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Research Article

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As for decision making rules based on research results while forensic science activities

While forensic research, obtained results should be evaluated in order to ensure adoption of correct conclusion regarding the research object. For this purpose forensic experts should use established decision rules to substantiate a statement about conformity of an object or certain requirements, or parameters, or characteristics. Currently, the need to ensure that a decision is made based on results of forensic examination using the concept of decision rules is constantly increasing. Therefore, consideration of the issue of establishing rules for making decisions while forensic science activity at international and national levels is relevant. Relevance of this issue is justified not only by the requirements of ISO/IEC 17025:2017 for testing laboratories but by the requirements for the objectivity of expert opinion. ISO/IEC 17025:2017 recognizes that there is no single rule for deciding on conformity. In other words, in a specific situation there will be its own decision making rule. This also applies to forensic science activity.

Therefore, this article purpose is necessary for forensic science activity to determine:

- *general guidelines for choosing appropriate decision making rule;*
- *directives for determining the components of decision making rules depending on the object and the task of forensic examination;*
- *rules for applying certain requirements to the research results of carried out in accordance with requirements of research methods, research object and the type of quantitative or qualitative research.*

Thus, this article defines and considers the process of establishing the rules for making decisions, criteria which the rules for making decisions are established by, options for making a decision on compliance/non-compliance with requirements.

The authors declares no conflict of interest of relavance to this topic.

Keywords: *decision making rules, uncertainty, conformity assessment, measurements, protective strip.*

Formulation of Research Problem. Forensic science activity under the Law of Ukraine: *On Judicial Examination* [1] includes research on wide range of objects and requires specific expertise in many subject matters. While research on objects various techniques are used, from visual inspection to complex instrumental techniques. In this case, the units of forensic science institutions conduct researches through measuring and/or testing in order to determine quantitative and qualitative indicators of the objects submitted for examination. For forensic science institutions, all these actions are researches that are carried out according to the methods entered in the relevant Register of the Ministry of Justice of Ukraine. However, the results obtained while forensic examination should be evaluated in order to ensure a correct conclusion about research object. For this purpose, forensic experts should apply certain decision making rules to justify the object compliance statement with certain requirements, parameters or characteristics. Currently, there is a growing need to ensure decision making based on results of forensic examination using the concept of decision making rules. Therefore, consideration of the issue of determining the rules of decision making during forensic science activities at international and national levels is relevant. Relevance of this issue is justified not only by the *ISO/IEC 17025:2017* [2] General requirements for the competence of testing and calibration laboratories but by requirements for the objectivity of forensic expert conclusion.

Analysis of Essential Researches and Publications. The issue of decision making rules is covered in many publications of domestic and foreign scientists such as O. Madera, I. Blank, A. Chernikov, T. Kravchenko, D. Isayev and others [3]. In their research papers, this issue is largely covered, however is not considered in the field of forensic science activity.

The **Article Purpose.** *ISO/IEC 17025:2017* [4] recognizes that there is no single rule for compliance. In other words each specific situation involves its own decision

[1] Про судову експертизу : Закон України від 25.02.1994 р. № 4038-XII (asamended and supplemented). URL: https://zakon.rada.gov.ua/laws/show/4038-12 (date accessed: 02.03.2021).

[2] ДСТУ EN ISO/IEC 17025:2019. Загальні вимоги до компетентності випробувальних та калібрувальних лабораторій (EN ISO/IEC 17025:2017, IDT; ISO/IEC 17025:2017, IDT) : затв. наказом ДП «УкрНДНЦ» від 23.12.2019 р. № 483. [Чинний від 23.12.2019]. URL: http://online.budstandart.com/ru/catalog/doc-page.html?id_doc=88724 (date accessed: 17.02.2021).

[3] Мадера А. Г. Принятие решений в условиях неопределенности при актуализации в будущем множества возможных шансов и рисков. *Международный журнал прикладных и фундаментальных исследований.* 2014. № 4. P. 136—140. URL: https://applied-research.ru/ru/article/view?id=5087 (date accessed: 19.02.2021) ; Бланк И. Принятие решений в условиях неопределенности [Электронный ресурс]. URL: https://www.kpilib.ru/article.php?page=302 (date accessed: 19.02.2021) ; Кравченко Т. К., Исаев Д. В. Принятие стратегических решений в условиях риска и неопределенности. *Финансы: теория и практика.* 2016. Т. 20. № 4. P. 22—31. DOI: https://doi.org/10.26794/2587-5671-2016-20-4-22-31 (date accessed: 19.02.2021).

[4] ДСТУ EN ISO/IEC 17025:2019.

making rule. This applies to forensic science activity, so it is for forensic science activity to determine:

- general guidelines for choosing the appropriate decision making rule;
- guidelines for determining the constituent rules of decision making depending on the object and task of forensic examination;
- rules for applying certain requirements to research results of (according to the requirements of the research methods, research object of and research species: quantitative or qualitative).

Main Content Presentation. According to *ISO/IEC 17025:2017* for quantitative researches where the result of measurements/tests is the value of the measured quantity, decision making rule is a rule describing how to take into account the uncertainty of measurement while determining the object compliance of forensic examination with these requirements.

For establishing the rules for decision making on uncertainty, it is necessary to determine the methods of estimating and standardizing uncertainty of measurements while quantitative tests that requires significant financial costs for relevant research. Therefore, we propose to determine the rules of decision making according to other criteria and after their definition to list these values in measurement uncertainty.

Examples of this approach are documents of *Eurachem* and *CITAC* (*Cooperation on International Traceability in Analytical Chemistry)* on uncertainty application in conformity assessment. According to their proposals, characteristics of measurement results (correctness, reproducibility, limits of conformity, etc.) are evaluated and target uncertainty is determined using these characteristics.

For realizing this approach it is necessary to apply the following characteristics:

- limit of the tolerance field, limit of technical requirements: stipulated upper or lower limit value for admissible values of parameter (property). This term is associated with the *tolerance field* term as a range of valid values;
- acceptance limits: stipulated upper or lower limit value for admissible measured quantity values;
- receiving range: range of allowable measured values (receiving interval usually contains receiving limits);
- defective range : range of measured values that are considered as unacceptable ones;
- protective strip: range between the boundary of tolerance field and the corresponding receiving limit.

For establishing acceptance rule in the case of simple acceptance, acceptance range is equal to the admission field and it is possible to determine the areas of acceptance and rejection using acceptability limits of forensic research result.

In this case, the tolerance should be set on the parameter (or property) value for measured value, for example:

- It should not be more (or less) a certain value;
- It has to be in the range from… to…;
- It should be (quantitative value) and in a technique it is defined through what means of measuring equipment to carry out measurements with indication of its type or the maximum admissible error (accuracy class).

While performing measurements and notification of compliance or non-compliance of forensic examination object with specific requirements, there are 2 possible options:

- A. Making the right/wrong decision on compliance with requirements;
- B. Making the right/wrong decision on non-compliance with requirements.

In this case, each measured value has an associated measurement uncertainty. For example, if there is a minimum value, a nominal value and a maximum value of the parameter, then if measurement result plus/minus uncertainty is in the range from minimum to maximum value, the result is recognized as appropriate. If the uncertainty value is such that the result of the measurement plus/minus uncertainty goes beyond acceptance limits, it is necessary to have a decision making rule for compliance.

The use of protective strips can reduce likelihood of wrong decision making about compliance. In fact, it is a protective factor built into decision making based on measurement result that is to narrow the receiving limits below the tolerance field. Therefore, the length of protective strip is the difference between tolerance field and the receiving limit. This means that if the measurement result for the upper tolerance limit is within the receiving limit, then measurement result is considered to meet specification.

In description of protective strip often indicate the upper and lower limits of the tolerance field. A protective strip: of length zero indicates that any measurement result that is below the tolerance field is accepted. This is a simple assumption called *shared risk*, as probability of being outside the tolerance field can reach 50 % if the measurement result is at the level of tolerance field (meaning a symmetrically normal distribution of results).

The binary decision rule is used when the choice for the result is limited to two options: *Pass/Fail*. The non-binary decision making rule is used when decision on the result can be expressed in several variants (satisfactory, conditionally corresponding, conditionally not corresponding, unsatisfactory).

In default of a protective strip, the binary statement of compliance with the upper value of tolerance field for the rule of simple acceptance is made by means of:

- *Pass*: measured value is below the tolerance field;
- *Fail*: measured value is above the tolerance field.

In case of establishing protective strip, the binary declaration of conformity is made by means of:

- *Pass*: result of the measured value below receiving upper limit (upper value of the tolerance field minus the protective strip value);
- *Fail*: failure is based on a protective strip if the measurement result is above receiving limit.

Examples are presented on Fig. 1–3.

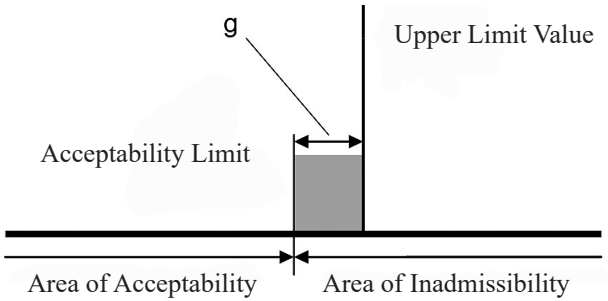

Fig. 1. Protective Range (g), limit of acceptability and areas of acceptability and inadmissibility determined in accordance with the stipulated upper limit value and decision making rules that ensure high conclusion reliability of compliance

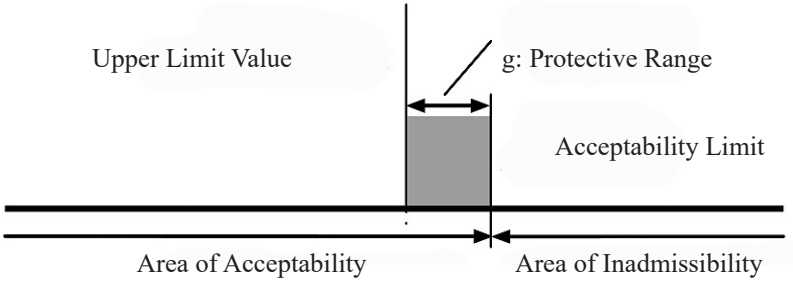

Fig. 2. Protective range (g), limit of acceptability and areas of acceptability and inadmissibility determined in accordance with the stipulated upper limit value and decision making rules that ensure high conclusion reliability of compliance

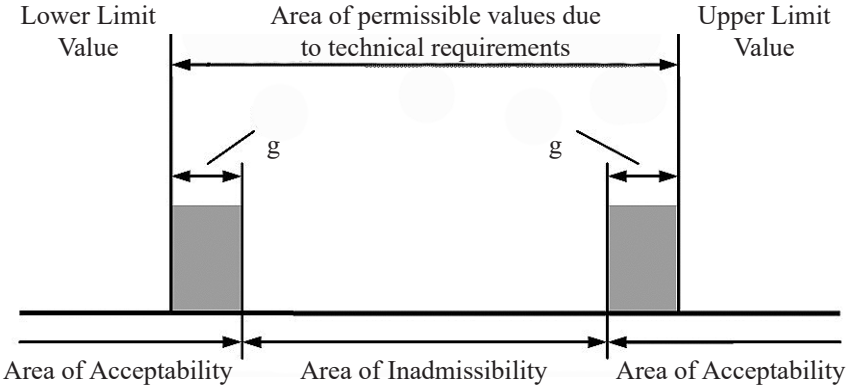

Fig. 3. Protective ranges (g), limits of acceptability and areas of acceptability and inadmissibility determined in accordance with the stipulated upper limit value and decision making rules that ensure high conclusion reliability of compliance

According to *ISO/IEC 17025:2017* [1] decision making rule is a rule describing how to take into account the measurement uncertainty while determining compliance with specified requirements.

ISO/IEC 17025:2017 [2] sets out criteria related to decision rules and declarations of conformity, for example:

- in clause 7.1.3: "*when the customer requests an opinion on specification conformity or standard for testing or calibration (e.g. suitable/ unsuitable, within tolerance/out of tolerance), specification or standard and decision rules should be clearly defined. If decision making rule is not specified in the specification or standard, it should be reported to the customer and agreed with*";
- in clause/subclause: 7.8.3.1 b): "*if necessary, a statement of compliance with the requirements or specifications*" and in in clause/subclause: 7.8.3.1 (c) "*where applicable, the uncertainty of the measurements, presented in the same units as the measured quantity, or in relation to the measured quantity (for example, as a percentage), when this concerns probability or application of test results; this is required by the customer; or measurement uncertainty affects compliance with the established limits*".

Clause/subclause: 7.8.4.1 a), 7.8.4.1 e), 7.8.6.1, 7.8.6.2 of *SO/IEC 17025:2017* [3] defines the criteria for when and by what rules compliance should be established. However, it is important to note that conformity assessment is performed on compliance with technical conditions, technical specifications or standards. In default of a decision making rule in methodology, it should be agreed with customer. Uncertainty in decision making rules is applied *"where it can be applied"* or where it *"affects compliance with established limits"*.

Defining uncertainty decision-making rules requires knowledge of a certain normative value of measurement uncertainty, such as the maximum allowable uncertainty that would be defined in the measurement/test methods. In default of such a value, the target uncertainty value can be applied. According to *VIM (ISO/IEC Guide 99:2007)* [4], target uncertainty is measurement uncertainty set as the upper limit and selected based on the expected use of measurement results.

If uncertainty is significant, there is a limit to right decision making about compliance. The values of maximum allowable uncertainty for specific measurements in international practice are obtained by rounds of interlaboratory

[1] ДСТУ EN ISO/IEC 17025:2019.

[2] Ibid.

[3] Ibid.

[4] ISO/IEC Guide 99:2007 (E/R). International Vocabulary of Metrology — Basic and General Concepts and Associated Terms (VIM) (Международный словарь по метрологии. Основные и общие понятия и соответствующие термины (VIM)). 2007. 92 с. URL: https://metrology.kiev.ua/files/ISO_IEC_Guide_99_2007.pdf (date accessed: 17.02.2021).

comparisons. Indirect values of uncertainty are also established in international documents. For example, for measuring equipment as a ratio of its maximum permissible error.

ISO/IEC 17025:2017 [1] requires laboratories to assess measurement uncertainty and to apply a documented decision making rule while applying for conformity declaration.

As mentioned above, approaches used can vary significantly depending on the situation and different protective strips can be used. The most common is the use of target uncertainty for protective strip . However, in many cases use a factor for the value of uncertainty other than 1. Table 1 *ILAC-G8:09* [2] demonstrates examples of different protective strips to achieve certain levels of specific risks based on the customer's application.

Table 1

Examples of protective strips

Decision making rule	Protective strip	Specific risk
6 sigma	3	<1 ppm probability of erroneous acceptance
3 sigma	1,5 U	< 0.16 % probability of erroneous acceptance
ILAC G8:2009 rule	1 U	< 2.5 % probability of erroneous acceptance
ISO 14253-1:2017	0,83 U	< 5 % probability of erroneous acceptance
Simple acceptance	0	< 50 % probability of erroneous acceptance
Uncritical	–U	Object deviates by a measured value greater than < 2.5 % probability of erroneous acceptance
Defined by the customer		Customer determines protective strip value
Note. In table U – the value of extended uncertainty		

The expanded target uncertainty can be clarified by some performance characteristics of methods. For example:

- as 1/8 of the width of the correspondence range;
- reproducibility of measurements (R) by 2.8 and multiply by 2;
- multiply the standard deviation determined while proficiency check by 2.

[1] ДСТУ EN ISO/IEC 17025:2019.

[2] ILAC-G8:09:2019. Настанова щодо правил прийняття рішення та висновків щодо відповідності (Guidelines on Decision Rules and Statements of Conformity). URL: https://naau.org.ua/wp-content/uploads/2021/03/ILAC_G8_09_2019_Nast-ano-va-shhodo-pravy %60l-pry %60jnyattya-rishen %60.pdf (date accessed: 17.02.2021).

The provisions of some documents [1] can also be applied while determining in laboratory the rules of decision making on measurements carried out according to specific research methods in forensic science activities. However, the use of uncertainty for decision making in conformity assessment when:

- there are no national standards for methods of calibration of measuring equipment;
- uncertainty of measurements that is estimated while calibration of measuring equipment significant compared to deviations of its readings from the reference value;
- measurement uncertainty is not required at national level, it is possible only on the basis of application of real decision making rules on conformity on the basis of theory of admissible control, defined by methods and other documents of requirements to objects of forensic researches, admissible norms to measured sizes, normalized errors of the applied measuring equipment. Application of such real rules makes it possible to list them in the value of uncertainty to ensure realization of the requirements of *ISO/IEC 17025:2017* [2]. However, this is only possible for quantitative methods of research of objects provided for forensic research.

Professionals have been using mathematical decision making methods for a long time to determine the rules of decision making. When using these methods, objects are divided into *simple* and *complex* ones. Exact mathematical models that are adequate to the research object can be applied to simple objects. Therefore, simple objects can usually be identified in the case of quantitative researches where the object is studied by measuring its inherent characteristics or parameters. Therefore, in this case, it is possible to apply methodology for establishing the rules of decision making proposed above.

While conducting qualitative research, the object should be considered as a complex one. The following objects are characterized by the following:

- its characteristics cannot be quantified;
- there is no formalized description of the object or it is very complex;
- much of information about this object exists only as the ideas and wishes of forensic experts based on their experience of researching on similar objects.

[1] ILAC-G8:09:2019 ; ДСТУ ISO/IEC Guide 98-4:2018. Невизначеність вимірювань. Ч. 4 : Роль невизначеності вимірювань під час оцінювання відповідності (ISO/IEC Guide 98-4:2012, IDT). URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=81670 (date accessed: 17.02.2021) ; ISO 14253-1:2017. Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment. Part 1 : Decision rules for verifying conformity or nonconformity with specifications (Геометричні технічні характеристики виробу (GPS). Перевірка шляхом вимірювання деталей та вимірювального обладнання. Ч. 1 : Правила прийняття рішень для перевірки відповідності чи невідповідності специфікаціям). URL: https://www.iso.org/ru/standard/70137.html (date accessed: 17.02.2021).

[2] ДСТУ EN ISO/IEC 17025:2019.

Therefore, methodology proposed above for quantitative research cannot be applied while qualitative research. For such research, a different methodology should be developed for decision making based on fuzzy logic, for example.

Conclusions. The practice of domestic and foreign forensic institutions indicates that high-quality conformity assessment is the basis for ensuring a high scientific and technical level of their researches and confidence in the results. Institutions that apply compliance decision making rules and assess compliance with regulatory requirements, measurement uncertainties and risks will have an advantage over other forensic science institutions in terms of international standards for research quality.

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С. Я. Парасків, С. А. Оноприєнко, І. О. Спасенко

Щодо правил прийняття рішень за результатами досліджень під час судово-експертної діяльності

У процесі судово-експертного дослідження здобуті результати слід оцінювати з метою забезпечити прийняття правильного висновку щодо об'єкта дослідження. Саме тому експерти мають застосовувати визначені правила прийняття рішень для обґрунтування заяви про відповідність об'єкта або певним вимогам, або параметрами, або характеристиками. Станом на сьогодні постійно зростає потреба в забезпеченні винесення рішення за результатами експертизи із застосуванням концепції правил прийняття рішень. Тому розгляд питання визначення правил прийняття рішень під час судово-експертної діяльності на міжнародному та національному рівні є актуальним. Актуальність цього питання обґрунтовано не тільки вимогами ISO/IEC 17025:2017 до випробувальних лабораторій, а й вимогами до об'єктивності експертного висновку. ISO/IEC 17025:2017 визнає, що єдиного правила прийняття рішення щодо відповідності не існує. Тобто кожна конкретна ситуація передбачає своє правило прийняття рішення. Це також стосується судово-експертної діяльності, тому саме для судово-експертної діяльності необхідно визначити:

- *загальні настанови щодо вибору відповідного правила прийняття рішення;*
- *настанови щодо визначення складових правил прийняття рішень залежно від об'єкта й завдання експертизи;*
- *правила застосування певних вимог до результатів проведених досліджень (відповідно до вимог методики досліджень, об'єкта досліджень і виду дослідження — кількісного чи якісного).*

Отже, у статті з'ясовано й розглянуто процес визначення правил прийняття рішень, критерії, за якими встановлено правила прийняття рішень, варіанти прийняття рішення про відповідність/невідповідність вимогам.

Ключові слова: *правила прийняття рішень, невизначеність, оцінювання відповідності, вимірювання, захисна смуга.*

С. Я. Параскив, С. А. Оноприенко, И. О. Спасенко

О правилах принятия решений по результатам исследований в процессе судебно-экспертной деятельности

В процессе судебно-экспертного исследования полученные результаты должны быть оценены с целью обеспечения принятия правильного

заключения относительно объекта исследования. Для этого эксперты должны использовать установленные правила принятия решений для обоснования заявления о соответствии объекта или определённым требованиям, или параметрам, или характеристикам. В настоящее время постоянно увеличивается потребность в обеспечении вынесения решения по результатам экспертизы с применением концепции правил принятия решений. Поэтому рассмотрение вопроса установления правил принятия решений во время судебно-экспертной деятельности на международном и национальном уровне актуально. Актуальность этого вопроса обосновывается не только требованиями ISO/IEC 17025:2017 [2] к испытательным лабораториям, но и требованиями к объективности экспертного заключения. ISO/IEC 17025:2017 признаёт, что единого правила принятия решения о соответствии не существует. То есть в конкретной ситуации будет своё правило принятия решения. Это касается также и судебно-экспертной деятельности.

Поэтому целью статьи является определить необходимые для судебно-экспертной деятельности:

- *общие указания по выбору соответствующего правила принятия решения;*
- *установки по определению составляющих правил принятия решений в зависимости от объекта и задачи экспертизы;*
- *правила применения определённых требований к результатам проведённых исследований в соответствии с требованиями методики исследований, объекта исследований и вида исследования — количественного или качественного.*

Таким образом, в статье определён и рассмотрен процесс установления правил принятия решений, критерии, по которым устанавливаются правила принятия решений, варианты принятия решения о соответствии/несоответствии требованиям.

Ключевые слова: *правила принятия решений, неопределённость, оценки соответствия, измерения, защитная полоса.*

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