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ISO 17025 and ISO 9001: A Review on Quality Management in Digital Forensics Laboratories

ISO 17025 ve ISO 9001: Adli Bilişim Laboratuvarlarında Kalite Yönetimi Üzerine Bir İnceleme

Özet

Etkin ve verimli bir çalışma için her organizasyonun, başarıya ulaşmalarını sağlayacak temel bir yönetim sistemi geliştirmesi gerekmektedir. Dünya genelinde birçok organizasyon, yönetim sistemlerini geliştirmek için uluslararası standartları bir rehber olarak kullanmaktadır. Ancak, adli bilişim laboratuvarları için bu tür bir sistemi geliştirmeye yönelik özel bir standart bulunmamaktadır. ISO/IEC 17025, laboratuvarlarda test ve kalibrasyon yeterliliği için genel bir standarttır ve adli bilişim laboratuvarlarını akredite etmek için uyarlanmıştır. Standardın adli bilişim laboratuvarlarına ne derece uygun olduğu konusunda birçok belirsizlik bulunmaktadır ve bu durum, alanında daha fazla araştırma yapılmasını gerektirmektedir. Bu standart, yalnızca Kalite Yönetim Sistemi (KYS) için tasarlanmış olan ISO 9001:2015 ile kıyaslandığında, ISO 17025:2017 minimum KYS gereksinimlerini içermektedir.

Bu çalışma, adli bilişim laboratuvarlarında kurulacak olan yönetim sistemleriyle yakından ilgili iki uluslararası standarda odaklanmakta ve adli bilişim laboratuvarlarının etkinliğini ve verimliliğini artırabilecek metodolojiler önermektedir. İncelemede iki akreditasyon, adli bilişim alanına uygulanabilirliği bağlamında gözden geçirilmiş, benzerlikleri ve sınırlamaları KYS ile ilgili bağlamlarıyla birlikte karşılaştırılmıştır. Kalite yönetimi ile ilgili adli bilişim laboratuvarları özelinde uygulanacak olan bir taslak standart hakkında öneriler sunulmuştur.

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Abstract

In order to operate effectively and efficiently, every organization needs to develop a basic management system that will enable them to achieve success. Many organizations around the world use international standards as a guide to develop their management systems. However, there are no specific standards for developing such a system for digital forensics laboratories. ISO/IEC 17025 is a general standard for testing and calibration competence in laboratories and has been adapted to accredit digital forensics laboratories. There are many uncertainties about how suitable the standard is for digital forensics laboratories, and this requires further research in the field. This standard includes the minimum Quality Management System (QMS) requirements of ISO 17025:2017, compared to ISO 9001:2015, which is designed only for (QMS).

This study focuses on two international standards that are closely related to the management systems to be established in digital forensics laboratories and suggests methodologies that can increase the effectiveness and efficiency of digital forensics laboratories. In the review, the two accreditations were reviewed in terms of their applicability to the field of digital forensics, and their similarities and limitations were compared in their context regarding QMS. Recommendations have been made about a draft standard regarding quality management that will be applied specifically to digital forensic laboratories.

Introduction

With the advancement of technology, habits of data recording, the places where data is stored, and the methods of accessing these locations have significantly changed. While digital platforms

have become the norm, traditional media such as paper have become exceptions. The capabilities provided by technology are altering human behaviors and, consequently, daily life routines. Beyond communication, "instant messaging" applications offer numerous conveniences, such as video calls, sending pictures, videos, voice recordings, and location sharing, making these applications rapidly popular. These devices are becoming increasingly complex, offering users a wide range of services.

Technology has created new crime areas for criminals while also advancing techniques to combat crime. It is crucial that data obtained from digital devices can be used as evidence to establish a connection with the incident. Digital evidence shares similar characteristics with traditional evidence but differs significantly in processes such as collection and examination.

To ensure that digital evidence is valued in judicial settings, the reliability and legality of forensic tools, techniques, and procedures must be investigated. Evidence will be considered valuable and valid in court when obtained through scientific methods (Pollitt, Caloyannides, Novotny, & Shenoi, 2004).

Typically, digital forensics involves recovering lost or hidden data from digital devices or retrieving data from digital storage media after an incident affecting an information processing system. Regardless of the specific details of the case, the general overview of handling a forensic case by a digital forensics laboratory follows the processes of preserving evidence, identifying evidence, extracting evidence, documenting the procedures performed, evaluating the evidence, and finally presenting the prepared report to the requesting authority based on the case's requirements (Watson & Jones, 2013).

Digital forensics laboratories must implement policies, processes, and procedures to ensure the integrity and reliability of the work performed. At this point, standards come into play. Standards encompass a wide range of activities, from product creation to services such as material supply for organizational needs. While most standards address technical issues for different applications, in recent years, there has been increasing recognition that voluntary, consensus-based standards can contribute much more to the business world and society in general than just technical requirements, test methods, and measurement protocols (Nelson, Phillips, & Steuart, 2010; Hatto, 2013).

A Quality Management System (QMS) defines the structure of an organization that must establish policies and objectives to meet specified quality requirements (e.g., ISO accreditation). Additionally, quality is defined as a product/service fit for its intended purpose, so for digital forensics laboratories, quality is determined by the competence of individuals and the organization, as well as the validity of established procedures and methods, as these determine whether they meet the quality objective. To date, digital forensics laboratories implementing a quality management system to achieve international accreditation have mostly done so by adopting and applying the requirements of the ISO/IEC 17025 standard (Al Hanaei & Rashid, 2014; Doyle, 2018).

In this study, the ISO 9001:2015 and ISO/IEC 17025:2017 standards were examined. The adequacy of the ISO/IEC 17025:2017 standard in terms of digital forensics laboratory quality management was evaluated, and the contribution of adopting the ISO 9001:2015 standard to address the remaining deficiencies and enhance the laboratory's efficiency was emphasized. Additionally, the conclusion of the study includes recommendations for improving the management effectiveness of the digital forensics laboratory.

1. Method

In this section, we introduce and compare the ISO 9001:2015 and ISO/IEC 17025:2017 standards to assess their suitability for quality management in digital forensic laboratories. Initially, we provide a comprehensive overview of each standard, outlining their key components and objectives. ISO 9001:2015 focuses on general quality management systems applicable across various industries, emphasizing customer satisfaction, process improvement, and organizational efficiency. Conversely, ISO/IEC 17025:2017 is specifically tailored for testing and calibration laboratories, with stringent requirements for technical competence and the reliability of test and calibration results.

Following the introduction of these standards, we conduct a comparative analysis based on several criteria pertinent to quality management. These criteria include documentation

requirements, personnel competency, equipment calibration, and the overall effectiveness of quality management systems. The comparison aims to highlight the strengths and weaknesses of each standard in the context of digital forensic laboratories, providing a basis for determining their applicability and effectiveness in ensuring high-quality forensic processes and outcomes.

1.1. ISO 9001: 2015

ISO 9001 is an internationally recognized standard for quality management. It helps organizations of all sizes and sectors improve their performance, meet customer expectations, and demonstrate their commitment to quality. The requirements define how a quality management system (QMS) should be established, implemented, maintained, and continually improved. With over one million certifications issued to organizations in 189 countries, ISO 9001 is the world's most widely used quality management standard. Within the ISO 9000 family, which defines the seven quality management principles, ISO 9001 is the only standard that can be certified (International Organization for Standardization [ISO], 2015).

Over the past thirty years, the ISO 9001 standard has had a significant impact on the perception and management of quality, arguably playing the most critical role in quality assurance. Despite criticisms and objective errors attributed to these standards, the contributions of the ISO 9000 family to global quality regulation are extremely important (Medić, Karlović & Cindrić, 2016).

The ISO 9001 standard is based on seven principles fundamental to a quality management system. These principles aim to enhance the quality of organizations and ensure compliance with the criteria set by the standard. These core principles include customer focus, leadership, engagement of people, process and system approach, continual improvement, evidence-based decision-making, and relationship management. Effective implementation of these principles ensures the successful adoption and maintenance of the ISO 9001 standard by organizations (Schmuck, 2021).

ISO 9001:2015 consists of 10 sections, as illustrated in Figure 1. Sections 1-3 provide information on the application, terms, and definitions of the standard, while sections 4-10 specify the requirements of the QMS. Additionally, the standard includes section 0, which explains its purpose and principles, and two annexes, A and B, that provide supplementary information (Cochran, 2015).

Figure 1. ISO 9001:2015 Sections

1.2. ISO/IEC 17025:2017

The ISO 9001 standard does not encompass all activities conducted within forensic laboratories; hence, an international standard that addresses these specific requirements is necessary. Currently, there is no international standard specifically designed for the management systems of forensic laboratories. While the ISO 27000 family of standards provides certain requirements for specific activities, these requirements are generally not directly related to management systems and are more effective in the design of customer service processes (Veber & Klíma, 2014).

ISO/IEC 17025:2017 outlines the requirements for laboratories performing calibration, testing, and sampling, expecting to produce reliable and valid results. This standard is applicable to all laboratories, including those in private or public sectors, universities, and research or inspection bodies. It also encompasses conditions for the competence of tests and calibrations performed using non-standard and laboratory-developed methods (ISO 2017; Turkish Standards Institution [TSE], 2017).

To enhance the consistency of forensic processes from the pre-incident stage to case closure, standardization across all levels, including technical, managerial, and oversight, is necessary. Evidence examination is one of the fundamental stages of evidence investigation in forensic laboratories, and an accredited laboratory ensures the reliability of the results. The ISO/IEC 17025 standard can be utilized for the overall accreditation of forensic laboratories. ISO/IEC 17025 serves as a normative reference that defines the general requirements for evaluating the competence of laboratory operations and is applicable to laboratories and their activities (Sommer, 2018).

ISO/IEC 17025:2017 consists of eight sections; sections 1-3 include the scope, normative references, and terms and definitions, whereas sections 4-8 elaborate on the requirements that must be implemented in laboratories to meet the defined criteria and scope. Additionally, this standard includes two annexes, A and B. The main sections of ISO/IEC 17025:2017 are illustrated in Figure 2 (Miguel, Moreira, & Oliveira, 2021).

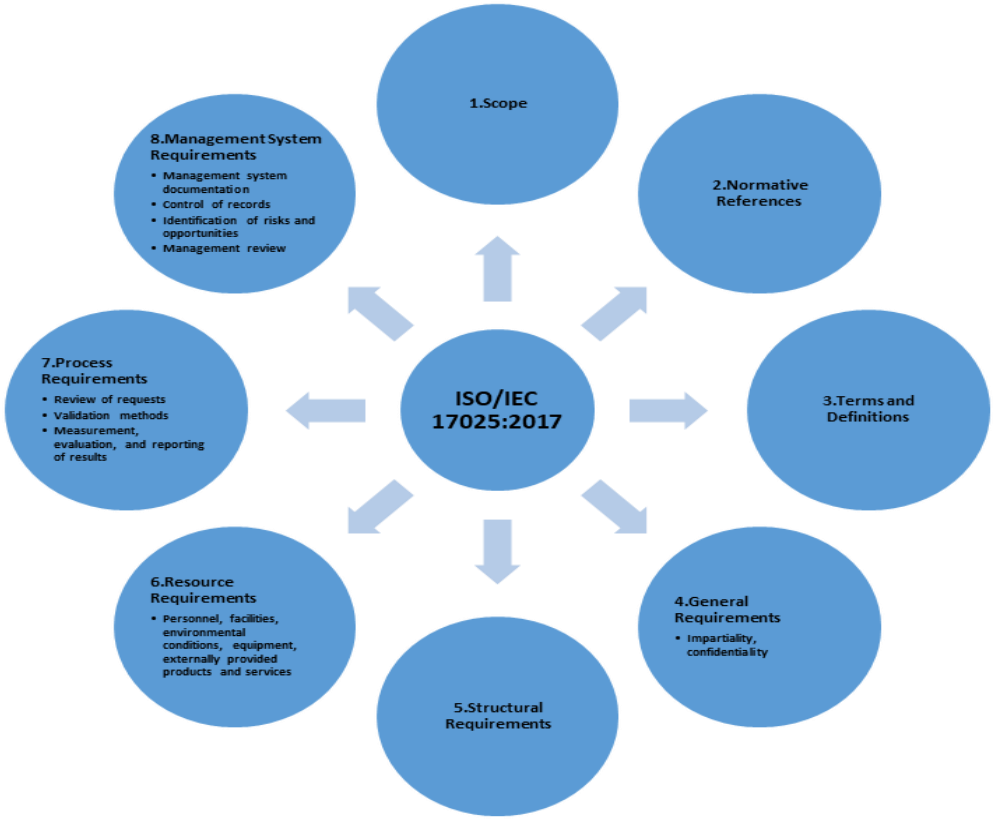

Figure 2. ISO/IEC 17025: 2017 Sections

1.3. Comparison of ISO 9001:2015 and ISO/IEC 27015:2017 Standards in Terms of Quality Management

Although the ISO/IEC 17025 standard is not specifically designed for forensic laboratories, it can serve as a good starting point when establishing a management system. Additionally, there exists a widely recognized quality management system standard, such as ISO 9001:2015. This standard provides a framework that ensures the basic management system requirements, which can be adopted by any organization (Guo & Hou, 2018).

The ISO/IEC 17025 standard has three different versions: 1999, 2005, and 2017. The update from 1999 to 2005 included commitments and responsibilities for top management in continuous improvement and the development of communication mechanisms in customer relations. These changes align with an approach consistent with ISO 9001 standard.

From a quality management system perspective, one of the differences between ISO 9001:2015 and ISO/IEC 17025:2017 lies in their management system requirements. ISO 9001:2015 encompasses broad quality management system requirements, including leadership, planning, support, operation, performance evaluation, and improvement, while ISO/IEC 17025:2017 includes specific requirements to ensure the competence, impartiality, and consistent operation of laboratories. This standard also places great emphasis on technical requirements such as method validation, uncertainty measurement, and the accuracy of test results (Hoyle, 2017).

Another difference between the two standards is their approach to customer relations. ISO 9001:2015 places significant importance on customer satisfaction and emphasizes integrating customer feedback into quality improvement processes, whereas the ISO/IEC 17025:2017 standard addresses customer relations more in terms of technical agreements and the technical evaluation of customer requirements (Gotzamani & Tsiotras, 2001).

When looking at the differences in documentation and record-keeping, ISO 9001:2015 aims to document the general management processes of the organization and ensure interaction and continuity between processes, while ISO/IEC 17025:2017 provides more detailed documentation requirements for the traceability and verifiability of laboratory results. It is necessary to maintain precise records for the validity of laboratory test results and calibrations.

These standards are internationally recognized; however, while ISO 9001:2015 can be applied to any organization, ISO/IEC 17025:2017 is applicable only to laboratories. ISO 9001:2015 is a general standard that outlines the QMS requirements necessary for accreditation; ISO 17025:2017, on the other hand, describes the minimum requirements. Therefore, when a laboratory implements the minimum requirements, some aspects may be lacking. For instance, ISO 9001:2015 addresses additional factors such as the context of the organization (section 4), leadership (section 5), quality objectives (section 6), and monitoring and measurement (section 7), which are not covered in ISO 17025:2017. The additional QMS requirements and similarities related to ISO 17025:2017 when implementing ISO 9001:2015 are illustrated in Table 1 (Haluszka & Mansour, 2023).

Table 1. Comparison of ISO 9001: 2015 and ISO/IEC 2715: 2017 Standards in terms of QMS

ISO 9001:2015	ISO/IEC 17025:2017	Results
Section 4	5.4, 4.1.3, 4.2.1, 7.9.2, 5.3	ISO 9001 addresses external and internal issues relevant to the parties involved and determines the scope of the QMS; ISO/IEC 17025:2017, on the other hand, only emphasizes the importance of complying with the requirements of the laboratory and other parties (ISO 2017; ISO 2015).
4.1	5.4	External factors in the digital forensics laboratory include the rate of change, for example due to regular updates of software, hardware and applications(Sommer, 2018). That's why organizations need to create and implement a security policy that includes regular software updates. Internal issues, on the other hand, involve human errors because they are prone to cognitive bias and ultimately affect the results of the review. However, ISO/IEC 17025:2017 does not make such a classification(Sunde & Dror, 2019; Christensen, Crowder, Ousley & Houck, 2014).
4.2	4.1.3, 4.2.1, 7.9.2	According to ISO 9001:2015, it is essential to define the relevant parties and their requirements before providing services and products. However, ISO/IEC 17025:2017 emphasizes the importance of impartiality, confidentiality and complaints (ISO 2017; ISO 2015). Interested parties include stakeholders such as decision makers and customers who are interested in the outcome of the investigation (Graves, 2014; C. Armstrong, 2012)
4.3	5.3	ISO 9001:2015 states that organizations must determine requirements according to their goals and objectives and implement them within the scope of the QMS. ISO/IEC 17025:2017 states that laboratories must specify the range of activities they will perform and adhere solely to these specifications (ISO 2017; ISO 2015).
Section 5	8.2.3, 8.9.1	ISO 9001:2015 describes leadership and commitment as well as developing a quality policy. Although ISO/IEC 17025:2017 does not address these issues, it does touch on the importance and roles of laboratory management (ISO 2017; ISO 2015).
5.1	8.2.3	ISO 9001:2015 addresses top management's responsibility for the QMS and its effectiveness, as well as ensuring it meets the requirements of all relevant parties within the organization.

		However, ISO 17025:2017 defines that there must be a management system implemented with relevant evidence to prove its effectiveness (ISO 2017; ISO 2015). The credibility of forensic science is called into question when there is a significant lack of leadership in the forensic science community, leading to the application of poor standards and wrongful convictions (Houck, McAndrew, Porter & Davies, 2015). Additionally, implementation of forensic investigation preparation by senior management is essential to preserve digital evidence before and after the incident, and these include data security, security training and awareness of staff, etc. (R. Rowlingson, 2004). Because forensic sciences lack senior management leadership consideration, all activities associated with forensic sciences are accredited with ISO/IEC 17025:2017, including digital forensics. Therefore, it will be useful to address these factors in order to fully meet the requirements of ISO 9001:2015.
5.2	8.9.1	According to ISO 9001:2015, top management must implement and maintain an effective quality policy that is appropriate to the purpose and context of the organization and communicate with its personnel (ISO 2015). The ISO/IEC 17025:2017 standard requires the laboratory to maintain a management system in accordance with the procedures implemented and to review it regularly to ensure its effectiveness and continuous improvement (ISO 2017).
Section 6	8.7.1, 8.8.2	ISO 9001:2015 emphasizes the importance of QMS, but ISO/IEC 17025:2017 does not include QMS objectives (Stores, 2020).
6.2	8.2.1, 8.2.2, 8.5.1b, 8.9.1, 8.9.2	ISO 9001:2015 emphasizes that management must establish quality objectives for all business functions and departments in an organization and that these must be measurable, updated and in line with the quality policy (Advisera, 2016). Laboratory management is responsible for maintaining policies and objectives in accordance with ISO/IEC 17025:2017 and consistent with all laboratory operations. ISO/IEC 17025:2017 emphasizes the importance of quality assurance (QA) as it ensures that quality requirements are met.
Section 7	6.1, 6.6.1, 7.2.1, 8.2.1	Although ISO 9001:2015 addresses basic support elements such as, resources, competent people, necessary infrastructure and environment, etc. (ISO 2017; ISO 2015). ISO/IEC 17025:2017 also covers many factors necessary for the successful operation of laboratories, but it does not cover all the requirements of ISO 9001;2015, especially in matters such as institutional information, monitoring and measurement of resources.
7.1.5	6.2.5f, 6.6.2b, 8.9.2, 6,7	According to ISO 9001:2015, organizations must provide the necessary appropriate resources when monitoring whether the products and services produced comply with the requirements, and measurement traceability must be available when needed. However, ISO 17025:2017 However, ISO 17025:2017 states that procedures should be established for requires laboratories to identify authorized personnel, determine the performance of external providers, etc. (Sunde & Dror, 2019; Christensen, Crowder, Ousley & Houck, 2014).
7.1.6	6.2	ISO 9001:2015 states that the organization must provide and determine the information necessary to carry out its processes in order to adhere to the products and services it produces, for example by providing training, experience or qualifications. However, ISO 17025:2017 discusses the importance of the competence of personnel, including their training and experience, as it affects the quality assurance of products and services (FSR, 2020).

2. Findings

ILAC (International Laboratory Accreditation Cooperation) has emphasized the advantages offered by accreditation based on the ISO/IEC 17025 standard. Among these advantages are the international recognition of testing competence, comparative performance evaluation, marketing benefits, and global recognition of laboratories (Watson & Jones, 2013).

Although the ISO/IEC 17025 standard is used for the accreditation of forensic laboratories, several authors in the literature have noted that this standard is not suitable for forensic laboratories in many respects. Marshall and Paige (2018) stated in their study that the definition of forensic methods and the requirements related to tools and methods align to some extent.

Hong Guo and Junlei Hou (2018) highlighted ongoing debates about whether this standard is the most appropriate option for forensic laboratories. The mandatory implementation of this standard for forensic laboratory accreditation in the United Kingdom is a focal point of these discussions. The authors also noted that many forensic experts oppose the ISO/IEC 17025 standard due to reasons such as costs, misunderstanding of instructions, poor practices, and inconsistencies. They emphasized that the implementation of the standard requires specialized expertise.

Hykš and Koliš (2014) suggested that two international standards, although not specifically designed for forensic laboratories, could be useful for the initial steps in designing a management system. They indicated that the requirements could be modified and supplemented to meet the specific needs of such an organization. It should be noted that designing a management system based on international standards may impose certain limitations on monitoring and improving organizational performance.

Haluszka and Mansour (2023) examined the direct applicability of the ISO/IEC 17025:2017 standard to forensic laboratories, and their findings are presented in Table 2.

Table 2. Suitability of ISO/IEC 17025: 2017 Standard for Digital Forensics Laboratory

Clause Number	Clause Title	Suitability
4	General requirements	
4.1	Impartiality	Completely suitable
4.2	Confidentiality	Completely suitable
5	Structural Requirements	Completely suitable
6	Resource requirements	
6.1	General	Completely suitable
6.2	Personnel	Completely suitable
6.3	Facilities and environmental conditions	Conditionally suitable
6.4	Equipment	Completely suitable
6.5	Metrological traceability	Conditionally suitable
6.6	Externally provided products and services	Completely suitable
7	Process requirements	
7.1	Review of requests, tenders, and contracts	Completely suitable
7.2	Selection, verification, and validation of methods	Completely suitable
7.3	Sampling	Not suitable
7.4	Handling of test or calibration items	Completely suitable
7.5	Technical records	Completely suitable
7.6	Evaluation of measurement uncertainty	Completely suitable
7.7	Ensuring the validity of results	Completely suitable
7.8	Reporting of results	Completely suitable
7.9	Complaints	Completely suitable
7.10	Nonconforming work	Completely suitable
7.11	Control of data and information management	Completely suitable

Discussion and Conclusion

Forensic sciences have developed over the past millennium as science and society have advanced and a need for the public use of science has emerged. Digital forensics has significantly expanded in dimension and scope over the past few decades. Digital forensics emerged as a new field when law enforcement agencies discovered the need to collect digital evidence from computers that were part of crime scenes. Several attempts have been made to derive digital forensics methodologies from the development efforts of other disciplines, particularly forensic sciences. However, at this point, digital forensics has established itself as a sub-discipline of forensic sciences (Hankins, Uehara, & Liu, 2009).

While the ISO/IEC 17025 standard is widely used for the accreditation of forensic science laboratories in most countries, it cannot be said that this standard fully aligns with all forensic science disciplines. Expecting this standard to fit digital forensics—a relatively new discipline with rapid changes compared to other forensic science disciplines—would be an unrealistic approach.

Some authors consider the ISO/IEC 17025 standard a good starting point for the creation of standards in digital forensics, even though it cannot be fully applied. Others view these standards as difficult to understand, expensive, and lacking in consistency (Guo & Hou, 2018).

Essentially, as outlined in Table 1, it is noteworthy that ISO 9001:2015 addresses more quality requirements compared to ISO/IEC 17025:2017, as it deals with additional factors. However, since most countries use ISO/IEC 17025:2017 accreditation for digital forensics laboratories and because this standard better reflects the activities conducted within a digital forensics laboratory, its applicability to digital forensics laboratories has been examined in Table 2.

The analysis of the applicability of the ISO/IEC 17025 standard to digital forensics laboratories resulted in three different categories: fully applicable clauses, non-applicable clauses, and partially applicable clauses. Additionally, clauses that are not directly applicable to digital forensics laboratories but can be designed to fill gaps in practice were identified. In cases of partial scope, it is recommended to use ISO 9001 requirements because ISO/IEC 17025 does not fully cover the requirements of ISO 9001. Given the relationship between the two standards, ISO/IEC 17025 can be effectively used to meet requirements when it fully encompasses ISO 9001. The primary difference between ISO/IEC 17025 and ISO 9001 is that ISO/IEC 17025 does not require a process-based structure. Considering the unique activities of digital forensics laboratories, a model that integrates process and project approaches should be developed in accordance with ISO 9001 requirements. The integration of ISO 9001 and ISO/IEC 17025 requirements will ensure the implementation of an effective and efficient management system tailored to the characteristics of the laboratory (Hykš & Koliš, 2014).

Voluntary and consensus-based standards hold significant importance in national and international infrastructures, economies, and commerce, even though they are often overlooked. These standards offer accepted methods for naming, defining, measuring, testing, managing, and reporting. While most standards cover technical issues, it has become increasingly evident in recent years that they can contribute beyond technical specifications, test methods, and measurement protocols, impacting the business world and society at large. This awareness has spurred the development of general management system standards such as the ISO 9000 series.

ISO/IEC 17025:2017 is recognized as a general standard for the competence of testing and calibration laboratories. It is also used for accrediting digital forensics laboratories in most countries. However, this standard has been inappropriately applied when addressing specific risk levels associated with digital evidence. ISO/IEC 17025:2017 has been adapted to accredit a digital forensics laboratory without aligning it with the requirements and excluding risk factors (points of failure).

ISO 9001:2015 addresses more comprehensive quality requirements compared to ISO/IEC 17025:2017. However, when it comes to activities conducted in laboratories, ISO/IEC 17025:2017 encompasses a broader scope of the tasks performed and is thus more applicable to digital forensics laboratories.

In terms of quality management systems within a digital forensics laboratory, neither ISO 9001:2015 nor ISO/IEC 17025:2017 alone fully cover the activities conducted in the laboratory.

Therefore, quality management in digital forensics laboratories would yield more successful outcomes if these two standards are applied in a complementary manner.

There may be some challenges in using both standards interactively at the same time. Initially, it can be confusing and may require additional documentation.

On the other hand, there are also challenges in establishing a quality management standard that integrates both standards and is tailored for digital forensics laboratories. It should be noted that the established standard should not only cover the quality management system but also other operations of the digital forensics laboratory. Since the application of the clauses within the system is mandatory, the newly planned system must have the capacity to support all other clauses.

As there is no anticipated development activity for a new standard specific to digital forensics laboratories at present, it is recommended that a quality management system to be established in digital forensics laboratories should be based on the similarities and cross-references identified between ISO 9001:2015 and ISO/IEC 17025:2017 through this review. Furthermore, this review could serve as a starting point for future draft standard efforts related to quality management systems in digital forensics laboratories.

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