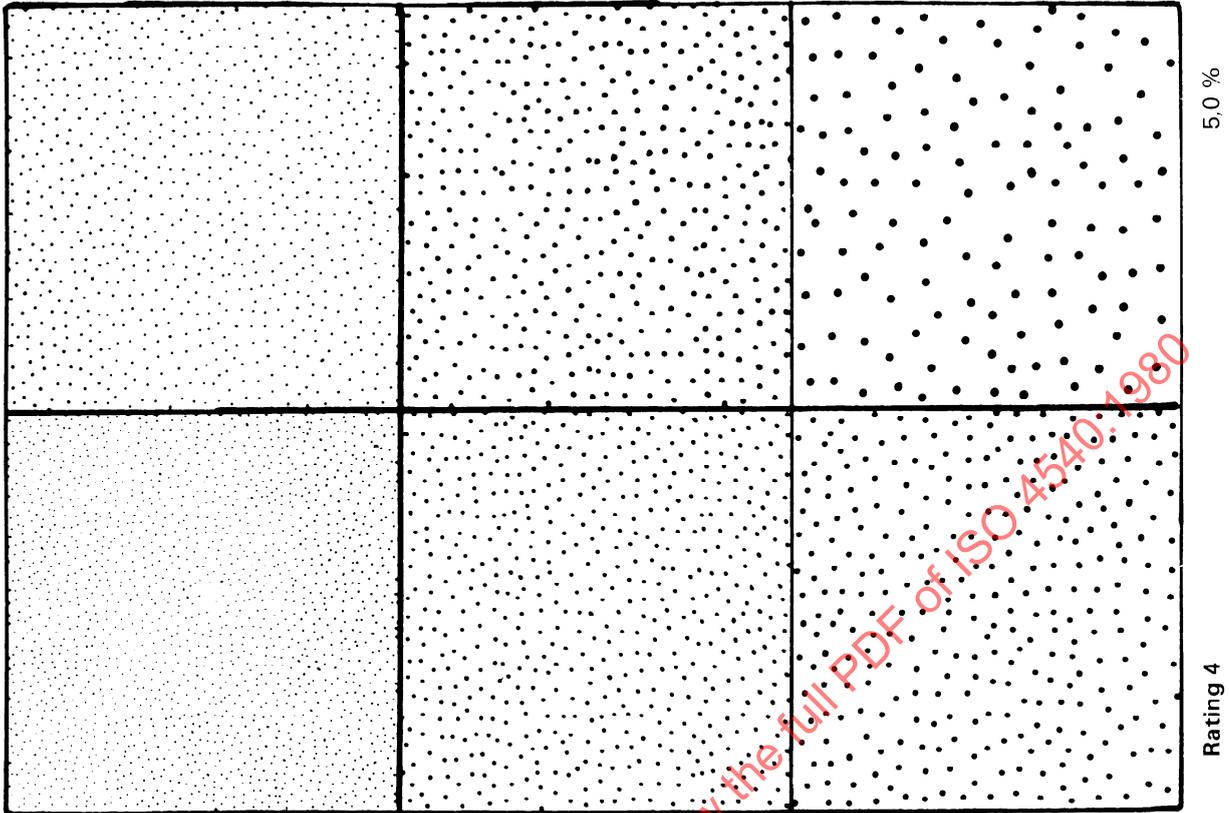
B.2 Photographs

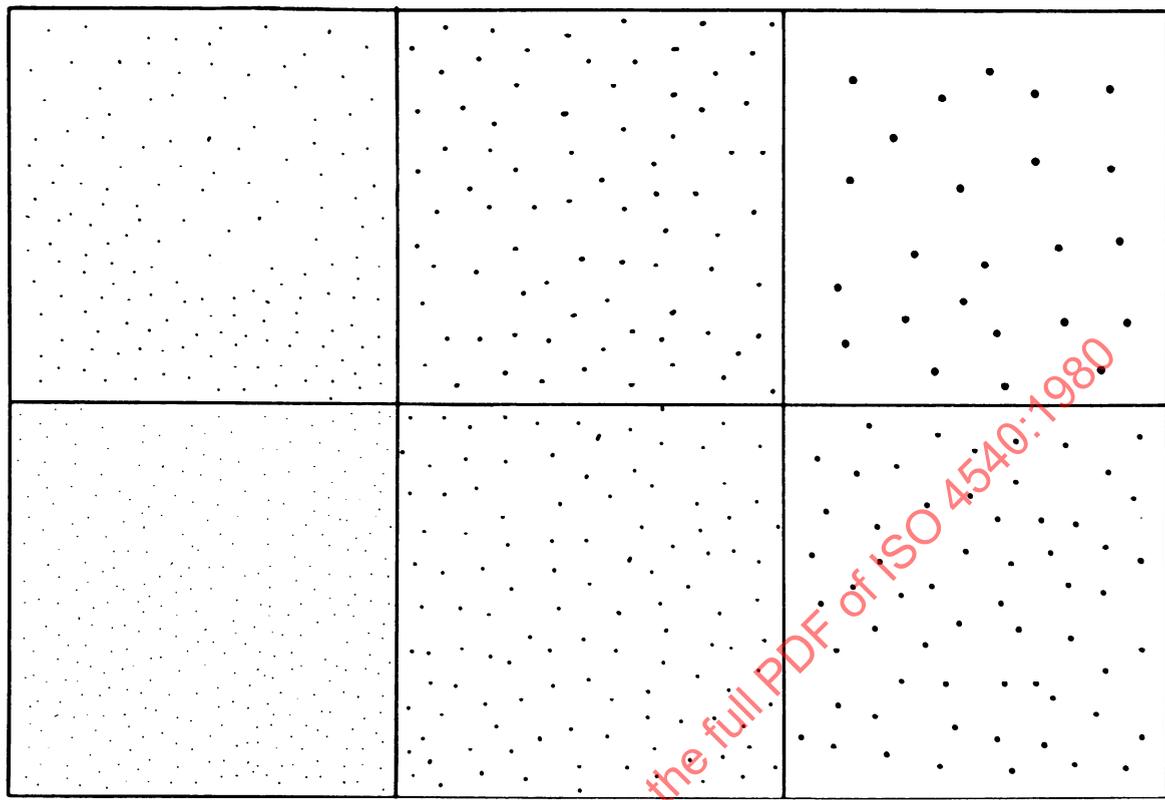
The photographs are usually more helpful when determining the extent of corrosion in marine atmospheres.

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¹⁾ The dot charts and photographs were supplied by the American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, Pennsylvania 19103. The colour photographs will be included at the final stage of printing.

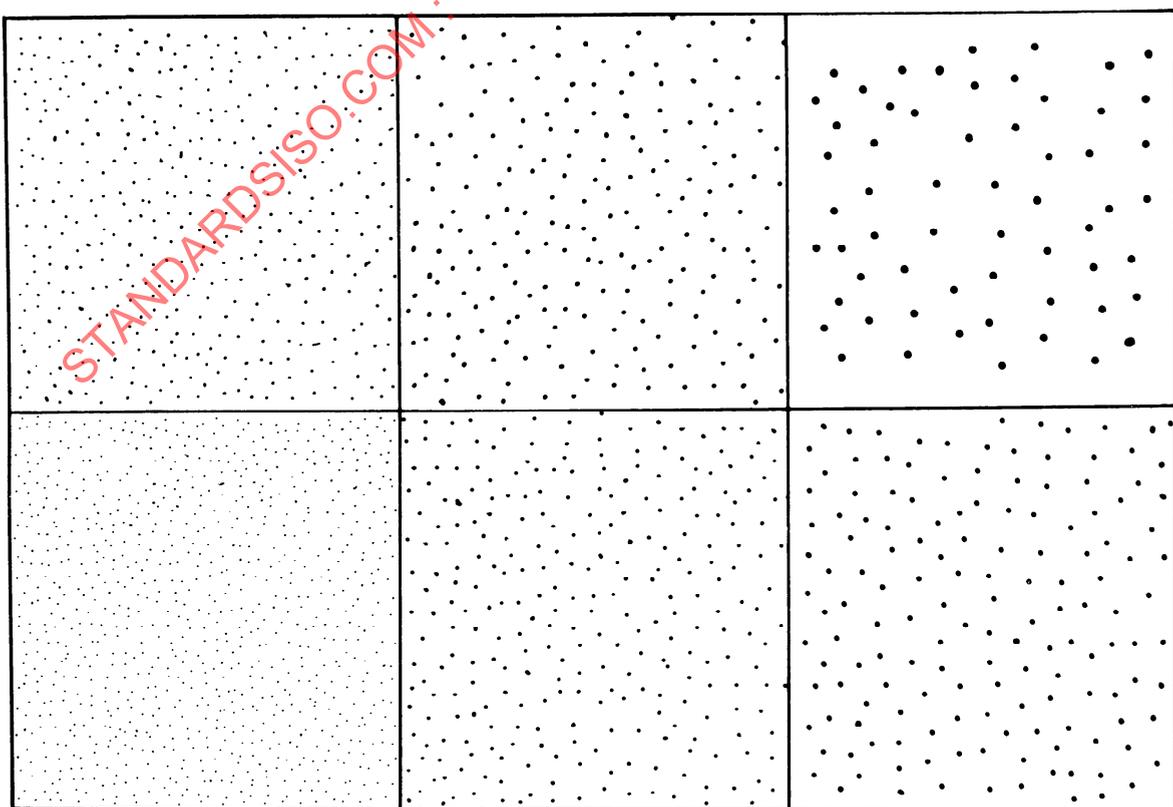






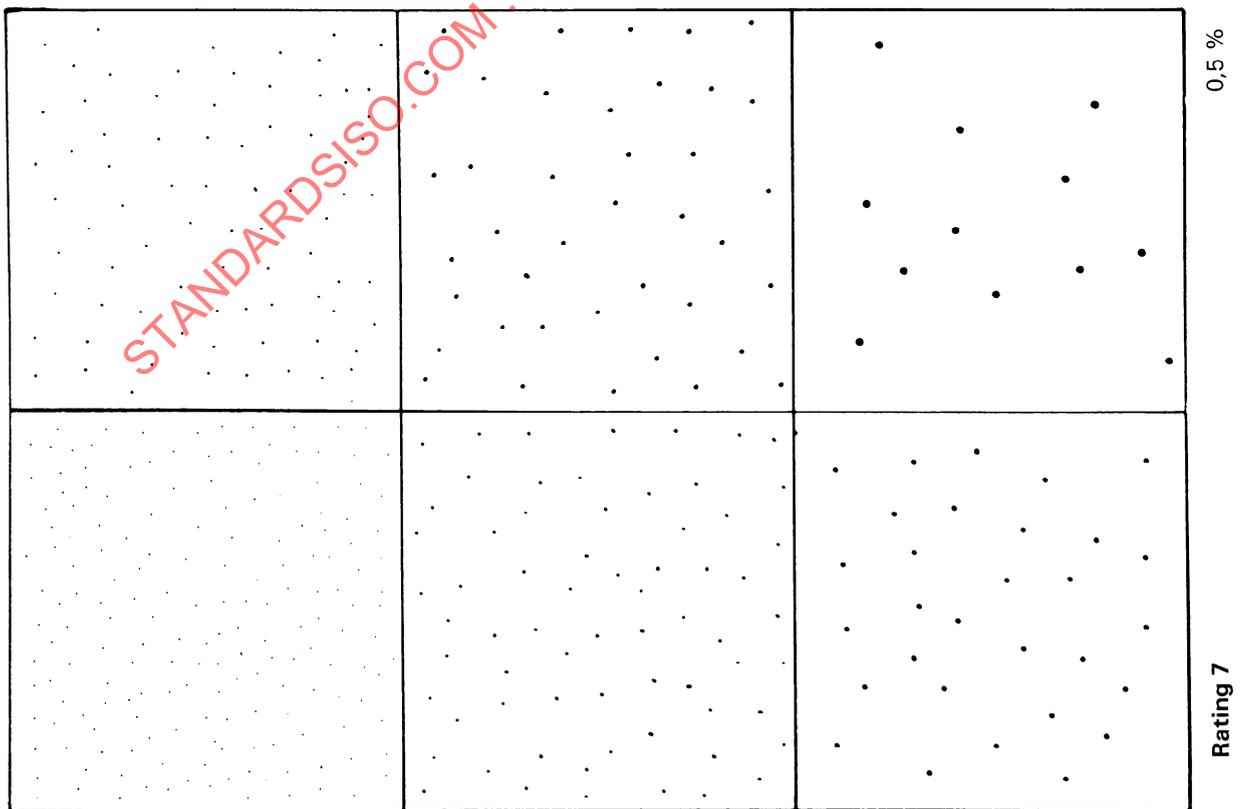
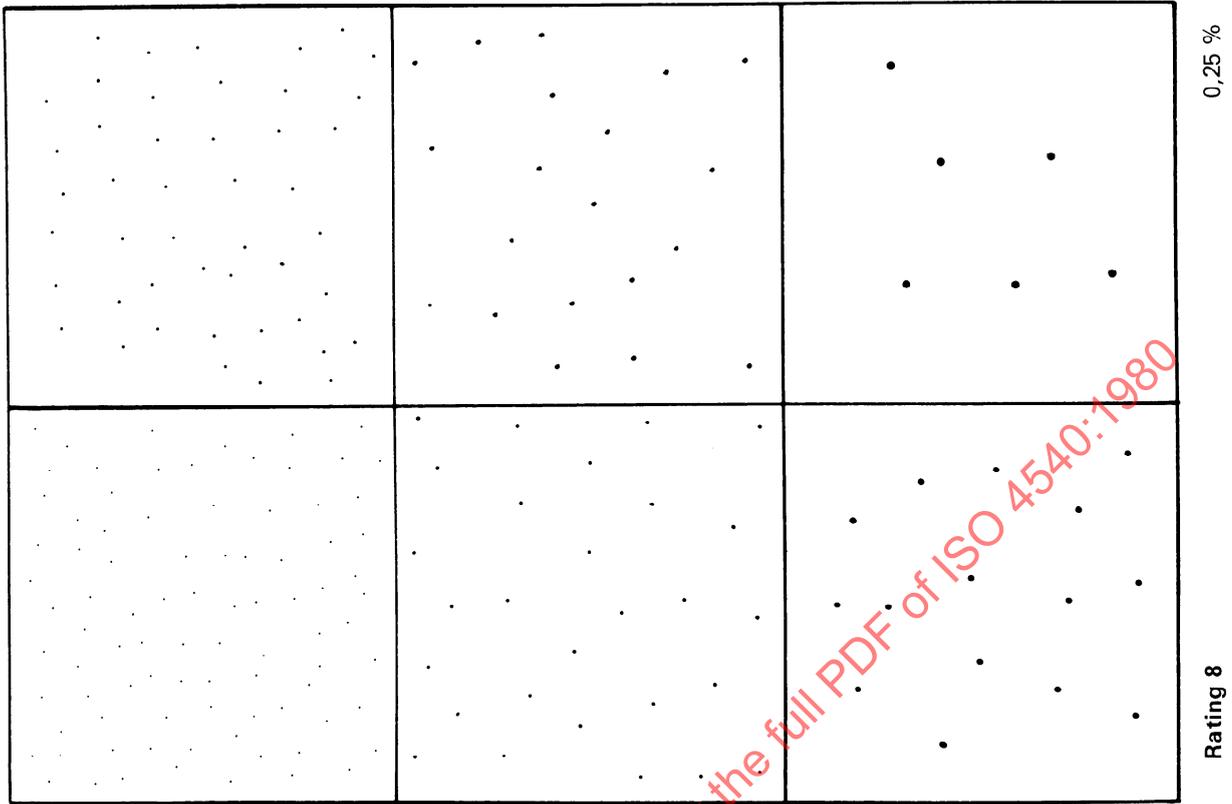
1,0 %

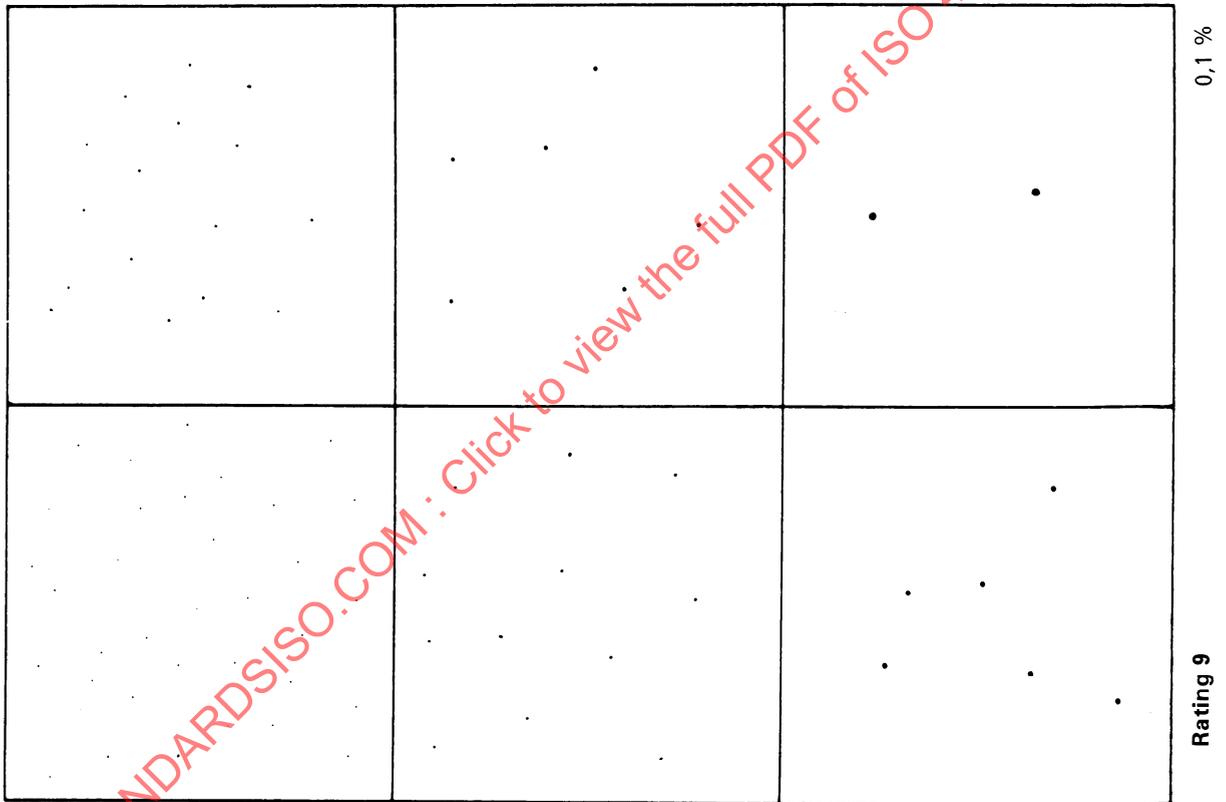
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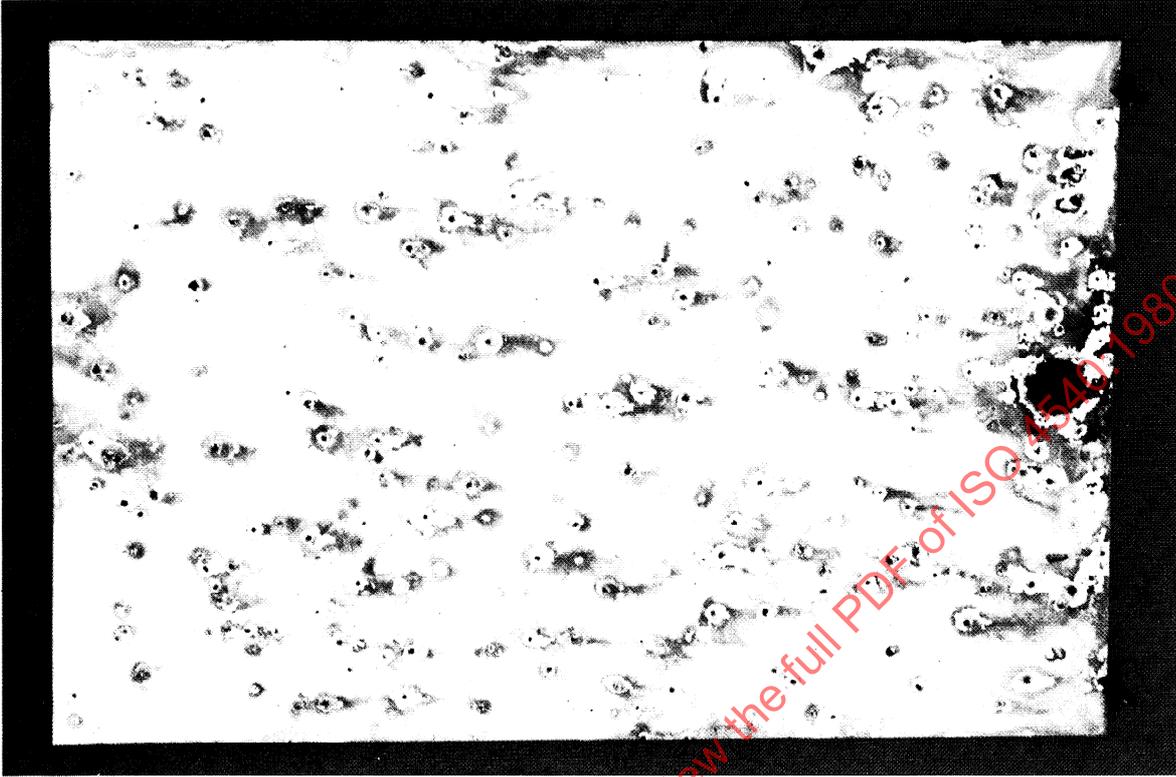


2,5 %

Rating 5



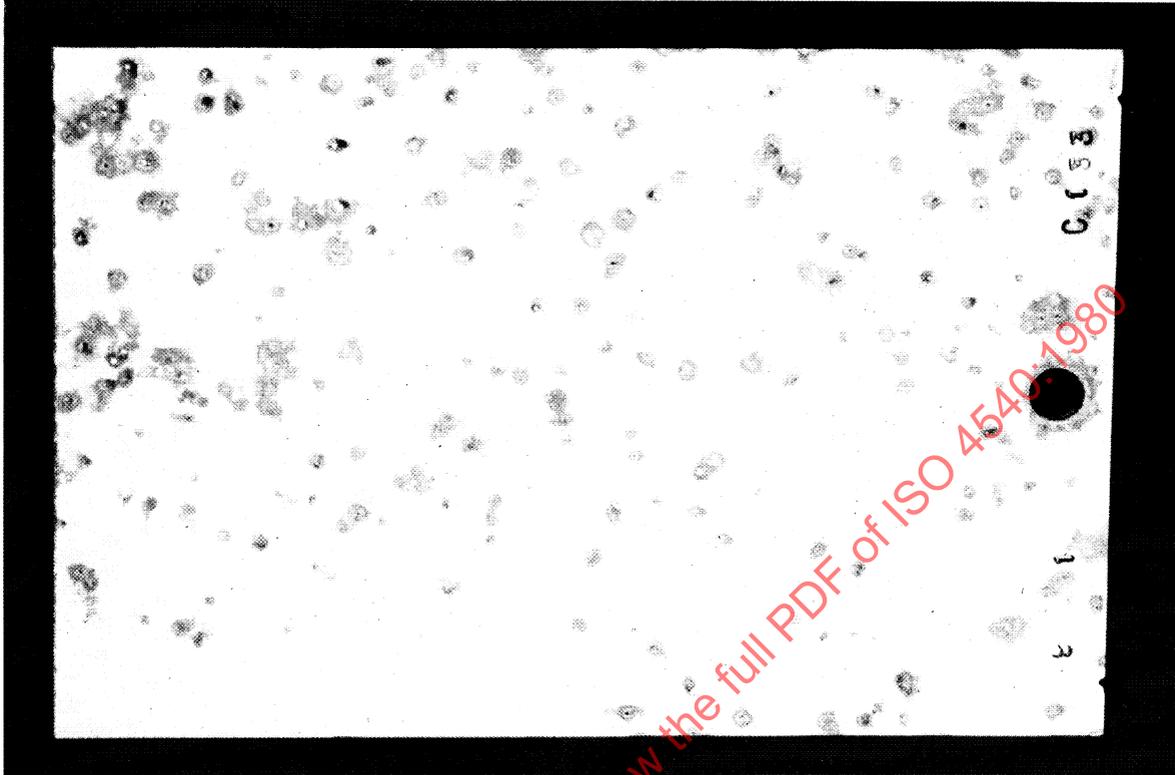




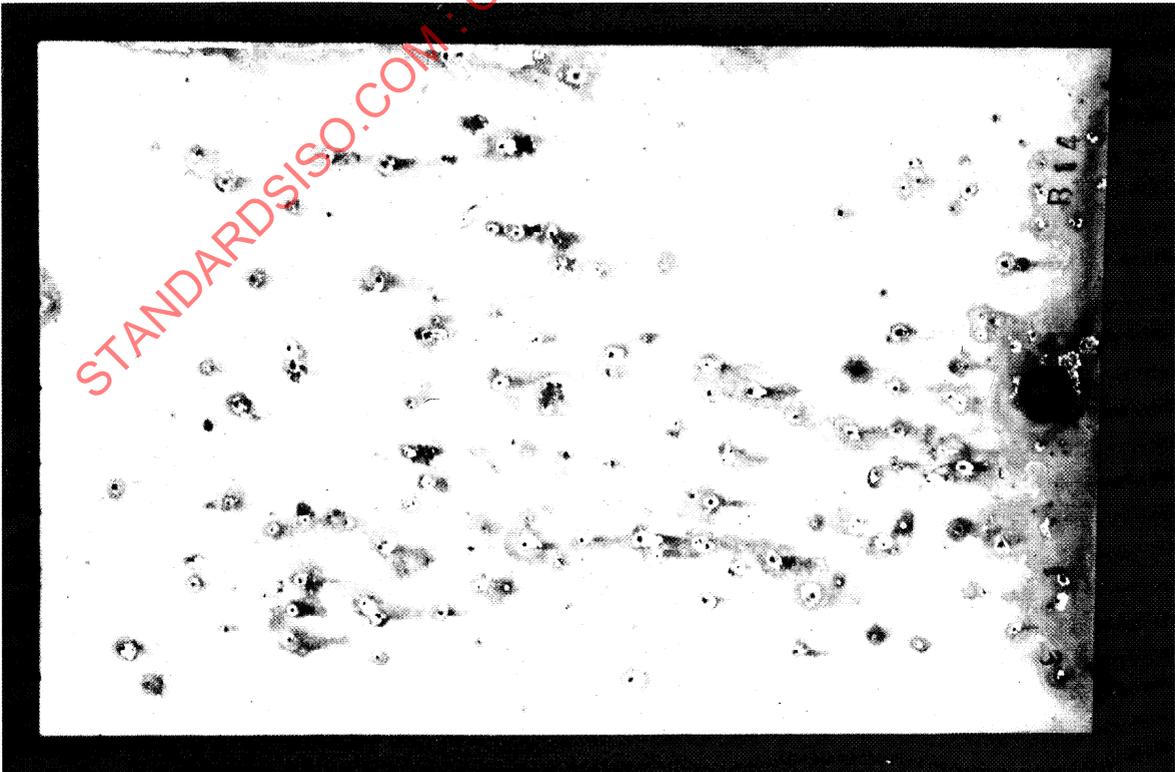
Protection rating 2



Protection rating 1



Protection rating 4



Protection rating 3



Protection rating 6



Protection rating 5