

Coating thickness measures for verification of thickness meters

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Coating thickness meters are verified in accordance with verification schedule [1] and requirements of GOST 8.502-84 «State system for ensuring the uniformity of measurements. Coating thickness gauges. Verification methods and means». Coating thickness measures are the main means of verification.

Measures are subdivided into natural ones (NCTM) and imitators (CTI).

Structurally, natural measure represents basis with coating of given thickness applied on its middle part.

Coating thickness imitator represents round or square flat plate of certain thickness.

Measures differ by materials of coatings and bases. Coatings on measures can consist of single layer or multiple layers of different materials.

Measures are combined into sets and cover certain range of coating thicknesses. One measure basis without coating is included into the composition of set.

When set includes both natural measures and imitators, it is called as Combined set of coating thickness measures (CSCTM).

Typical design of coating thickness natural measures is presented in MI 1903-96 [2]. Schematic drawing of the coating thickness measure applied in Russia for verification of coating thickness meters is presented in Fig.1.

Measure has square shape and stepped design. Overall dimensions of the measure basis: 40x40x10 mm. Overall dimensions of coating located in the center of basis: 20x20 mm. There is uncoated part of basis around coating required for measurement of coating thickness on a measure.

In 2006, coating thickness measures of MC-on-MB (magnetic coating on magnetic basis), MC-on-DCB (magnetic coating on diamagnetic conducting basis), DCC-on-MB (diamagnetic conducting coating on magnetic basis), DCC-on-DCB (diamagnetic conducting coating on diamagnetic conducting basis) type and CTI

imitators have passed tests and were entered into the State Register of measurement means (no. 34825-07).

Table 1 presents recommended materials for measures, while Table 2 provides the main technical characteristics.

Table 1.

Measure type	Material	
	Coating	Basis
MC-on-DCB	Nickel	Copper alloy (L 62, BrC-08, etc.)
MC-on-MB	Nickel	Structural steel (steel 20, etc.)
DCC-on-DCB	Chromium, copper, silver, gold	Copper alloy (L 62, BrC-08, etc.); titanium, aluminum and other alloys
DCC-on-MB	Chromium, copper, zinc, cadmium, stannum, copper + chromium, nickel + copper + chromium	Structural steel (steel 20, etc.)
CTI	Dielectric (quartz glass, silicium, polyethylene, fluoroplastic, etc.)	Structural steel (steel 20, etc.). Brass (L 62, etc.)

Table 2

Item	Coating thickness measure type	Rated thickness value, μm	Limits of permissible error, μm
1	MC-on-MB	5 – 10 – 20 – 50 – 75 – 100	$\pm(0.02X + 0.15)$
2	MC-on-DCB	5 – 10 – 20 – 50 – 75 – 100.	$\pm(0.02X + 0.15)$
3	DCC-on-MB	5 – 20 – 50 – 10 – 150 – 200	$\pm(0.02X + 0.15)$
4	DCC-on-DCB	5 – 20 – 50 – 100 – 150 – 200;	$\pm(0.02X + 0.15)$
5	CTI films:	12 – 20 – 50 – 75 – 100 – 150 – 200 – 350	$\pm(0.02X + 0.15)$
	quartz glass:	500 -750 – 1000 – 1500 – 2000 – 5000 – 10000 – 20000	$\pm 0.01X$

Indicated coating thickness measures are reference ones and are intended mainly for verification of thickness meters.

In industry, in addition to these measures, coating thickness measures made of materials being the same as ones of tested articles are applied. Such measures

are referred to working ones. By design, they are similar with reference ones and are measured by the same measurement means.

Recently, great attention is paid to creation of measurement means for the thickness of nickel coating applied on aluminum alloy. Under applicable classification, such combination of materials is referred to the group magnetic coatings applied on the diamagnetic conducting basis (MC-on-DCB). In practice, measurement range of up to 100 μm is mostly spread.

In FGUP “VNIIMS”, pilot samples of the sets of nickel coating thickness measures on the aluminum alloy D16T are developed and manufactured.

Production technology for measure set consists of following operations:

- manufacturing of measure bases and finishing of working surface;
- measurement of flatness deviation and roughness of the working surface of basis;
- application of coating under special technology;
- measurement of coating thickness on measures.

Table 3 presents measurement results for flatness deviation and roughness of the basis working surface of measures following finishing. As is seen from the Table, obtained flatness deviation across the whole working surface of bases (40x40 mm) is within limits from 0.25 to 3.35 μm , surface roughness R_a is within limits from 0.012 to 0.031 μm .

Finished measure bases were used for application of nickel coating.

For production of thickness measures of nickel coating on the aluminum alloy D16T, modified industrial technology was applied.

Under above disclosed technology, two sets of thickness measures of nickel coating on the aluminum alloy D16T were produced; these sets included measures with rated coating thicknesses 30 – 50 – 60 – 100 μm .

Coating thickness on measures was measured under methodology MI 1903-97 by means of Form Talysurf instrument of the Taylor Hobson Company (England).

Thickness in i -th point of the coating profile h_i is determined under formulae $h_i = h_{pi} + \delta_{pi}$, where: h_{pi} – is thickness defined as perpendicular drawn from given

point of the thickness profile to assumed measurement base; δ_{pi} – is correction for flatness deviation of the basis surface in given point.

Coating thickness attributed to a measure is defined as arithmetic average of measurement results on the given working area of measure coating under the following formulae

$$h = \frac{\sum (h_i + \delta_{p_i})}{n} = \frac{\sum h_i}{n} + \frac{\sum \delta_{p_i}}{n},$$

where: $n = N \cdot K$; N – is the number of profile diagram points where coating thickness is determined; K – is the number of profile diagrams obtained on a measure.

Table 4 presents the following: measurement results for coating thickness in both sets; evaluation of the mean square deviation (MSD) of arithmetic average (σ); limits of permissible error (3σ); and relative error (in %).

As is seen from Table 4, absolute error of measures is within the limits from 0.12 to 0.63 μm , which corresponds with relative error within 0.4 to 0.6%.

Experimental studies [3] have shown that elaborated technology makes it possible to manufacture thickness measures of nickel coating on the aluminum alloy D16T within the thickness range of up to 100 μm with absolute (relative) error within 0.12 – 0.63 μm (0.4 – 0.6%); it is sufficient for verification of thickness meters of similar destination having error of less than 1%.

Currently, reference and working coating thickness measures are produced under individual orders and are used to equip the number of metrology and standardization centers, as well as metrological departments of enterprises.

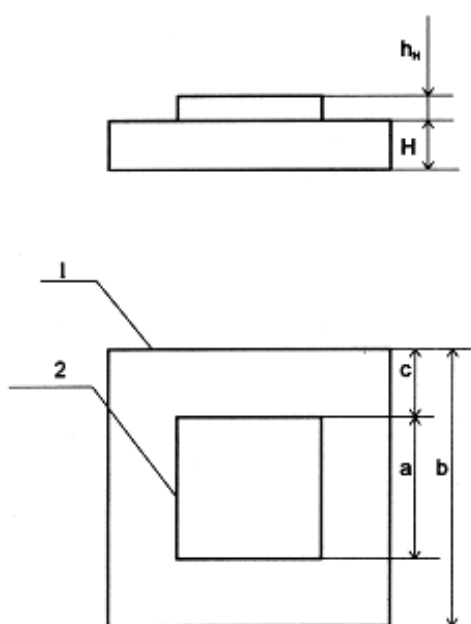


Fig. 1. Coating thickness measure drawing

1 – basis; 2 – coating; $a = 20 \pm 0.5$ mm; $b = 40 \pm 0.5$ mm; $c = 10 \pm 0.5$ mm; $H = 8 - 10$ mm.

Table 3. Characteristic of measure basis surface and corrections to flatness deviation

Number of sample	Flatness deviation, μm	Surface roughness, Ra, μm	Correction to flatness deviation, μm
02	0.6	0.012	- 0.020
04	1.9	0.023	+ 0.40
06	0.4	0.029	+ 0.10
07	0.3	0.029	+ 0.005
08	0.25	0.029	+ 0.050
10	0.4	0.031	+ 0.026
11	0.3	0.028	+ 0.014
12	0.4	0.025	+ 0.070

Table 4. Measurement results of coating thickness in sets

Designation of set	Number of measure	Arithmetic average of measurement results, μm	MSD of measurement result arithmetic average, μm	Limits of permissible error (3 MSD), μm	Relative error, %
MC-on-DCB no.1	08	29.72	0.04	0.12	0.4
	07	50.25	0.07	0.21	0.4
	12	61.33	0.11	0.33	0.5
	02	105.64	0.21	0.63	0.6
MC-on-DCB no.2	11	30.21	0.04	0.12	0.4
	10	48.09	0.07	0.21	0.4
	06	62.64	0.13	0.39	0.6
	04	100.01	0.14	0.42	0.4

References.

1. R 50.2.006-2001. State system for ensuring the uniformity of measurements (SSEUM). State verification schedule for means measuring of the coating thickness in the range of 1 to 20,000 μm .
2. MI 1903-97 SSEUM. Coating thickness reference gauges. Verification methods.
3. Babadzhhanov L.S., Babadzhhanova M.L. Metrological support of coating thickness measurements. Theory and practice. IPC Publishing house of standards. 2004