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APPLICATION OF ISO–IEC 80000–6:2008 IN THE DESCRIPTION OF TECHNICAL SYSTEMS

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Abstract: Systems that perform a function are often referred to as technical systems. A technical system can consist of one or more subsystems. Technical systems are described using numbers, units and mathematical expressions. A special form of notation is dedicated to systems based on the laws of physics encompassed under the name Electromagnetism. The number of scientists for whom physics is not the primary profession and who study electromagnetism is constantly growing. Therefore, an unambiguous way of writing in accordance with the standards is extremely important. The international standard that defines Electromagnetism is ISO – IEC 80000–6: 2008 Quantities and units – Part 6: Electromagnetism. The International Organization for Standardization, in cooperation with the International Electrotechnical Commission (IEC), enacts the above standard, which introduces order in the way of writing: names, symbols, and definitions for quantities and units of electromagnetism. The paper gives a brief overview of the role of ISO in Sustainable Development Goals. Furthermore, it provides an overview of all parts of ISO 80000 with special reference to IEC 80000–6: 2008 recommendations. In order to analyse the applicability of the standard, an analysis of published articles in five scientific journals during an arbitrarily selected year was performed. The numerical indicators of published papers, the average number of pages per paper and the percentage of elements in the papers for each of the journals are graphically presented. Finally, an assessment of the correct application of the standard in the respective journals was carried out.

Keywords: standard, ISO, IEC 80000–6:2008, electromagnetism, technical systems

1. INTRODUCTION

A technical system is every system that performs a function. Examples of technical systems include cars, pens, books and knives. Any technical system can consist of one or more subsystems. A car is composed of the subsystems engine, steering mechanism, brakes, etc. Each of these is also a technical system unto itself (with its own series of subsystems) — and each performs its own function. The hierarchy of technical systems spans from the least complex, with only two elements, to the most complex with many interacting elements, [1].

A description of a technical system is inconceivable without numbers. In 1883, Lord Kelvin said: "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be." [2].

Pythagoras assured his followers: Everything is a number. They coined the word *philosophy* as well as the word *mathematikoi* which means "erudite people" and from which the word "mathematics" was derived, [3]. Mathematics, as an essential tool for physics, is used for the description of Electromagnetism, a branch of physics that analyses the interaction among electric charges, magnetic moments and the electromagnetic field. The number of scientists for whom physics is not the primary profession and who study electromagnetism is constantly growing. The way of writing particular terms is often not in line with the standards. Therefore, the standard–related recommendations are of utmost importance. The international standard that defines Electromagnetism is ISO – IEC 80000–6: 2008 Quantities and units – Part 6: Electromagnetism, [4]. This paper gives an overview of the guidelines recommended by the standard and the application of these guidelines by analysing five scientific journals.

2. STANDARDS AND STANDARDIZATION

Standardization is the activity of establishing an optimum degree of order for common and repeated use in a given context with regard to potential problems or actual problems, [5]. A standard is a document adopted and agreed by consensus and approved by a recognized body. It is intended especially for repeated use because it gives guidelines, rules and describes activities with the aim of optimizing the process, [5]. The function of a standard is to efficiently connect systems, provide quality of service and reduce a variety of different systems and describe processes and products. Standards can be divided into formal (DIN, CEN), informal (IEEE, VDI) and private, [6]. One of the most important institutions is the International Organization for Standardization (ISO). With respect to sustainability, ISO has set 17 Sustainable Development Goals, Table 1.

Table 1 describes ISO goals with respect to sustainable development and the number of standards which can be related to individual areas. ISO has developed over 23919 International Standards and all are included in the ISO Standards catalogue. The number of standards from 1996 to 2018 is shown in Figure 1, [8].

Table 1. ISO Sustainable Development Goals, [7]

No. of norms	Goal
340	No poverty – end poverty in all its forms everywhere
529	Zero hunger – end hunger, achieve food security and improved nutrition and promote sustainable agriculture
2768	Good health and well–being – ensure healthy lives and promote well–being for all at all ages
476	Quality education – ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
176	Gender equality – achieve gender equality and empower all women and girls
539	Lean water and sanitation – ensure availability and sustainable management of water and sanitation for all
815	Affordable and clean energy – ensure access to affordable, reliable, sustainable and modern energy for all
2394	Decent work and economic growth – promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
12461	Industry, innovation and infrastructure – build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
499	Reduced inequalities – reduce inequality within and among countries
2304	Sustainable cities and communities – make cities and human settlements inclusive, safe, resilient and sustainable
2528	Responsible consumption and production – ensure sustainable consumption and production patterns
1067	Climate action – take urgent action to combat climate change and its impacts
273	Life below water – conserve and sustainably use the oceans, seas and marine resources for sustainable development
1036	Life on land – protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
154	Peace, justice and strong institutions – promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
	Partnerships for the goals – strengthen the means of implementation and revitalize the global partnership for sustainable development
340	No poverty – end poverty in all its forms everywhere

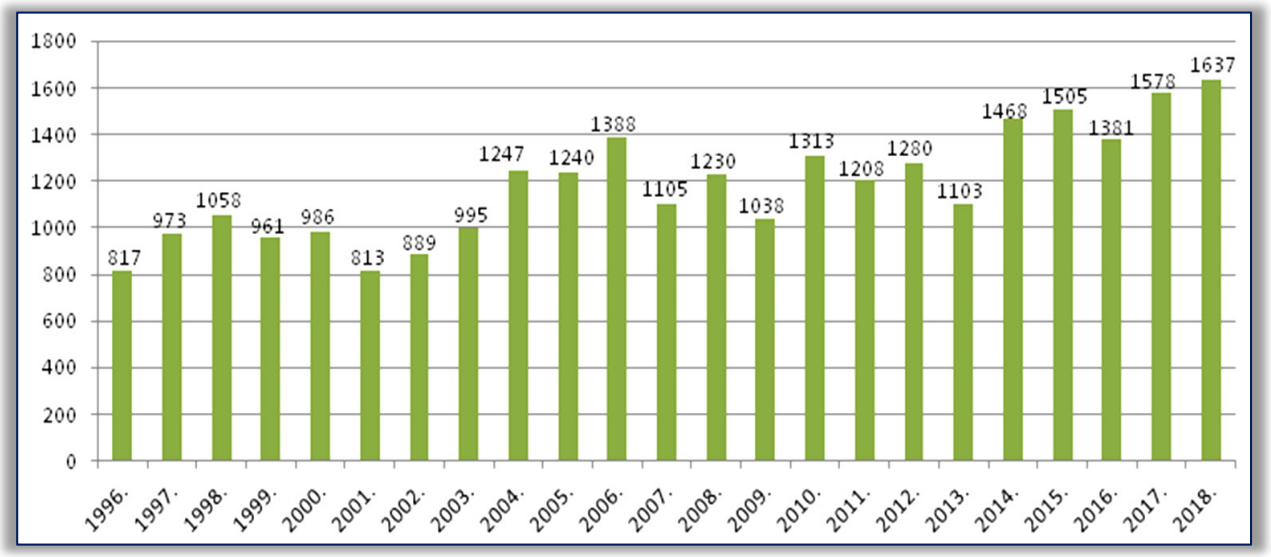

Figure 1. The number of newly published ISO standards by year, [8]

Technical systems are mainly based on Electromagnetism and mathematical models that need to be described in the documentation, which in part translates into instructions for use, maintenance instructions and service instructions. In the field of defining standards which are used to define the correct writing of the description of technical systems, ISO, in cooperation with the International Electrotechnical Commission (IEC), issued the ISO 80000 standard, which consists of 14 parts, [9]. The ISO 80000 series of standards was published from 2007 to 2011. The IEC played the leading role in the development of parts 6, 13 and 14, and ISO in the others. The first page of the printed editions contains the logos of both international organizations; however, the logo of the organization that played the leading role in developing that particular standard appears in the first position. The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) have accepted and published only some of the ISO 80000 series of standards. CEN and CENELEC published Part 8 and Parts 6, 13, 14, respectively, [9]. Individual standards designation and scope of application are:

ISO 80000–1:2009	Quantities and units – Part 1: General
ISO 80000–2:2009	Quantities and units –– Part 2: Mathematical signs and symbols to be used in the natural sciences and technology
ISO 80000–3:2006	Quantities and units –– Part 3: Space and time
ISO 80000–4:2006	Quantities and units –– Part 4: Mechanics
ISO 80000–5:2007	Quantities and units –– Part 5: Thermodynamics
EN 80000–6:2008	Quantities and units –– Part 6: Electromagnetism
ISO 80000–7:2008	Quantities and units –– Part 7: Light
EN ISO 80000–8:2007	Quantities and units –– Part 8: Acoustics
ISO 80000–9:2009	Quantities and units –– Part 9: Physical chemistry and molecular physics
ISO 80000–10:2009	Quantities and units –– Part 10: Atomic and nuclear physics
ISO 80000–11:2008	Quantities and units –– Part 11: Characteristic numbers
ISO 80000–12:2009	Quantities and units –– Part 12: Solid state physics
EN 80000–13:2008	Quantities and units –– Part 13: Information science and technology
EN 80000–14:2009	Quantities and units –– Part 14: Telebiometrics related to human physiology

3. SCOPE OF APPLICATION OF IEC 80000–6:2008

Scope of IEC 80000–6:2008 encompasses names, symbols, and definitions for quantities and units of electromagnetism. It also provides insight into conversion factors. The International Standard IEC 80000–6 has been prepared by IEC Technical Committee 25: Quantities and Units, and their letter symbols in close cooperation with ISO/TC 12, quantities, units, symbols, conversion factors. IEC 80000–6 cancels and replaces the second edition of ISO 31–5, published in 1992, and its amendment 1 (1998). The standard is based on the SI System of Units, as acknowledged and reflected in the standards of ISO and IEC. The SI has seven base units, among them metre, symbol m, kilogram, symbol kg, second, symbol s, and ampere, symbol A. For quantities that vary sinusoidal with time, and for their complex representations, the IEC has standardized two ways to build symbols. Capital and lowercase letters are generally used for electric current and voltage, and additional marks for other quantities. An example of quantities described in the standard is shown in Table 2.

Table 2. An example of quantities as described by IEC 80000–6:2008

Name	Symbol	Definition and Remarks
Poynting vector	S	$S = E \times H$ where E is the electric field strength and H is the magnetic field strength
source voltage, source tension	U_s	The voltage between the two terminals of a voltage source when there is no electric current through the source. The name "electromotive force" with the abbreviation EMF and the symbol E is deprecated.
apparent power	$\lvert\underline{S}\rvert$	$\lvert\underline{S}\rvert = UI$ where U is the rms value of voltage and I is the rms value of electric current $U = \sqrt{\frac{1}{T}\int_o^T u^2 dt} \quad I = \sqrt{\frac{1}{T}\int_o^T i^2 dt}$
power factor	λ	λ=|P|/|S| where P is the active power and S is the apparent power.

4. ANALYSIS OF THE APPLICATION OF IEC 80000–6:2008 IN SCIENTIFIC AND TECHNICAL JOURNALS

Standards exist to bring order in a particular field and provide unambiguous designation. The best way to present an analysis of the application of IEC 80000–6:2008 is using examples from scientific journals which keep the highest standards with respect to the presentation of scientific papers. In accordance with previous research on ISO 8000 applicability described in the final paper [8], the same journals in which the analysis of the standard ISO 80000–2:2009 applicability which deals with mathematical texts were selected. The analysis of the application of IEC 80000–6:2008 was carried out in papers published in 2018 in the following journals:

- Tehnički vjesnik/Technical Gazette ISSN 1330–3651, [10];
- Engineering Review, ISSN 1330–9587, [11];
- Acta Polytechnica Hungarica ISSN 1785–8860, [12];
- American Journal of Electrical Power and Energy Systems ISSN: 2326–912X, [13], and
- International Journal of Renewable Energy Research ISSN: 1309–012, [14].

The analysis was performed by the first author as part of the final paper written at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek, [15]. The total number of analysed papers was 701; however, the conducted analysis is a subjective review and despite careful analysis, there is a possibility of deviation from the actual situation. The number of published articles during the year differs significantly for each journal, Figure 2.

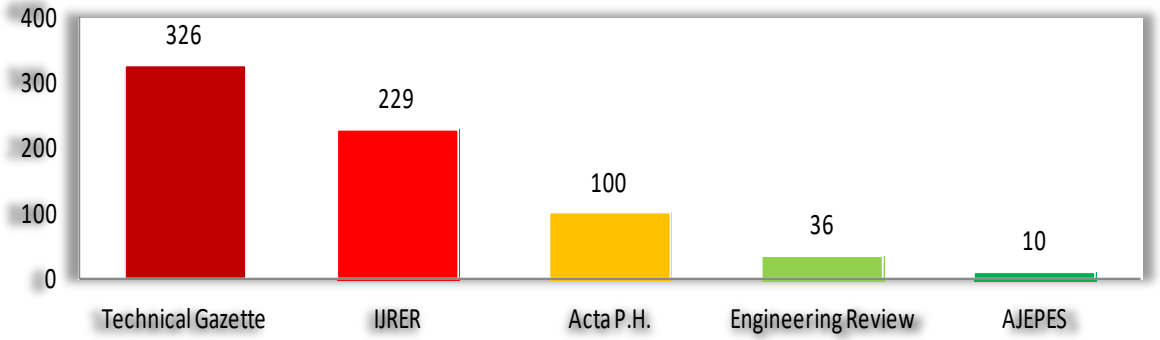

Figure 2. Number of published scientific papers in the journal per year

On average, Tehnički vjesnik/Technical Gazette publishes 40 articles per issue which results in a high number in Figure 2. The International Journal of Renewable Energy Research is quarterly published with an average of 57 articles per issue. Acta Polytechnica Hungarica published 8 issues per year and has an average of 12 papers. Engineering Review is published in three issues with an average number of 12 papers per issue. In 2018 American Journal of Electrical Power and Energy Systems published six issues with two papers per issue. The number of pages per paper also differs which is shown in Figure 3.

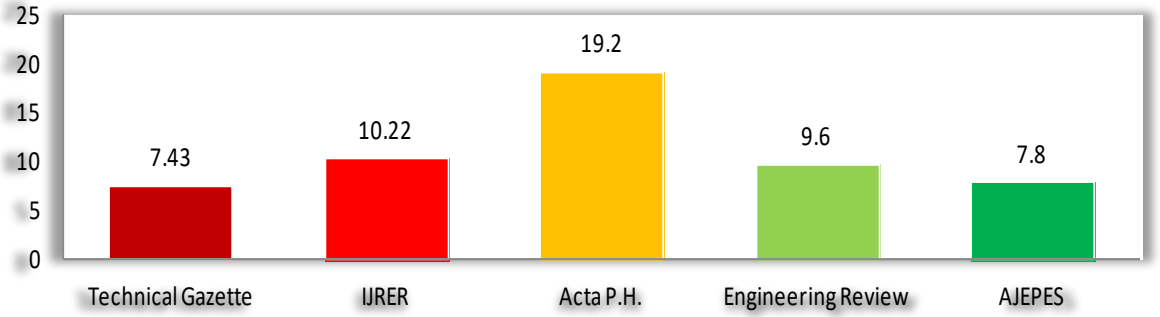

Figure 3. Number of pages per scientific papers

A significant number of pages per paper can be visible in Acta Polytechnica Hungarica which is due to the one–column format, while other journals use the two–column format. The share of the text related to Electromagnetism and subject to the guidelines of the sixth part of the standard, in all papers published in 2018, is shown in Figure 4.

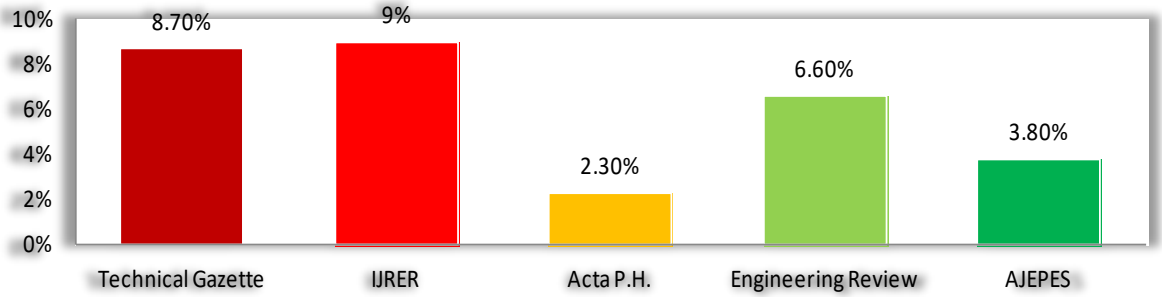

Figure 4. Share of the text subject to IEC 80000–6:2008 guidelines

The frequency of text deviates considerably compared to the average of the two journals Acta Polytechnica Hungarica and American Journal of Electrical Power and Energy Systems. Deviation from the average only shows the frequency of the topics which deal with Electromagnetism, whereas Table 3 presents compliance with the standard with respect to deviation from standard recommendations. In other words, in Table 3 a classification of application of the standard in individual journals using grades from 1 to 5 was conducted.

Table 3. Evaluation of the application of IEC 80000–6:2009

Journal	Grade
Tehnički Vjesnik/Technical Gazette	5
Engineering Review	3
Acta Polytechnica Hungarica	4
American Journal of Electrical Power and Energy Systems	4
International Journal of Renewable Energy Research	4

5. CONCLUSION

Systems that perform a function are often referred to as technical systems. A description of a technical system is inconceivable without numbers and symbols. Most technical systems include phenomena that we encompass under the name Electromagnetism. The number of scientists for whom physics is not the primary profession and who study electromagnetism is constantly growing. Therefore, an unambiguous way of writing complying with the standards recommendations is extremely important. The international standard that defines Electromagnetism is ISO – IEC 80000–6: 2008 Quantities and units – Part 6: Electromagnetism. The International Organization for Standardization, in cooperation with the International Electrotechnical Commission (IEC), enacts the above standard, which introduces order in the way of writing: names, symbols, and definitions for quantities and units of electromagnetism. The IEC 80000–6: 2008 provides examples of records of all sizes describing the field of Electromagnetism through name, symbol, definition and notes. The rules that are used in the standardisation system allow only for a brief overview on the examples of quantities described by the standard. From a handful of examples, we opted for the Poynting vector which describes the direction of energy movement, voltage source, apparent power and power factor. The application of the standard is shown on the example of five international scientific journals. The practical analysis was performed by the first author as part of the final paper and about 700 scientific papers were analysed. Taking the above into account, the conducted analysis is a subjective review and despite careful analysis, there is a possibility of deviation from the actual situation. The results of the analysis presented graphically indicate that the elements in the articles related to the standard are represented on average by 6%. The average applicability of the standard is up to 75%, and Technical Gazette is an example of full compliance with the standard recommendations.

Note: This paper was presented at IIZS 2021 – The XI International Conference on Industrial Engineering and Environmental Protection, organized by Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad, in Zrenjanin, SERBIA, in 07–08 October, 2021.

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