

**MATERIALS AND COATINGS  
SALT SPRAY TEST OF 5% NaCl  
AND METHODS OF GRADING****1. OBJECT AND FIELD OF APPLICATION**

The object of this method is to define the principle, the characteristics of the reagents and of the equipment, as well as the method of operation of a salt spray test guaranteeing good reproducibility. Whatever the volume of the chamber, the conditions of the spray density, the concentration and pH of the solution must conform to this méthode.

In the test report, the indication of the results must take into account the type of test specimens.

In fact, for test specimens intended for resistance to salt spray appraisal, the coatings must be distinguished electro-negative and electro-positive in relation to the iron. For the first (electro-negative) this test shall be considered a corrosion test, for the second (electro-positive) this test shall be considered a porosity inspection test.

Under no circumstances must this test be considered as a means of studying resistance to salt sprays.

The characteristics for the use of the test for the various inspections and research which it provides, must be the subject of normes specific to each material or coating envisaged.

This test may be used for the inspection of the quality of materials or coatings in relation to established specifications.

However it does not allow the establishment of a base for the relationship between the resistance observed during the test and the resistance to corrosion in the various environments where the materials may be used.

In the same way, after the tests for the purpose of comparison, it does not allow the relative behaviour of different materials in the conditions of use to be evaluated.

This méthode is based on the norme NFX 41-002.

**2. PRINCIPLE**

Accelerated corrosive attack by an artificial salt spray of defined composition, in precise conditions of temperature and pressure.

The degree of corrosion is appraised either by the loss of mass of the test specimens, by the density of pitting per unit area, by the total area of the spots or by comparison with standardised scales, etc. . . .

### 3. REAGENTS

#### 3.1. SALINE SOLUTION

The percentage must be  $5\% \pm 0,5\%$ .

##### 3.1.1. SODIUM CHLORIDE

The sodium chloride must not contain, in the anhydrous state, more than 0,2% total impurities and more than 0,1% Sodium iodide. It must be free from nickel and copper.

##### 3.1.2. WATER

The distilled water or de-ionised water must not contain more than 0,02% impurities.

Its pH must be  $7 \pm 1$ .

Its conductivity must be less than 0,2mS/m (measurements to be made less than 6 hours before use).

##### 3.1.3. PREPARATION

Dissolve 5 parts of sodium chloride by weight into 95 parts of distilled water.

Check the concentration by measuring the density of the solution at  $35^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . Carry out this check each day.

The density of the 5% solution must be between 1030 and 1040 kg/m<sup>3</sup>.

Adjust the pH of the solution to the value 7,0 (-0,5/+0,2).

Before spraying, eliminate if required the impurities in suspension by filtering or decanting.

#### 3.2. COMPRESSED AIR

The air must be pure, maintained at 85-90% relative humidity at a temperature of  $35^{\circ}\text{C} \pm 1^{\circ}\text{C}$  and delivered to the sprayers at a pressure of 0,1 Mpa at an accuracy of 20% ( $1\text{ bar} \pm 0,2\text{ bar}$ ).

3.2.1. In order to purify it, pass it through a water filter.

3.2.2. In order to maintain a constant concentration of the saline solution, humidify the air at a higher temperature than  $35^{\circ}\text{C}$  by making it pass in finely divided bubbles through a saturator containing water heated to a suitable regulated temperature. The height of the column of water is less important than the fineness of the bubbles since saturation of very fine bubbles is almost instantaneous. The water in the saturator must be changed each week to eliminate impurities.

#### 3.3. SALT SPRAY

The salt spray is defined by the characteristics of the solution gathered in the collectors during the test.

3.3.1. The intensity of the spray must be such that for each 80 cm<sup>2</sup> of the horizontal collecting surface  $2\text{ ml} \pm 1\text{ ml}$  of solution is gathered per hour, on the basis of a minimum operating time of 16 hours.

3.3.2. The solution gathered must have the density and the pH specified in paragraph 3.1.3. above.

## 4. EQUIPMENT

The equipment comprises :

- a spray chamber (see appendix 1),
- sprayers,
- a heating device,
- a saline solution supply device,
- a compressed air supply device,
- spray collectors.

### 4.1 SPRAY CHAMBER

The dimensions and the method of construction of the spray chamber are left to the discretion of the constructors and the users, on the condition that the following arrangements are observed:

- 4.1.1. The walls of the chamber, the frame and the supports situated on the inside must resist the salt spray corrosion. Among the materials which exhibit good resistance are: glass, rubber, certain plastic materials, cement.
- 4.1.2. The design of the chamber must be such that the spray can be deposited directly by weight onto the parts or specimens. To this end, a suitable arrangement is being studied for the sprayers and the orifices for evacuating the condensed liquid.
- 4.1.3. The design of the walls of the chamber, the framework and supports must be such that the liquid which runs over the surfaces cannot flow onto the parts or specimens. The condensed solution is evacuated at the bottom of the chamber without being re-used.

With a view to facilitating the rationalisation of the equipment, a recommended type of chamber is shown with its principal dimensions in appendix 1.

### 4.2. SPRAYERS

Use one or several compressed air sprayers. A diagram in appendix 2 describes a sprayer of this type as an example.

Preliminary tests allow the determination, once and for all, of the inclination to be given to the deflector in relation to the axis of the jet and its distance from the sprayer to obtain the most uniform distribution of spray possible, controlled by the quantities of solution gathered in the different collectors.

### 4.3. HEATING DEVICE

The heating device must be able to maintain the interior of the spray chamber at a temperature of  $35^{\circ}\text{C} \pm 2^{\circ}\text{C}$ .

Different methods may be used:

4.3.1. It is desirable that the air penetrates into the spray chamber at a temperature higher than  $35^{\circ}\text{C}$ .  
The degree of excess is controlled by:

- the maintenance of a temperature of  $35^{\circ}\text{C}$  inside the chamber.
- the thermal capacity per unit mass of the walls and the ambient temperature
- the volume of pulsed air
- the air pressure, which determines the temperature necessary to obtain the required humidity.

This temperature is between  $43^{\circ}\text{C}$  and  $47^{\circ}\text{C}$  for a pressure between 0,08 MPa and 0,12 MPa (0,8 and 1,2 bar).

4.3.2. It is desirable, in general, that the ambient temperature around the spray chamber should be as uniform as possible. To this end the chamber may be placed in a room at constant temperature, or the chamber may be surrounded by an envelope containing water at a suitable temperature. The chambers which are completely insulated may be heated with warm air. However this method may require the use of an automatically controlled source of auxiliary heating, allowing the temperature to be raised rapidly after opening the chamber.

It is practically impossible to satisfy the temperature characteristics by the use of heating elements immersed in the reservoir of the saline solution.

4.3.3. The device for measuring the temperature inside the chamber must allow either continuous inspection or a routine of two inspections a day. One may therefore use either a continuous recording device inside the chamber or a thermometer where the reading may be effected from the outside. The reading of the temperature must be carried out with the chamber closed in order to avoid, when opening, condensation on the thermometer bulb which could lead to errors in reading.

### 4.4. DEVICE FOR THE SUPPLY OF SALINE SOLUTION

The saline solution is contained in receptacles manufactured from materials which cannot affect the pH of the solution. To this end steel receptacles covered with rubber or plastic material, or glass receptacles, may be used.

These receptacles continuously supply the reservoir situated in the chamber and in which the level of the saline solution is constantly maintained to within 5 mm. The sprayers are connected to this reservoir.

### 4.5 DEVICE FOR THE SUPPLY OF COMPRESSED AIR

The device for the supply of compressed air comprises:

- an air compressor at a pressure of 0,1 MPa to within 20% ( $1\text{ bar} \pm 0,2\text{ bar}$ ).
- a pressure regulator if required.
- manometers.
- an air purifier.
- a water saturator.

#### 4.6 SPRAY COLLECTORS

Use as spray collecting devices glass funnels 10 cm in diameter fitted into pierced stoppers placed in measuring cylinders. A 10 cm diameter funnel has a surface opening of approximately 80 cm<sup>2</sup>.

Place at least two collectors in the area of exposure, in such a way as to gather the spray falling directly into the funnels, with the exclusion of the liquid which drains from the exposed samples or from any other part of the chamber.

The collectors are placed in a such a way that one of them is as close as possible to a sprayer and another is as far as possible from all the sprayers.

### 5. METHOD OF OPERATION

#### 5.1. PREPARATION OF THE TEST SPECIMENS

Completely clean the surfaces or the specimens before submitting them to the test. According to their type the cleaning may vary and specifications may be established.

For particular studies of coatings, the specifications may provide for a pattern of score marks laying bare the base metal unless specified to the contrary (or particularised). The cut edges, the portion of the surface in contact with the supports and the rear surface of the test specimens are protected by a coating which is impervious to attack in the prescribed conditions.

#### 5.2. METHOD OF EXPOSURE OF THE TEST SPECIMENS

- 5.2.1. The test specimens must be placed in the chamber in such a way that they are not in the direct path of the atomised spray. Deflectors may be provided to prevent the direct spraying of the solution onto the test specimens.
- 5.2.2. The surface to be tested must be placed in the spray chamber face upwards at an angle of approximately 20° in relation to the vertical. This angle must be between 15° and 30°.
- 5.2.3. The supports of the test specimens must be manufactured from inert non-metallic materials: glass, plastic materials or wood suitably coated. If it is necessary for them to be suspended, the suspension materials must in no circumstances be metal but of synthetic fibres, cotton thread or other inert insulating material.
- 5.2.4. The test specimens must be arranged in such a way that they are not in contact with one another and the test surfaces exposed to the free flow of the spray. The test specimens may be placed at different levels in the spray chamber as long as the solution is not able to run down from the specimens or supports situated at a given level onto those at a lower level.

#### 5.3. CONTROLS

Check the temperature continuously or at least twice daily with a 7 hour interval.

Check the pressure twice daily with a 7 hour interval.

Measure the quantity of saline solution gathered in the collectors once a day.

Check the concentration and pH of the gathered solution.

#### 5.4. DURATION OF THE TEST

The duration stipulated is indicated in the documents (cahier des charges, normes or drawings) relative to the material or coating tested.

##### 5.4.1. CONTINUOUS TEST

During this test, spraying is interrupted only for checking the test specimens.

##### 5.4.2. NON-CONTINUOUS TESTS

###### 5.4.2.1. Non-continuous test first option

First period - spray for 96 hours without interruption, from Monday morning to Friday morning.

Second period - stop spraying from end of spraying on Friday until Monday morning.

During this stopped period, the temperature of the case is maintained at 35° C.

This cycle shall be repeated until the time required for the test of the specimen has elapsed.

This non-continuous test may only be envisaged if the duration of spraying exceeds 96 hours.

###### 5.4.2.2. Non-continuous test second option

First period - spray for 96 hours without interruption from Monday morning to Friday.

Second period - At the end of the first period, all the test specimens are removed, washed, plunged into running water in order to eliminate the salt deposits, then rinsed in deionised water and dried in free air without mechanical action to avoid aggravating any alterations of the material under study.

This cycle shall be repeated until the time required for the test of the specimen has elapsed.

**Note :** *If there is no indication on the documents, the practical test is the continuous test. In this case, the frequency of checking is mentioned in the test report.*

#### 5.5 CLEANING OF THE TEST SPECIMENS

At the end of the test or during the test, taking into account the type of certain test specimens, these are lightly washed or plunged into running water at a temperature not exceeding 37° C in order to eliminate the salt deposits, then they are immediately dried in free air without mechanical action. Particular specifications may provide, if necessary, for additional cleaning, scouring, light brushing.

### 6. EXPRESSION OF RESULTS

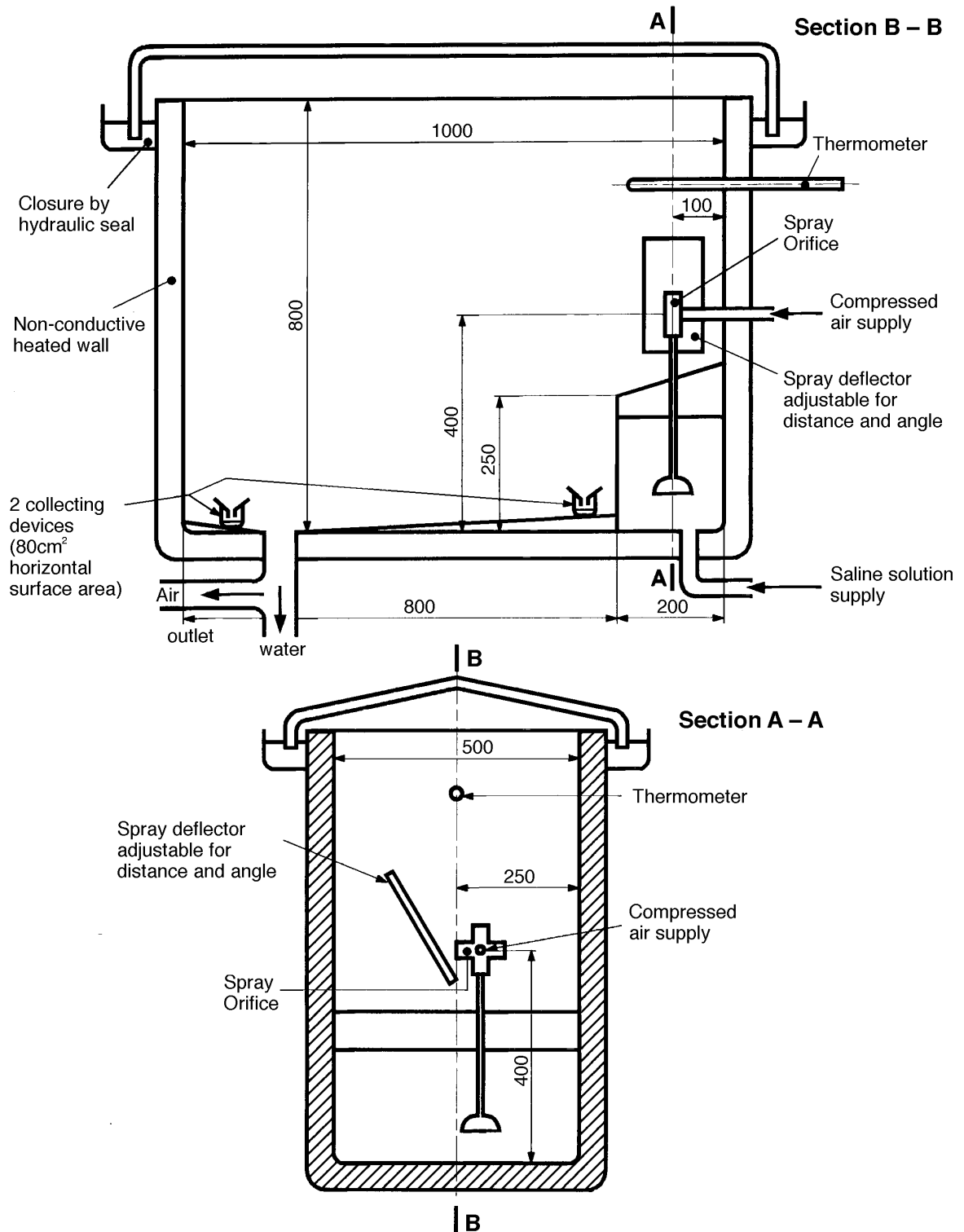
After the stipulated test duration (para 5.4), the degree of oxidation may be evaluated by the loss in mass of the test specimens, by the density of pitting per unit area, by the area of the blemishes or by comparison with standardised scales.

The results shall be expressed in terms of specific grading methods :

- for anodic and cathodic metallic coatings,
- for organic coatings of the paint type, mastics and similar products.

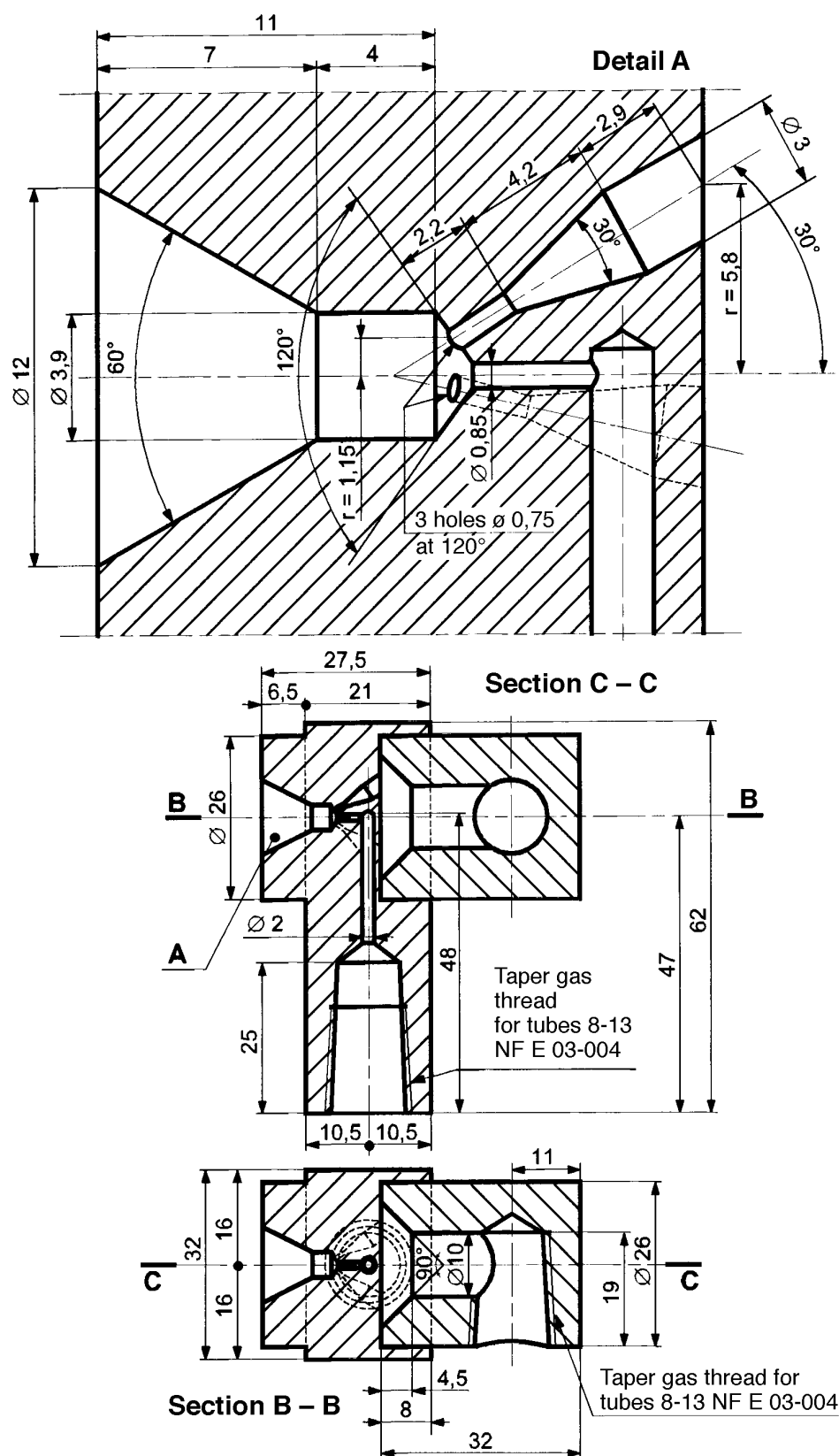
## APPENDIX 1

## DIAGRAM OF SPRAY CHAMBER



## APPENDIX 2

## SALT SPRAY ATOMISER (\*)



(\*) This atomiser is generally manufactured in transparent plastic material which does not deteriorate.



## APPENDIX 3 (1/5)

**METHOD OF GRADING  
COATINGS OF PAINT, MASTICS AND SIMILAR PRODUCTS**

**1.0 EXPRESSION OF RESULTS****1.1. OXIDATION OF COMPLETE PANEL**

The grading of 0 to 9 must be in accordance with the European scale of degrees of oxidation, see appendix 3 (3/5, 4/5 and 5/5).

The scale is comprised of 10 standard photographs showing an identical painted steel plate after a corrosion time of increasing duration.

**1.2. PEELING OFF BY ADHESIVE PAPER**

For this test, plates sizes 90 x 190 mm are used, the sharp edges of which must be protected (PVC tape for example). This test may be carried out in the same manner for components, if the surface of the latter permits. The adhesive tape, transparent or not, must have an adhesive ability of between 1,5 N/cm and 2,5 N/cm.

Before the salt spray test make a V shaped score mark with the aid of a hardened steel point, hardness 63 to 65 HRC and sharpened to a truncated point with a diameter at the end of 3/10 mm, down to the corrodible metal without cutting into it. The length of the cut shall be in the region of 10 cm.

At the end of the test, the test specimens shall be removed from the salt spray chamber, washed in running water and placed to dry for 2 to 3 hours at ambient temperature. Apply the adhesive tape over the whole length of one of the score marks, that is over 10 cm (or over the available length of the part). Pull the adhesive tape away sharply.

**Note :** The total width of the coating peeled off, its continuity or discontinuity.

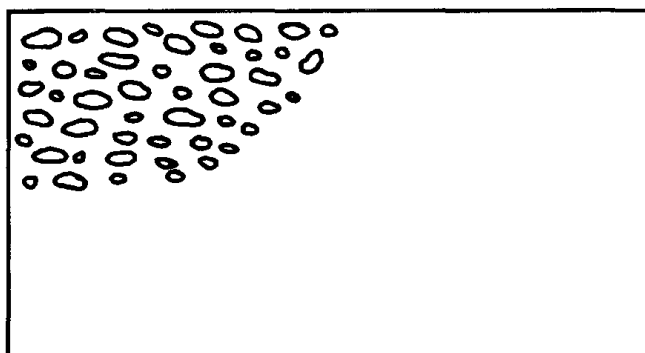
### 1.3 BLISTERING

The grading of 0 to 9 defines the percentage of surface area showing blistering in relation to the surface area of the part.

- 0 - no blistering.
- 1 - 10% of the surface shows blistering.
- 2 - 20% of the surface shows blistering.
- 3 - 30% of the surface shows blistering.
- 4 - 40% of the surface shows blistering.
- 5 - 50% of the surface shows blistering.
- 6 - 60% of the surface shows blistering.
- 7 - 70% of the surface shows blistering.
- 8 - 80% of the surface shows blistering.
- 9 - 90% of the surface shows blistering.

One may indicate the appearance of the blisters in relation to the other scale in the méthode d'essai D27 1571.

Example: Grading 2 (20% of the surface shows blistering, see sketch below).



### 2.0 TEST REPORT

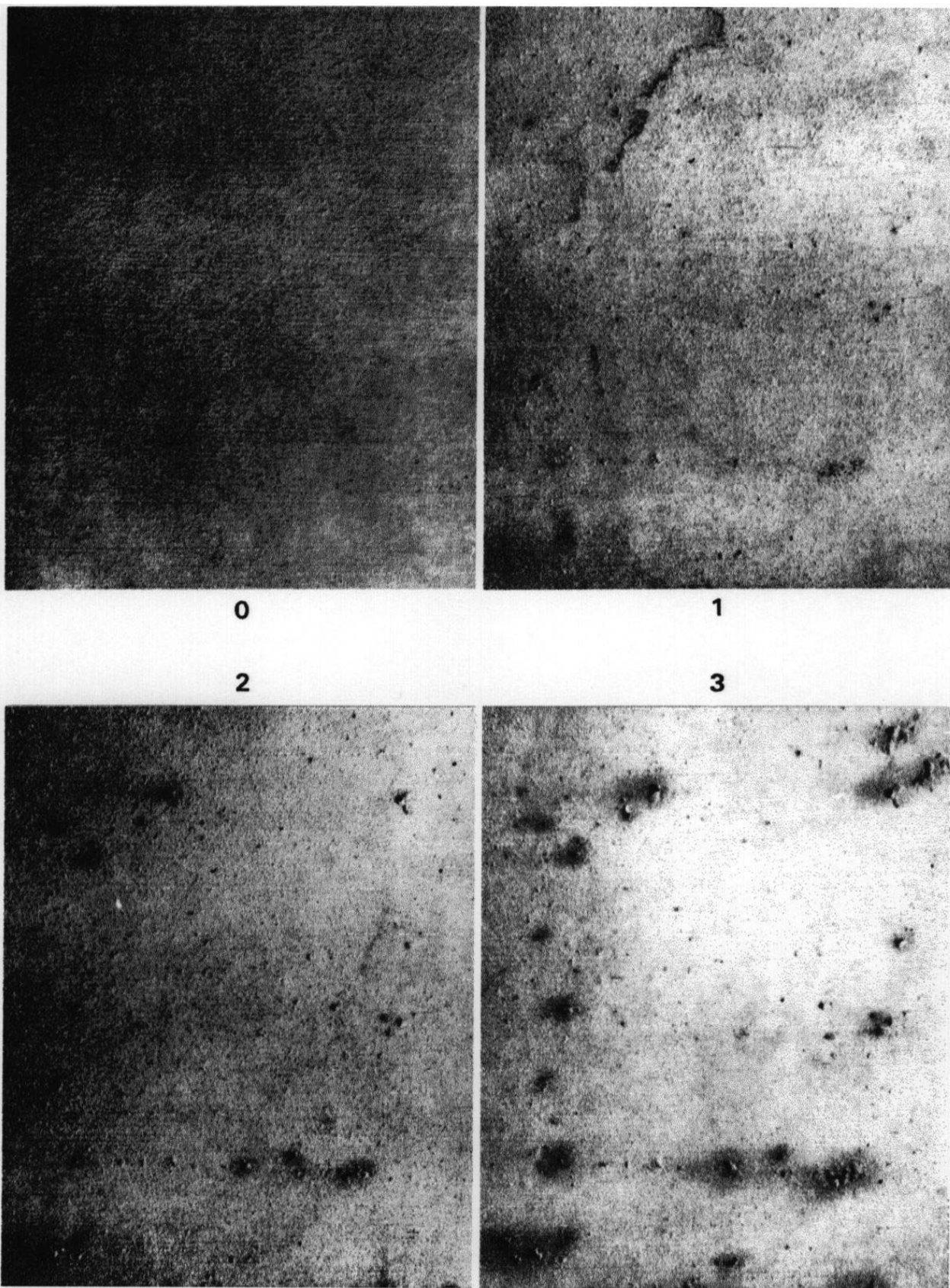
The test report must indicate:

- the concentration of the spray.
- the volume of solution gathered per hour and per collector, its concentration in NaCl and its pH.
- the principal characteristics of the tank.
- the temperature of the chamber and the air pressure.
- type and dimensions of the test specimens, their position in the chamber, their method of cleaning before, during and after the test, the method of protection of the parts not submitted to the test.
- type of test, continuous or non-continuous.
- the total duration of the test, the duration of the interruptions and their reason
- indications of the results.

Furthermore the test report must also mention all the operating details, which are optional or not, provided for in the method, as well as the possible incidents likely to have influenced the results.

## APPENDIX 3 (3/5)

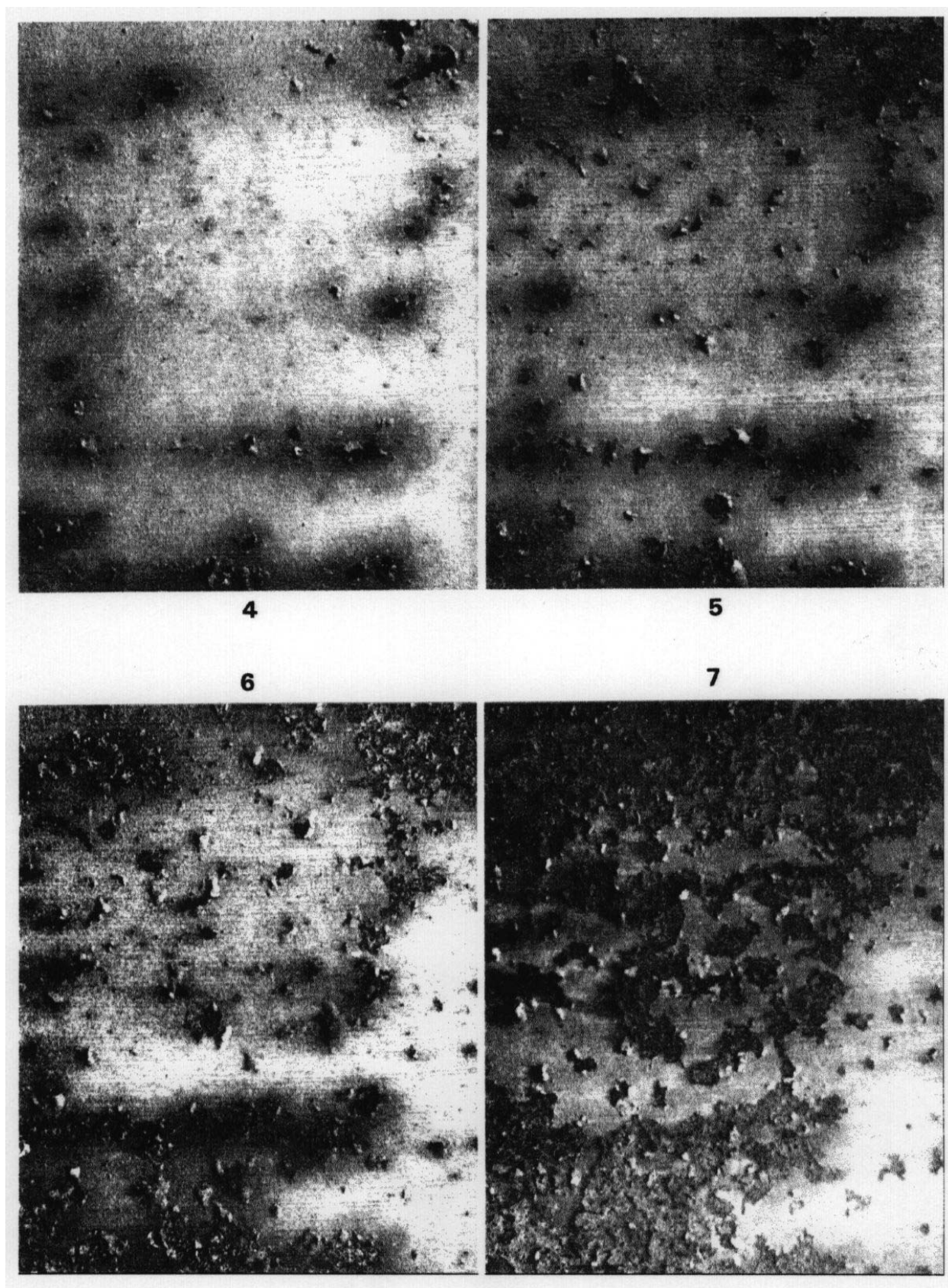
## EUROPEAN SCALE OF DEGREE OF OXIDATION IN MAIN PART OF PANEL



Photographic prints of these pictures are reserved for the user departments and will be issued on request.

## APPENDIX 3 (4/5)

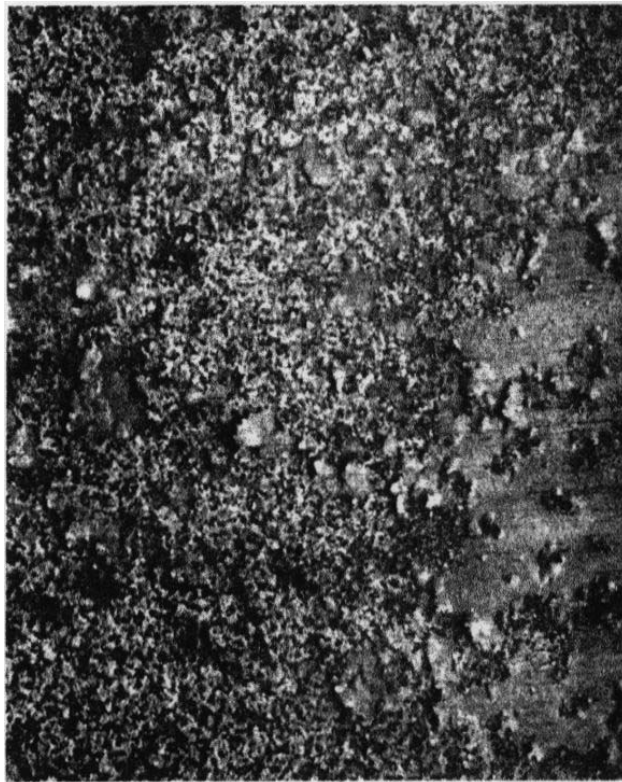
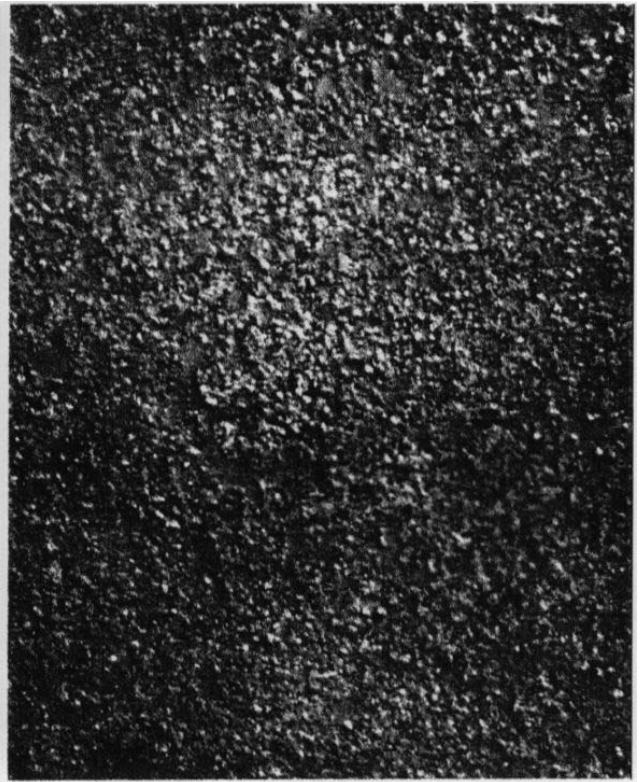
## EUROPEAN SCALE OF DEGREE OF OXIDATION IN MAIN PART OF PANEL



Photographic prints of these pictures are reserved for the user departments and will be issued on request.

## APPENDIX 3 (5/5)

## EUROPEAN SCALE OF DEGREE OF OXIDATION IN MAIN PART OF PANEL

**8****9**

Photographic prints of these pictures are reserved for the user departments and will be issued on request.



### 3.0 EXPRESSION OF RESULTS

Refer to the colour photographs in the norme NFA 91-020 reversing the numbers in conformity with the decision of the Congress of SCHEVENINGEN and while awaiting the up-dating of this norme.

#### STANDARD PHOTOGRAPHS

The two series of six standard photographs show a scale of the degree of attack, with the grading 0-2-4-6-8-10.

- 0 - Initial state unaltered.
- 2 - Alteration of the metal coating without rust (anodic coating).
  - Possible loss of gloss (cathodic coating).
- 4 - Attack of the metal coating without rust with a possible tendency to change to a yellowish tint (anodic coating):
  - isolated pits of rust, the rust is eliminated by rubbing (cathodic coating)
- 6 - Obvious destruction of the coating:
  - spots of brown rust (anodic coating)
  - enlargement of the pits with persistent rust (cathodic coating).
- 8 - Extension of the areas of rust:
  - enlargement of the spots of brown rust (anodic coating)
  - increase in the number and the size of the places of rust (cathodic coating).
- 10 - Extension of the areas of rust until an agreed state exists as the limiting state of the observation.

The standard photographs are life size representations of the states of corrosion on flat test specimens, of square form, with an area of 1 square decimetre, where for purposes of observation a zone around the edges of the test specimen has been eliminated.

The photographs were taken on test specimens straight from the test without any washing.

The comparative observation of these standard photographs is therefore valid for portions of flat surfaces in the same order of size and where the thickness of the coating is appreciably homogeneous. In the case of components with surfaces of complex form, it may be that particular observation specifications should be considered, which may give different gradings for the different parts of the components.

**Note :** *Graph of Corrosion*

*In correlation to the examination of the standard photographs, one may consider establishing a graph of corrosion, where the grading references of the standard photographs are shown as ordinates and the test duration times shown as abscissas.*

*The figures 1 and 2 of the norme NF A 91-020 show a diagram of such graphs, where the observation characteristics corresponding to the numbers of the grading have been referenced.*



#### 4.0 TEST REPORT

The test report must indicate :

- the concentration of the spray
- the volume of solution gathered per hour per collector, its concentration in NaCl and its pH.
- the principal characteristics of the tank.
- the temperature of the chamber and the air pressure.
- the type and dimensions of the test specimens, their position in the chamber, the method of cleaning them before, during and after the test, the method of protection of the parts not submitted to the test.
- the type of test, continuous or non-continuous.
- the total duration of the test, the duration of the interruptions and their reason.
- indication of the results.

Furthermore the test report must also mention all the operating details, which are optional or not, provided for in the method, as well as the possible incidents likely to have affected the results.



**7. RECORDS AND REFERENCE DOCUMENTS****7.1. RECORDS****7.1.1. CREATION**

- OR : 01/09/1979 - CREATION OF THE NORME.

**7.1.2. SUBJECT OF THE MODIFICATION**

A : 01/06/1985 - MODIFICATIONS TO TEXT AND APPENDIX 3

B : 26/09/1997 - INTRODUCED INTO IDEM (*French only*).

**7.2. REFERENCE DOCUMENTS****7.2.1. PSA DOCUMENTS****7.2.1.1. Normes**  
D271571**7.2.1.2. Others****7.2.2. EXTERNAL DOCUMENTS**

NFA91-020(12/1963), NFE 03-004(12/1981), NFX41-022(08/1975)

**7.3. EQUIVALENT TO:****7.4. CONFORMS TO:****7.5. KEY-WORDS**