Analysis of regulatory documentation for thickness of coatings of materials and products

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Abstract. It is shown that normalizing the thickness of coatings in the design of products and finding the actual value of the thickness of the coating layer with a given accuracy in manufacturing is a pressing task. An analysis of the regulatory documentation was carried out, which showed that there are recommendations for normalizing the thickness of the coating to select only the minimum thickness of the coating. The maximum thickness of the coatings is not regulated, which leads to unnecessary over expenditure of the coating material, energy and other costs and does not allow selecting the means of measuring the thickness of the coatings depending on accuracy.

In the production of most machines and mechanisms, certain types of coatings are used. For example, paint coatings are used for protective and decorative purposes. Most metallic and non-metallic inorganic coatings have similar objectives. In addition, in modern technologies coatings are used to increase wear resistance of surfaces, hardness, strength of parts, etc.

One of the main indicators of the quality of the coating, which must meet the specified technical and economic requirements, is its thickness [1]. Therefore, rationing and determining the thickness of the coating is the basis for evaluating its quality.

The technical documentation indicates the minimum value of coating thickness, which should provide protective capacity and its functional and special properties under the specified operating conditions. In addition, the minimum thickness of the coatings should ensure the specified life of the products.

The maximum thickness of the coatings can be determined from material savings (e.g., precious metal coating) or from technological capabilities. Undue increases in coating thickness result in undue time, material and energy costs in coating applications [2, 3]. When applying coatings to the mating surfaces of the parts, increasing the thickness of the coatings will reduce gaps or increase interference in the mating.

It follows that it is an urgent task to normalize the thickness of coatings when designing products and finding the actual thickness of the coating layer with a given accuracy in manufacturing.

In order to identify recommendations on standardization of minimum and maximum values of coating thickness and to specify them in the design documentation, we will analyze the regulatory documentation. Let's look at the basic standards of the Unified Corrosion and Aging Protection System.

For application of coatings on the surfaces of carbon steel parts GOST 9.303-89 sets the thickness of protective and protective-decorative coatings in the range from 6 to 30 μm depending on the type of

coatings and conditions of operation and climatic design of the articles. For corrosion resistant steel coating thickness is recommended from 3 to 24 μm; by cast irons - from 3 to 40 μm. For copper and copper alloys - from 1 to 18 μm. Approximately the same recommendations on thickness GOST 9.303-89 leads for Aluminum, Zinc, Titanium and other alloys.

The standard provides recommendations for the assignment of coating thickness for parts mating by different fits and for threaded parts.

For the most part, the standard sets the minimum thickness of coatings. Where the thickness interval is given, the specific minimum thickness of the coating within the specified limits is specified in the regulatory and technical documentation taking into account the specifics of the product and the technology of obtaining the coating.

For four groups of coatings GOST 9.303-89 gives the permissible maximum thickness of metal coatings depending on the minimum value. If you use definitions for linear dimensions (GOST 25346-2013), the difference between maximum and minimum values is a tolerance for coating thickness. For the specified groups of coatings we will determine permissible values of thickness and we will assign to the minimum value of thickness. The calculation results are shown in figure 1.

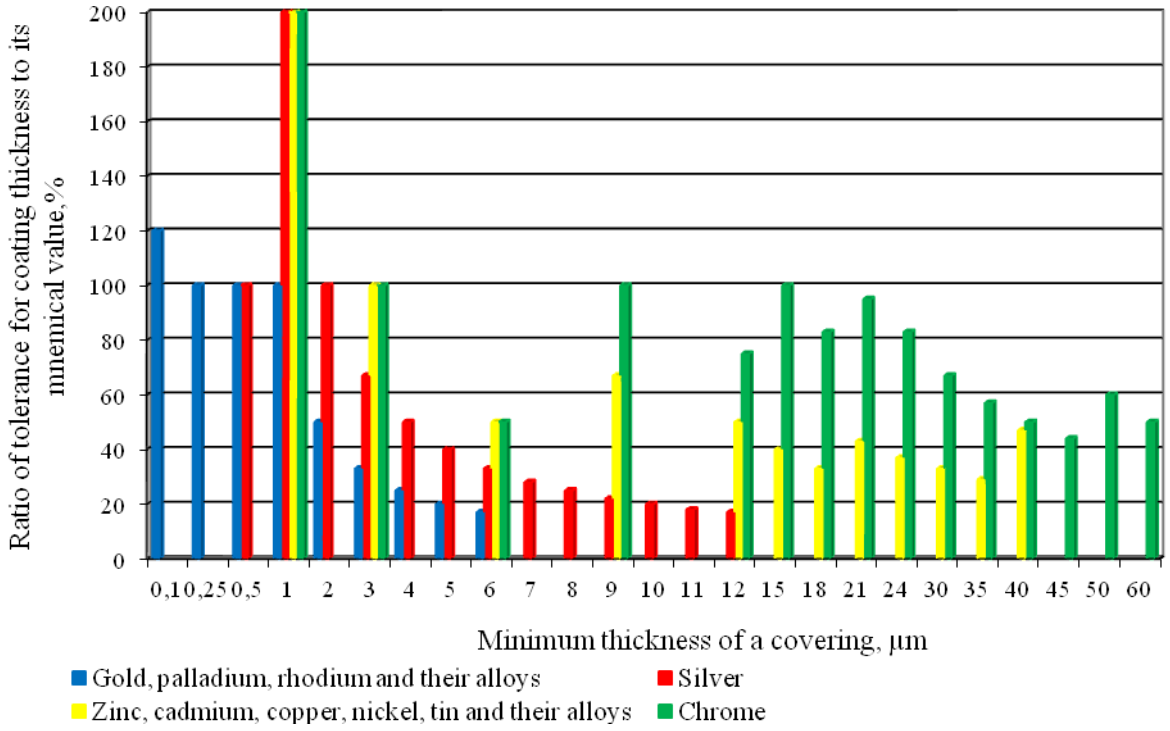

Figure 1. Ratio of tolerance to minimum thickness of coatings.

The graph shows that the ratio of tolerance to minimum coating thickness is non-systemic. Thickness ranges are different for each coating group, for example gold and others are normalized from 0.1 to 6 μm, silver from 0.5 to 12 μm, chromium from 1 to 60 μm, although GOST 9.303-89 does not exclude the possibility of expansion of these ranges. There is no association with rows of preferred numbers. In addition, these tolerances can exceed their nominal value up to twice, although in systems of tolerances for linear dimensions, splinted, threaded joints, etc., the tolerances are a certain part of the nominal size. Thus, the maximum thickness of the coating given in GOST 9.303-89 should be considered as a technologically or economically achievable value, not a parameter for determining the tolerance.

General requirements for coatings produced by gas-thermal spraying are set by GOST 9.304-87. The recommended minimum coating thickness should be 80 to 250 μm depending on the coating type

and service life. For coating thickness control GOST 9.304-87 recommends to use magnetic thickness meters with measurement range from 0 to 500 μm with relative measurement error not more than 10%.

The minimum thickness of protective and protective-decorative anode-oxide coatings applied on the surface of semi-finished products made of Aluminum and its alloys is normalized by GOST 9.031-74. The standard sets a minimum coating thickness of 9 to 30 μm, which depends on the type of coating and the corrosion aggressiveness of the atmosphere.

Thickness of zinc coatings applied by hot galvanizing method (GOST 9.307-89) must be not less than 40 μm and not more than 200 μm. Measuring tools for non-destructive testing of coating thickness shall have measurement error of not more than ± 10%. When controlling the thickness of coatings, the standard recommends the use of magnetic methods, as arbitration control - metallographic.

Thickness of Aluminum hot coatings according to GOST 9.315-91, applied by method of immersion in melt of building structures, steel sheets, pipes, etc., can be within the range from 50 to 200 μm. The specific coating thickness is specified in the product specification. The relative error of the magnetic measurement method shall not exceed ± 10%.

The application of metallic and non-metallic inorganic coatings to plastics has its own characteristics. General requirements for such coatings are set forth in GOST 9.313-89. The thickness of the coating depends on the specific operating conditions and should be in the range of 3 to 24 μm.

Thickness of paint coatings is normalized by GOST 9.105-80. The thickness of the coating layer, depending on the state of the paint material and the coloring method, is shown in table 1.

It can be seen that the thickness limits of one paint coating layer by the liquid dispersion material in various application methods are in the range of 6 to 50 μm. The exception is coatings applied with powder material, the thickness of which reaches 250 μm. Thickness of paint coating is comparable to thickness of metal coatings. Therefore, when normalizing the accuracy of coating thickness, it is possible to produce uniform recommendations.

Table 1. Values of paint coating layer thickness.

Condition of a coating composition	Coloring method	Thickness of one layer paint and varnish coverings, μm
Painting with liquid dispensed material	Pneumatic spraying without heating	6-10
	Pneumatic heating spray	20-50
	Airless spray without heating	8-45
	Airless heating spray	25- 50
	Electrostatic dispersion	10-25
	Pneumoelectrostatic dispersion	10-25
	Airless electrostatic dispersion	15-30
Powder material	All methods	250
In volume of material	Okunaniye	10-30
	Dipping followed by exposure to solvent vapor	10-30
	Dipping followed by centrifugation	10-30
	Anode electrodeposition	10-30
	Cathode electrodeposition	8-20
	Autosedimentation	25-35
Material stream	Jet having poured	10-30
	Jet plating with subsequent maintenance in solvent vapors	10-40
	Filling	15-40
Material layer	Roll	10-50
	Brush	10-25

Multi-layer coatings are often used in practice. Therefore, the thickness of the paint coating of the body of various car models is in the range of 70 to 240 μm. Thus for BMW cars the thickness of paint

coating of body elements is within 90 - 165 μm, for Citroen - 85 - 150 μm, for Ford - 105 - 235 μm, for Hyundai - 70 - 150 μm, for Lexus - 125 - 175 μm, etc. [4].

Grand Line metal siding has panels with a thickness of 0.45 or 0.5 mm. Coating thickness ranges from 25 to 200 μm.

Thickness of polymer coatings used in various industries is [5]:

- Polyester enamel (standard coatings) 25 - 30 μm;
- Polyester (polyester coating for household appliances) 25 - 35 μm;
- Polyurethane 30 - 50 μm;
- Plastisol 100 - 250 μm.

Protective coatings of steel main pipelines with diameter of 273 - 1420 mm at factory design are applied with thickness from 0.3 to 3.5 mm. With basic or trace coating, its thickness can be up to 6 mm.

Analysis showed that most coatings and articles with such coatings had a coating thickness of 1 to 300 μm. Only a number of precious metals and their alloys have a coating thickness of less than 1 μm. Large thicknesses are extremely rare and can reach 6 mm. The technical documentation gives the minimum value of coating thickness.

Tolerance values are not explicitly identified. GOST 9.303-89 for certain groups of coatings gives both minimum thickness and minimum thickness. Taking them as the largest and smallest thickness values, one can talk about the permissible variation of real values in estimating the validity of the measured parameter. However, this set of thickness values (see figure 1) is not systematized and is of a recommended nature when creating design documentation.

Most of the standards considered (except GOST 9.307-89, GOST 9.315-91, etc.) do not allow to make a reasonable choice of measuring instruments based on the accuracy of thickness meters.

The following conclusions can be drawn from the analysis:

1. The technical documentation specifies the minimum value of coating thickness (GOST 9.306-85), which does not allow to normalize the upper limit of coating thickness and makes the control one-sided. In addition, the absence of a normalized upper limit of coating thickness results in unnecessary over expenditure of coating material, energy and other costs, and does not allow the choice of coating thickness measuring means depending on accuracy.

2. The standards of the "Single Corrosion and Aging Protection System" series provide coating thickness values depending on the service purpose of the products, taking into account technological capabilities, as well as depending on the materials of the coatings and bases, the method of coating application and other factors. Recommendations on assignment of maximum permissible values of coating thickness are not identified.

3. Most coatings and articles have a coating thickness of 1 to 300 μm. This range of coating thicknesses can be recommended to the developers of measuring instruments, which will reduce the error of thickness meters.

References

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