

SCIENTIFIC

Automation of the control of technical documentation for the product of mechanical engineering and instrumentation

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Received: 28 June 2022; **Accepted:** 15 July 2022; **Published:** 01 August 2022

The article discusses the quality control of technical documentation for a product of mechanical engineering and instrumentation during metrological examination based on automatic calculation of the quality factor.

Keywords: product quality, technical documentation, metrological expertise, automation, verification of technical documentation, mechanical engineering, instrumentation

Introduction

The modern world is extremely difficult to imagine without information technology, which is firmly rooted in people’s lives. These technologies help us store and process information, manage documents, work with e-mail, and find the necessary information on various resources on the Internet, etc.

Intensive automation and digitalization cover more and more production processes every day. Future production systems will inevitably be based on a large number of digital solutions and data-driven smart tools, leading to the full digitalization of production and sustainable resource management.

Metrological assurance is an important element in the structure of production. It is responsible for the quality of products and provides reliable information to the consumer. The legal basis for metrological support is the Law of the Russian Federation “On Ensuring the Uniformity of Measurements.” In addition, an important aspect of metrological support is metrological expertise—analysis and assessment of the correctness of establishing and observing metrological requirements in relation to the object subjected to expertise. The metrological examination is carried out

on a mandatory (mandatory metrological examination) or voluntary basis.

Metrological examination of documentation

Metrological expertise is the analysis and evaluation of technical solutions in terms of metrological support (technical solutions for the choice of measured parameters, the establishment of requirements for measurement accuracy, the choice of methods and measuring instruments, and their metrological maintenance).

Metrological expertise is a tool of state regulation in the field of metrology, which stands guard over ensuring the uniformity of measurements.

However, as the technical level of the documentation increases, non-metrology engineers may make inaccuracies:

- incorrectly choose a measuring instrument;
- apply the wrong method;
- do not take into account the requirements of thematic regulatory documents;
- allow other metrological errors.

TABLE 1 | Classification of inconsistencies in technical documentation.

Category	Brief description of the discrepancy	Type of document in which this discrepancy can be detected
1	There are no necessary signatures and appropriate types of TD control in accordance with the regulatory documentation	All documentation
1	Insufficient documentation	All documentation
2	Inconsistency of measurement accuracy with the specified requirements in the terms of reference	Text documentation of all kinds
2	Incorrect form of recording measured (monitored) parameters	All documentation
2	Lack of technical requirements and nomenclature of measured (monitored) parameters	Text documentation of all kinds
2	Presence of unreasonable measured (controlled) parameters and measuring instruments	Text documentation of all kinds
2	Fitness control	Drawings of all kinds
2	Incorrect indication of tolerances of shapes and location of surfaces	Drawings of all kinds
2	Wrong assignment and roughness designation	Detail drawing and assembly drawing
2	Availability of references to canceled (replaced) documents, incorrect use of reference regulatory and technical documents, and lack of necessary references to regulatory documentation	All documentation
2	Incorrect recording of names and designations of quantities and their units	All documentation
2	Incorrect recording of metrology terms	All documentation
2	Lack of accuracy standards for the measured parameters (lack of permissible limit deviations and measurement errors)	All documentation
2	No requirements for measurement procedures (methods)	Text documentation of all kinds
2	Requirements for measuring instruments, means of tolerance control, technical systems and devices with measuring functions, and testing equipment and their metrological support are not presented in full or not presented at all	Text documentation of all kinds
2	Inconsistency of measurement accuracy with established requirements	All documentation
3	Incorrect designation of products and documentation	All documentation
4	Incorrect or ambiguous use of technical terms and symbols, spelling and grammatical errors, typos, misprints in drawings, drawings and text documents, and abbreviations	All documentation
5	Inconsistencies that require coordination with other inspection services (ambiguous violation of RD and competence of other inspectors)	All documentation
6	Other inconsistencies (edit paragraph, clarify, and recommendations)	All documentation

	B	C	D	E	F	G	H	I	J	K
	Last name of the developer	Department	Number of pages	date of presentation	Document designation	Remark/suggestion	Category of non-compliance by classifier	Points	F _q	0.7931
1	XXXXX	41.07	36	16.09.22	41.04.00-11000-00F079-19/00	Requirements for measuring instruments, means of tolerance control, technical systems and devices with measuring functions, testing equipment and their metrological support are not presented in full or not presented at all	2	2	F _n	0.26087
2	XXXXX	41.07	-	16.09.22	P1.04-00-11000-000079-19/00	Absence, incorrect establishment of requirements for metrological support of tests	2	2		
3	XXXXX	41.12	6	16.09.22	H1.04.00-11000-000045-19/00	Inconsistency of measurement accuracy with established requirements	2	2		
4	XXXXX	41.12	-	16.09.22	K1.04-00-11000-000045-19/00	Lack of accuracy standards for the measured parameters (lack of permissible limit deviations,	2	2		
5	XXXXX	41.12	-	16.09.22	71.04-00-11000-000045-19/00	Incorrect recording of names and designations of quantities and their units	2	2		
6	XXXXX	41.06	34	16.09.22	71.03.6100.000I3	Incorrect recording of names and designations of quantities and their units	2	2		
7	XXXXX	41.06	-	16.09.22	K1.03.6100.000I3	Incorrect recording of names and designations of quantities and their units	2	2		
8	XXXXX	41.06	-	16.09.22	H1.03.6100.000I3	Availability of references to canceled (replaced) documents, incorrect use of reference regulatory and technical documents, lack of necessary references to regulatory documentation	2	2		

FIGURE 1 | Journal of metrological examination with automatic calculation (F_n) of the coefficient of the weight of the discrepancy and (F_q) of the quality factor.

SUM : X ✓ fx =SUM (I2:I13)/SUM (D2:D13)

	B	C	D	E	F	G	H	I	J	K
	Last name of the developer	Department	Number of pages	date of presentation	Document designation	Remark/suggestion	Category of non-compliance by classifier	Points	Fq	0,7931
1	XXXXX	41.07	36	16.09.22	41.04-00-11000-00F079-19/00	Requirements for measuring instruments, means of tolerance control, technical systems and devices with measuring functions, testing equipment and their metrological support are not presented in full or not presented at all	2	2	Fn	
2	XXXXX	41.07	-	16.09.22	P1.04-00-11000-000079-19/00	Absence, incorrect establishment of requirements for metrological support of tests	2	2		
3	XXXXX	41.12	6	16.09.22	H1.04-00-11000-000045-19/00	Inconsistency of measurement accuracy with established requirements	2	2		
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6	XXXXX	41.06	34	16.09.22	71.03.6100.000I3	Incorrect recording of names and designations of quantities and their units	2	2		
7	XXXXX	41.06	-	16.09.22	K1.03.6100.000I3	Incorrect recording of names and designations of quantities and their units	2	2		
8										

FIGURE 2 | Formula (F_n) of the weight factor of the discrepancy.

SUM : X ✓ fx =1/((SUM (I2:I13)/SUM (D2:D13))+1)

	B	C	D	E	F	G	H	I	J	K
	Last name of the developer	Department	Number of pages	date of presentation	Document designation	Remark/suggestion	Category of non-compliance by classifier	Points	Fq	13))+1)
1	XXXXX	41.07	36	16.09.22	41.04-00-11000-00F079-19/00	Requirements for measuring instruments, means of tolerance control, technical systems and devices with measuring functions, testing equipment and their metrological support are not presented in full or not presented at all	2	2	Fn	0,26087
2	XXXXX	41.07	-	16.09.22	P1.04-00-11000-000079-19/00	Absence, incorrect establishment of requirements for metrological support of tests	2	2		
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7	XXXXX	41.06	-	16.09.22	K1.03.6100.000I3	Incorrect recording of names and designations of quantities and their units	2	2		
8										

FIGURE 3 | Formula (F_q) quality factor.

This can lead to a high percentage of scrap and unnecessary costs for debugging the process.

To avoid this, the metrological examination of technical documentation should be debugged into the organization. Draft documents should be subjected to metrological examination and checked for compliance with the requirements and norms that are established in the regulatory and technical documentation.

Classification of non-conformances by categories depending on their content

Over the course of 7 years of work, materials were collected on the identified inconsistencies (errors) in the technical documentation following the results of the metrological

examination. In the process of analyzing these errors, a classification of non-conformities into categories was developed depending on their content.

The classification of non-conformities is necessary to assess the quality of the developed technical documentation.

Identified inconsistencies in the technical documentation, depending on their causes and consequences, are divided into the following categories:

- Category 1 – inconsistencies that lead to the return of technical documentation without consideration;
- Category 2 – inconsistencies associated with non-compliance with the requirements established in external regulatory and technical documents;
- Category 3 – inconsistencies associated with non-compliance with internal regulatory, technical, organizational, and administrative documents;
- Category 4 – inconsistencies associated with grammatical, spelling, and stylistic errors in documents;
- Category 5 – discrepancies that require coordination with other services;
- Category 6 – other inconsistencies.

The classification of non-conformities by categories depending on their content is given in **Table 1**.

Documentation quality assessment is carried out in the following order:

- (a) inconsistencies identified during the ME are classified in accordance with the above tables (classifier). At the same time, each non-compliance, depending on the category, is evaluated by a certain number of points, where:
 - (1) 1 non-compliance of category 1 = 5 points;
 - (2) 1 non-compliance 2.3 categories = 2 points;
 - (3) 1 non-compliance of 4–6 categories = 1 point.
- (b) the quality factor of the documentation is determined by the following formula:

$$Fq = \frac{1}{Fn + 1} \cdot \frac{S}{N}$$

where: Fq – quality factor;
 F_n – non-conformity weighting factor;
 S – sum of scores of inconsistencies;
 N – number of formats.

This classification can be used to determine the quality of technical documentation in the process of metrological examination (**Figures 1–3**).

Document	Quality Factor	Efficiency
$F_q < 0.60$		Invalid
$0.60 \leq F_q$	<0.75	Admissible
$0.75 \leq F_q$	<0.95	Sufficient
$F_q > 0.95$		High

Conclusion

Based on the identified inconsistencies (errors) in the technical documentation during the metrological examination and on the basis of the classification, it is possible to analyze the quality assessment of the developed technical documentation by the quality factor.

Author contributions

AR and AF contributed to the study conception and design. AR contributed to the collection and processing of the material, performed the statistical processing, and wrote the manuscript. AF edited the manuscript. Both authors contributed to the article and approved the submitted version.

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