



TOGETHER
for a sustainable future

OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

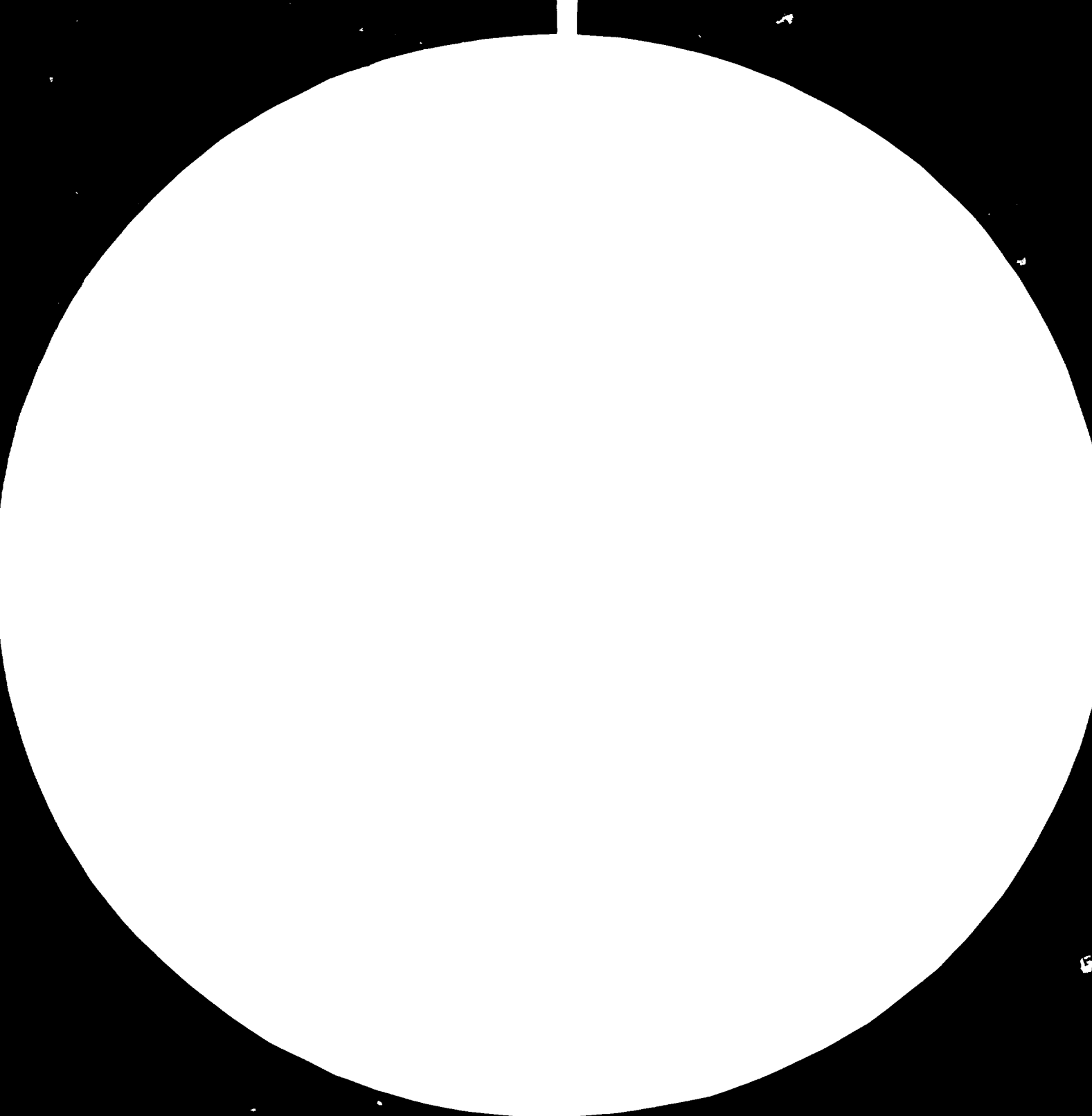
FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org



11.09.25/S- 701

15.12.1982

RESTRICTED

12117

STANDARDIZATION, QUALITY CONTROL
AND QUALITY CERTIFICATION IN THE
IRON AND STEEL INDUSTRY

BRAZIL.

DRAFT STANDARD ON CORROSION PROTECTION

BY

METAL THERMAL SPRAYED COATINGS.

PREPARED BY

JERZY M. ZAWADZKI

UNIDO EXPERT

DRAFT STANDARD ON CORROSION PROTECTION
BY
METAL THERMAL SPRAYED COATINGS

CONTENT	Page
Foreword	1
1. SCOPE AND PURPOSE	2
2. GENERAL REQUIREMENTS	2
3. DEFINITIONS	5
4. CLASSIFICATION	6
5. SELECTION OF COATING METALS AND COATING THICKNESS	7
5.1. Coating metal selection	7
5.2. Arc spraying <u>wires of non ferrous metals</u> ..	7
5.3. Flame spraying <u>wires of non ferrous metals</u> .	8
6. PREPARATION OF SURFACES	8
7. EXECUTION OF WORK	9
7.1. General	9
7.2. Thermal spraying	10
7.3. Painting over sprayed metal coating	10
8. REQUIRMENTS	13
8.1. Thickness	13
8.2. Appearance	13
9. TESTING	14
9.1. Grid test	14
9.2. Visual assessment	15
9.3. Measurement of coating thickness	15
9.4. Micrographic Cross-section	16
10. INVITATION TO TENDER, ACCEPTANCE AND GUARANTEE...	17

FOREWORD

Thermal metal sprayed coatings are industrially used for corrosion protection nearly 50 years. There are many national and international standards in this field. The essential documents are:

ISO 2063-1973 - Metallic coatings-Protection of iron and steel against corrosion - Metal spraying of zinc and aluminium.

BS 2569 - Sprayed metal coatings. Part 1 and Part 2.

DIN 8565 - Protection against corrosion of steel structures by thermal spraying of zinc and aluminium. General Principles.

DIN 8566 - Metals for thermal spraying

DIN 8567 - Pretreatment of metallic surfaces for thermic spraying.

Unfortunately this technology is not implemented in Brazil, where the climatic conditions are in favour of metallic rather than paint coatings.

To promote the use of metal-spraying technology for steel structure protection in steel industry, preparation of draft standard in this field have been requested by Project Manager of Project UNIDO/BRA/75/003 and following specification was elaborated by corrosion expert.

1. SCOPE AND PURPOSE

This Draft Standard applies to the protection against corrosion of steel structures by thermal spraying of zinc and aluminium, both in the case of new buildings and of repair work. In the case of new buildings, it is preferable to sand blast and spray before assembly, either at manufacturer's works or on the building site.

Steel structures within the meaning of this Standard are structures which require a strength calculation or a building inspectorate authorization. Such steel structures have to be protected against rusting in the atmosphere, in water, or in the ground.

This Draft Standard contains general principles outlining how steel structures and components of steel structures can be provided with a high grade protection against corrosion by thermal spraying of metal coats, and how good mechanical properties can be imparted at the same time to the sprayed coat. This Draft Standard also deals with the preconditions that have to be executed for the successful application of thermal spraying, and it gives instructions for the proper carrying out of the work.

2. GENERAL REQUIREMENTS

- 2.1. The specification should indicate areas not to be coated with metal (e.g. interior of a box girder may be left untreated when the outside is metal sprayed). This concerns also weld fusion faces, which should be cleaned and treated

by permanent paint coat subsequently (generally by sand-blasting and zinc-rich polyurethane coating).

- 2.2. Each painter employed should be skilled in metal spraying and experienced in painting and atmospheric conditions suitable for painting.
- 2.3. No further paint coat should be applied until the previous paint coat has dried or cured sufficiently.
- 2.4. Large flats and girders such as joint sections are suitable to metal spraying; lattice constructions and small sections are preferred for hot-dip galvanizing.
- 2.5. Due consideration has been given to the fact that all recommendations of a general character applied to the protection of steel structures against corrosion are being incorporated in the general corrosion prevention specification.
- 2.6. The special significance of thermal spraying with zinc and aluminium, as regards corrosion prevention, lies mainly in the fact that, similarly to what happens in the case of hot dip coatings (hot dip galvanizing), a preliminary metal coating is created on the steel surface. In conjunction with further organic coatings, it provides an exceptionally good system of long-term protection against corrosion, which obviates the necessity for further expensive and elaborate rust-proofing measures in conditions when the top coating is properly maintained or renewed in suitable time. For these reasons, an additional (top) coating applied thermally

sprayed base coat is recommended in all cases, even where the surface is only exposed to mild atmospheric environment.

- 2.7. Thermally sprayed coatings always exhibit a certain porosity, for technical reasons. Therefore a top organic coating which fills the pores and acts as a sealant is particularly recommended; it should be applied as soon as possible after completion of thermal spraying. On the other hand, thermally sprayed metal coats, thanks to the nature (roughness) of their surface, provide an exceptionally good anchorage for the top organic coatings applied subsequently, without requiring any special preparatory treatment to improve adhesion. They can be applied on large steel structures already assembled on site, and they can also be applied in a greater range of coat thicknesses.
- 2.8. It is self-evident that the favourable properties which can be achieved by means of thermally sprayed coats will in fact only be achieved in conditions that all: surface preparation, metal spraying and top coating work, are carried out conscientiously by skilled labour. This means that the workmen carrying out the job and their supervisors should have a level of training and experience at least equal to the standard.
- 2.9. The preconditions for durable protection against corrosion include: thorough cleaning and preparation of the surfaces to be protected, to be followed immediately as possible by thermal spraying resulting in an adequately thick coat of sprayed-on metal.

2.10. Thermally sprayed coats shall be provided with suitable additional coatings, e.g. of paint, if they are exposed to the atmosphere; if they are immersed in water or buried in the ground, they must be provided with suitable additional coatings.

2.11. Only structures, with surfaces requiring protection, which are easily accessible for preparation and spraying, can be effectively protected. All sharp edges and crevices must be avoided. Steel structures consisting of solid girders, tubes and components with other types of hollow cross-section are particularly well suited to thermal spraying. Because of their smooth surfaces, welded structures are preferable to rivetted or bolted structures. Areas susceptible to contact corrosion must be protected by suitable means, to be agreed with purchaser.

3. DEFINITIONS

3.1. Sprayed metal coatings are defined by their thickness which is measured over a reference surface of about 1 cm^2 according to draft standard (UNIDO/S-647)..

3.2. The measured thickness shall not be lower than the thickness given in the coating symbol.

3.3. The thickness may be measured both by supplier and purchaser, at the acceptance of the coated products. The number and distribution of these measurements over the whole surface may be specified by agreement between the interested parties.

3.4. In the particular case of very large surfaces it may be considered, by agreement between the interested parties, to measure the thickness over a reference surface of about 1 cm² for each portion of the surface of about 10 m².

4. CLASSIFICATION

The zinc or aluminium coatings covered by this draft Standard are classified according to their minimum thickness as shown in the Table 1 below.

Table 1 - Classification of sprayed coatings

Coating metal	Minimum thickness	Symbol
Zinc	40*	Zn 40
	80	Zn 80
	120	Zn 120
	160	Zn 160
	200**	Zn 200
Aluminium	80*	Al 80
	120	Al 120
	160	Al 160
	200	Al 200
	300**	Al 300

* These coatings are used for certain special applications.

** By special agreement, greater thicknesses may be used if the coating obtained remains in conformity with this International Standard.

5. SELECTION OF COATING METALS AND COATING THICKNESS

5.1. Coating metal selection

The following metals are recommended:

5.1.1. For town and rural atmosphere:
zinc

5.1.2. For industrial atmosphere:
Pure aluminium or zinc.

5.1.3. For sea atmosphere:
Pure aluminium, aluminium alloys (AlMg3, AlMg5),
zinc.

5.1.4. Under water and buried underground:
Sprayed-on metal coating individually selected
and most suitable for the particular case,
taking local experience into account and carrying
out special studies on corrosion.

5.1.5. Exposure to heat:
- Zinc, not exceeding 200°C in a dry atmosphere,
and not exceeding 60°C in aqueous media,
- Aluminium, not exceeding 450°C, but higher
temperatures are admissible in special
applications.

5.2. Arc spraying wires of non ferrous metals

5.2.1. Aluminium: Al 99,5, AlMg 3 or AlMg5 wires
should be used for rust protection. Al 99,5 wire
should be used with sealing.

5.2.2. Zinc: Zn 99,99 wire should be used for rust protection.

5.3. Flame spraying wires of non ferrous metals

5.3.1. Aluminium or zinc solid wires for flame spraying as designated in DIN 8566 Part 1 (1979) should be used.

6. PREPARATION OF SURFACES

6.1. Particular attention shall be given to the preparation of the surface before spraying. This preparation shall be carried out by blasting, with abrasive.

6.2. In general, one of the following abrasives shall be used to produce suitable surface roughness.

- hematitic chilled cast iron grit;
- corundum grit.

In some cases, crushed, sharp siliceous sand or steel grit may be used, but with special precautions to achieve sufficient roughness ensuring adhesion of the sprayed metal.

The grit size shall be between 0,5 and 1,5 mm.

6.3. Whatever abrasive is used, it shall be perfectly clean and dry and, in particular, free from soluble salts. In the case of abrasive blasting with the aid of compressed air, the air shall be sufficiently clean and dry to avoid contaminating the abrasive or the surface to be metal sprayed.

6.4. In all cases, the quality and the geometrical profile of the surface shall be verified by comparison with a reference surface prepared according to specifications agreed between the interested parties.

7. EXECUTION OF WORK

7.1. General

7.1.1. The preparation work and the spraying shall be carried out by specialist firms.

7.1.2. Throughout all this work, the currently valid versions of the accident prevention regulations must be observed.

7.1.3. All welding splatter, welding dribble and welding beads shall be removed from workpieces and welding seams. Welding seams shall be sand blasted with particular care and attention.

7.2. Thermal spraying

7.2.1. The condition of the technically clean joint face achieved by preparation must not exhibit any change up to the time the coat is sprayed on.

7.2.2. Steel structures shall be sprayed in their entirety or in sections, depending on size. Friction faces for high strength bolted fastenings and flanks shall be left untouched.

- 7.2.3. The metal spraying shall be carried out after the surface has been prepared by abrasive blasting, within a period such that the metal is sprayed onto a sanded (or blasted) surface which is still completely clean, dry and not oxidized.
- 7.2.4. In good weather, in a not too humid atmosphere, this period may be as much as a few hours. In rainy weather or in a humid or marine atmosphere, it may have to be reduced to 2 h or even less, but in this case the operation shall be carried out under cover.
- 7.2.5. If an appreciable deterioration in the surface to be coated is observed, by comparison with a metal surface of similar quality which has undergone the same preparation, the preparation treatment must be repeated on the surface to be coated.
- 7.3. Painting over sprayed metal coating
- 7.3.1. When a complex "sprayed metal + paint" coating is used, such a coating shall be regarded as a coherent whole in which the paint system is selected in relation to its compatibility with the sprayed metal and with the corrosive medium to which it is to be exposed.
- 7.3.2. Additional coatings shall preferably be applied immediately after the thermal spraying. Any corrosion products which may become apparent, and any dirt shall be removed before the coating is applied.

- 7.3.3. Top coating must fill the pores, act as a sealant, be resistant to swelling and have good adhesion. They must also be compatible with the sprayed-on coat and adequately cover any roughness peaks of the sprayed-on coat.
- 7.3.4. Renewal of the top coatings in good time greatly reduces the likelihood of build-up and rusting beneath the sprayed-on coat. All that is necessary prior to renewal of the top coating is a thorough cleaning of the surface, e.g. removal of the corrosion products, loose portions of coating and dirt.
- 7.3.5. Paint coating and thickness of metal and paint coating for different atmosphere to secure sufficient time to first maintenance according to Table 2.
- 7.3.6. Sealing and paint selection
- (a) As inhibitive pretreatment - before sealing zinc tetroxochromate two pack wash-primer on poliurybutyral/phenolic basis with 10% volume of solids should be applied by spraying (wet).
- (b) As sealing compound(s), aluminium pigmented varnish should be used with 15% volume of solids and 95% main pigment (Al) in total pigment by weight % minimum. Vinyl (non-saponifiable), two-pack epoxy, two-pack phenolic and two-pack poliurethane should be used as vehicle. Spraying application of 1-2 coats is advised.

Table 2 - Sprayed metal and metal-organic coating systems

Time to first maintenance (y)	Atmosphere (environment) during exposure of steel structure	Metal coating thickness (μm)		Paint coating thickness (μm)	
		Al	Zn	on Al (μm)	on Zn (μm)
15	Exterior exposed non polluted	160	-	120+S ¹⁾	160+S ¹⁾
10-15	" "	120	160	120+p ²⁾	120+p ²⁾
15	Exterior exposed polluted inland	160	300	160+S ¹⁾	200+S ¹⁾
10-15	" "	120	160	120+S+100p ²⁾	120+S+100p ²⁾
15	Exterior exposed coastal	200	350	160+S	200+S
10-15	" "	160	300	120+S	160+S
10-15	" "	-	-	120+S+100p ³⁾	120+S+100p ³⁾
15	Interior of wet building	160	160	120+S+100p	120+S+100p
10-15	" "	120	120	120+100p ³⁾	120+S+100p ³⁾
15	Non saline water	-	-	160+S	160+S
10-15	" "	-	-	160+S	160+S
15	Sea water splash or spray	-	-	160+S	300+S
10-15	" "	-	300	-	200+S
"	" "	-	-	120+S+100p ³⁾	120+S+100p ³⁾
15	Sea water immersed	-	-	160+S	300+S
10-15	" "	-	300	-	160+S
"	" "	-	-	120+S+100p ³⁾	120+S+100p ³⁾

- 1) Preatreatment (p) and sealing (s) as shown in 7.3.6(a) (b).
- 2) Painting as shown in 7.3.6 (c) with 100 μm coating thickness
- 3) Primer + top coat.

(c) As paint coat one to two coatings of suitable paint should be applied by brush or a gun, conforming to specification and environment aggressivity. This paint coating have to be replaced by a new one, when deteriorated, during repainting of steel structure.

8. REQUIREMENTS

8.1. Thickness

The thickness of the coating shall at no point be less than the minimum value defining the coating, in accordance with the indications in the Table 1 and 2.

The measurements of thickness shall be made by magnetic measuring methods which can be used in all cases, provided sufficient number of measurements which must be used for the arithmetic mean calculation.

In the case of dispute, use may be made of the micrographic cross section method, when possible.

8.2. Appearance

The surface of the coating shall be of uniform appearance, without blisters or bare patches, and free from non adhering metal.

8.3.

Adhesion. The coating shall conform the grid test i.e. at the end of the test, no separation from the basis metal shall have occurred within the squares cut.

9. TESTING

9.1. Grid test

(a) Principle

The coating is cut through to the basis metal to give a lattice pattern. At the squares of the lattice having given dimensions, no separation of the coating shall occur.

(b) Equipment

Cutting tool with a hard edge of a type similar to that shown in Figure 1.

(c) Procedure

Using the tool defined in Fig. 1 cut a lattice of the following dimensions:

Approximate surface covered by the lattice	Distance between cuts , mm	Thickness coating verified, μm
15mm x 15mm	3	up to 200
25mm x 25 mm	5	over 200

The depth of the cuts shall be such that the coating is cut through to the basis metal.

Where possible, after the lattice has been cut, a suitable adhesive tape, agreed between the interested parties, shall be applied to this part by means of a roller with a loading of 500g.

The adhesive tape shall then be pulled off in a quick and abrupt manner, in a direction perpendicular to the surface.

If this is not possible, a method of scrubbing the coating must be agreed between the interested parties.

(d) Interpretation of results

No part of the coating shall separate from the basis metal. The adhesion shall be considered satisfactory if, in each square of the grid, part of the coating still adheres while the remainder is stuck to the adhesive tape, breakage having occurred within the layer of coating metal and not at the interface.

9.2. Visual assessment

(a) A comparison with glass paper (emery paper) of granulation 100 to 200 will give an adequate indication for the visual assessment of the fineness of grain.

(b) A photomicrograph can be prepared for checking purposes.

9.3. Measurement of coating thickness

(a) Measurement of the thickness of coat on steel structures or finished parts can be carried out conveniently with the aid of coat thickness measuring instruments designed for non-destructive testing.

(b) The correct use of these test methods and the proper assessment of the results demand expert knowledge.

(c) The unavoidable range of error of non-destructive measurement methods should be pointed out, and this is made even worse by variations in surface roughness.

(d) Ten measurements shall be made uniformly distributed along one of the sides of the test piece and covering approximately the 20mm length of the cross-section (object surface), and the arithmetic mean of these shall be taken.

9.4. Micrographic cross-section

(a) Principle

Micrographic examination by means of a microscope on the cross-section of a test piece cut from the sample in accordance with the specifications given in ISO 1463.

(b) Comments

For the special case of coatings obtained by spraying, and in order to prevent the separation of the coating from the substrate, and the rounding of the edges, the test piece shall be mounted in an appropriate way.

10. INVITATION TO TENDER, ACCEPTANCE AND GUARANTEE

Before commencement of the work, it is recommended that all agreements concerning acceptance, guarantee and testing should have been concluded, taking the special conditions involved in each case into consideration.

The type, texture and thickness of the sprayed-on coat and the additional top coatings shall be laid down in the specification.

During the acceptance procedure, the surface finish and the minimum coat thickness in particular shall be determined by means of non destructive test methods. The scope of these testings and of further testings if necessary shall be mutually agreed.

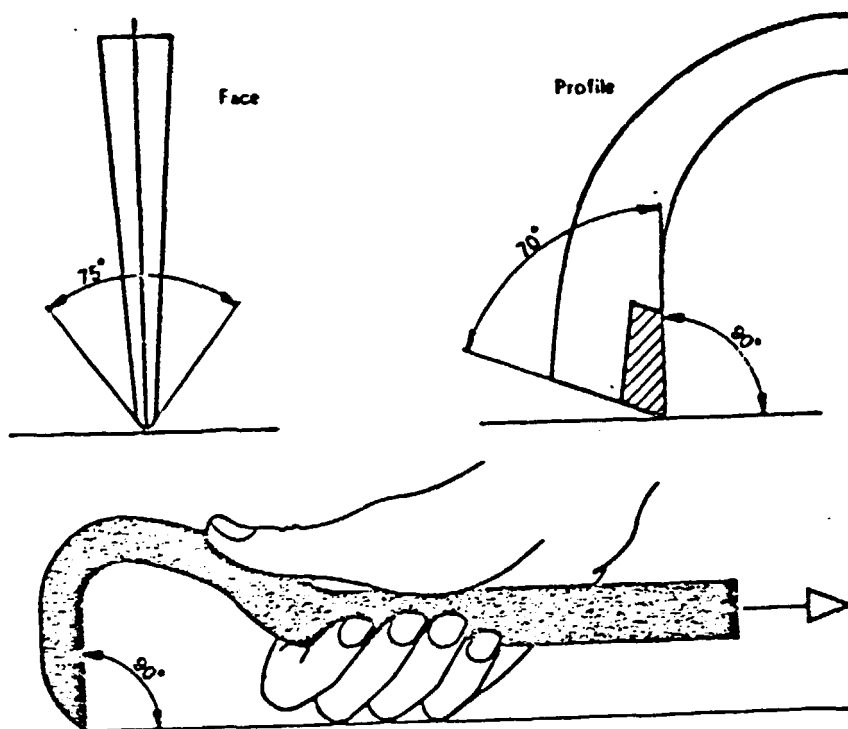


Fig. 1 - Grid test cutting tool



