19. Pidsumky orhanizatsiinoi diialnosti oblasnykh, Kyivskoi ta Sevastopolskoi miskykh orhanizatsii Tovarystva za 1979 rik (1980) [Results of the organizational activities of the regional, Kyiv and Sevastopol city organizations of the Society for 1979]. *Pamiatky Ukrainy,* 2, 63 (in Russian).
20. *Rudko, V.* Shkola patriotyzmu (1982). [School of patriotism]. *Sotsialistychna Kharkivshchyna,* October 22 (in Ukrainian).
21. Spravochnik po arheologii Ukrainy. Harkovskaya oblast [Handbook of archeology of Ukraine. Kharkov region] (1977). Kyiv: Naukova dumka, 156 p. (in Russian).
22. Statut Ukrainskoho tovarystva okhorony pamiatnykiv istorii ta kultury: Postanova Rady Ministriv ukrainskoi RSR vid 12 chervnia 1967 r. № 378. Zakonodavstvo pro pamiatnyky istorii ta kultury: zb. normatyvnykh aktiv [Statute of the Ukrainian Society for the Protection of Historical and Cultural Monuments: Decree of the Council of Ministers of the Ukrainian SSR dated June 12, 1967 No. 378. Legislation on historical and cultural monuments: coll. normative acts]. Kyiv: Vydavnytstvo politychnoi literatury Ukrainy, 47–66 (in Ukrainian).
23. *UTOPIK*. URL: http://pamjatky.org.ua/

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CREATION OF THE SYSTEM FOR ENSURING THE UNIFORMITY OF MEASUREMENTS IN UKRAINE IN THE XX CENTURY

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Abstract. In this article analyzes the formation and development of the system of ensuring the uniformity of measurements in Ukraine, in particular its technical basis – the reference base. The role of the main metrological center of Ukraine – the National Scientific Center «Institute of Metrology» (NSC «Institute of Metrology») in the creation of a unique reference base in Ukraine is outlined. The activity of scientific metrological institutions of Kyiv, Lviv and Ivano-Frankivsk is considered. The stages of formation of the Ukrainian system of ensuring the uniformity of measurements from the creation of the first verification tent in Kharkiv to the creation of a network of research institutions in the field of metrology are investigated. Three 3 main stages of development are distinguished: I stage 1901–1952; II stage 1952–1991; III stage began in 1991. The types of measurements that contributed to the development of the industrial complex of Ukraine, the establishment and improvement of measurement standards are considered. On the basis of legislative documents, scientific literature, archival materials, the organization and further development of the reference base of Ukraine at the end of the twentieth century is considered. The programs for the creation of the reference base of Ukraine in 1992, 1993–1997, despite a number of difficulties, lack of necessary funding, loss of metrological equipment, equipment, scientific relations were implemented. It is substantiated that the main scientific center for the implementation of the program was the NSC «Institute of Metrology». On the basis of this institution, conditions were created for the storage of 52 state primary standards and 16 secondary standards. The SSC «Institute of Metrology» is located at 42 Myronositskoho Street. in July 2022, it came under artillery shelling. The building was partially destroyed.

Key words: standard, uniformity of measurements, national metrological service, Ukraine.

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СТВОРЕННЯ СИСТЕМИ ЗАБЕЗПЕЧЕННЯ ЄДНОСТІ ВИМІРЮВАНЬ В УКРАЇНІ В XX СТ.

Анотація. У статті проаналізовано становлення і розвиток системи забезпечення єдності вимірювань в Україні, зокрема її технічної основи – еталонної бази. Окреслено роль головного метрологічного осередку України – Національного наукового центру «Інститут метрології» (ННЦ «Інститут метрології») у створенні унікальної бази еталонів в Україні. Розглянута діяльність наукових метрологічних закладів Києва, Львова та Івано-Франківська. Досліджено етапи становлення української системи забезпечення єдності вимірювань від створення в Харкові першої перевірочної палатки до створення мережі науково-дослідних інституцій у галузі метрології. Виокремлено три основні етапи розвитку: І етап охоплював 1901–1952 рр., ІІ етап – 1952–1991 рр., ІІІ етап розпочався у 1991 р. Розглянуто види вимірювань, які сприяли розвитку промислового комплексу України, становленню та вдосконаленню еталонів вимірювань. На основі законодавчих документів, наукової літератури, архівних матеріалів розглянуто організацію та подальший розвиток еталонної бази України наприкінці XX ст. Програми створення еталонної бази України 1992 р., 1993–1997 рр., незважаючи на низку труднощів, відсутність необхідного фінансування, втрату метрологічного обладнання, устаткування, наукових зв'язків, були реалізовані. Обґрунтовано, що головним науковим осередком із реалізації програми був ННЦ «Інститут метрології». На базі цього закладу створено умови для зберігання 52 державних первинних еталонів та 16 вторинних еталонів. ННЦ «Інститут метрології» розташований на вулиці Мироносицького, 42, у липні 2022 р. зазнав артилерійського обстрілу. Будівля була частково зруйнована.

Ключові слова: еталон, єдність вимірювань, національна метрологічна служба, Україна.

Introduction. The function of assuring the uniformity of measurements in the country is performed by the national standard base. The standard base represents the technical basis of the system for ensuring the uniformity of measurements, the level of its development determines the pace of scientific and technological progress, development of international trade and integration into the international economy. The measurement standard base contributes to the consumer and state interests protection in the field of product quality and safety. The measurement standards system is a part of the metrological assurance of the uniformity of measurements. The system of measurement standards in Ukraine began to develop in the first half of the twentieth century and is associated with the establishment of the Ukrainian Main Chamber of Weights and Measures [1].

The works [14–15] are devoted to the history of development and creation of the standard base of Ukraine. Some problems of the standards creation are considered in the work of B.A. Hrytsko [7]. General information about the periods of standard base formation and some information about the creation of individual types of standards and the standard complex of the NSC «Institute of Metrology» can be found in the monograph [8]. However, in the fonds of the State Archive of Kharkiv region, the Central State Archive of the higher authorities there are materials that can significantly extend the information about the trends of formation and development of the standard base and the formation of some types of measurements in the NSC "Institute of Metrology".

The aim of the article: on the basis of generalization of archival materials and documents of the research part of the Kharkiv Institute of Metrology to highlight the stages of development and show the features of the standard base formation in Ukraine in the twentieth century.

Methods. Research methods are based on the principles of historical knowledge. Also in the study were used general scientific methods of analysis and synthesis, method of logic and classification. Special historical methods were applied: problem-chronological, historical-comparative, historical-typological, historical-systemic, retrospective. The basic

was the problem-chronological method, which made it possible to organize the entire array of information on the formation of the reference base in Ukraine in chronological order, to divide the broad topics into narrower, specific problems, as well as to characterize the features of each stage.

Research development in the field of metrology and establishment of the first national institutions. The beginning of the formation of the Ukrainian standard base is connected with the creation of the first verification tent in Kharkiv. The initiator of the metrological institution was D. I. Mendeleev. The scientist reformed the state measurement system and initiated the development of a new draft law on weights and measures. According to the resolution of D. I. Mendeleev, a number of verification institutions were opened. Particular tent in Kharkiv was the first metrology institution in Ukraine. The staff of the verification tent was mainly engaged in the questions of applied metrology, such as verification and branding of mass measures – weights and scales, volume measures – capacities and length measures. Therefore, the first metrological activities, which were carried out in the verification tents, were connected with the society's daily needs. Trade, for example, has always had a fundamental place in human life and mass measurement is one of the oldest forms of measurement linked to the market economy. Before the transfer to the metric system of measures in 1918, Russian pound was taken as the unit of mass in the Russian Empire, which included part of Ukraine. It was equal to 0.40951241 kg. The analysis of Kharkiv verification tent and other verification tents of Ukraine, formed in the following years, has shown that there were practically no activities in the field of metrology. The work of the employees of the Kharkiv metrology tent was related to the practical realization of the trade requirements and maintenance of uniformity in the measuring economy of the country. However, even these attempts did not have the necessary effect. For this reason, it was decided to set up the Ukrainian General Chamber of Weights and Measures (UTC) in 1922. This was the first scientific institution of a special metrology type in Ukraine. Research laboratories were set up in the UTC to carry out various scientific research [3, p. 7–21].

It is worth mentioning that in the beginning of XX century, Kharkiv was an industrial city – Kharkiv was a developing industrial city with enterprises and institutions of higher technical education. And therefore the creation of Ukrainian General Chamber became essential for the development of an industrial complex. For example, for large enterprises in Kharkiv it was important to maintain the exact time, which influenced the creation of its own time and frequency standard. First transmissions of exact time signals were carried out from 1929. At the end of 1929 precise time signals were broadcasted through the RO-20 radio station. Astronomical research also regularly determined corrections to Rifler times. During 1930–1940, Kharkiv Metrology Service was a member of the International Time Service. Since 1935, the reference frequencies were transmitted by a radio transmitter which was manufactured and installed in Kharkiv. This was the first and main transmitting station of the time and frequency service of the USSR Gosstandart (State Standard) [4, p. 2–5].

Since the late 30s of the XX century, UTC started to work in the field of linear and angular measurements. High–precision interference measurements were also carried out. In 1931–1941, the limits and accuracy of absolute interference measurements were extended and improved, modern methods of measuring threads and thread gauges were created, and schemes for transfer of units dimensions from standards to working measuring instruments for machine building industry were worked out. Since 1945, the work in the direction of increasing the accuracy of reproduction of units, certification and research of measurement standards and original measures of length was carried out [5, p. 11–23].

In 1940, the laboratory of mass measures of the Kharkiv State Institute of Measures and Measuring Instruments (KhSIMMI) was reorganized, which carried out the standard works and activities on state supervision. It should be noted that work aimed at ensuring the uniformity of mass measurement in Ukraine was very important. Under the control of the Kharkiv State Institute of Measures and Measuring Instruments were not only the territory of Ukraine but also many other regions. Thus, the Institute had under its authority 53 laboratories

of the state inspection located in Ukraine, Moldova, the Transcaucasian Republics, Rostov, Krasnodar, Stavropol and Belgorod oblasts [6, p. 1–8].

Within the USSR, the fundamental research on time and frequency was carried out at the Institute of Physical–Technical and Radio–Technical Measurements (Moscow). There, the primary state standard of a unit of time and frequency was developed and reproduced on a new scientific basis – the atomic scale. The signals of this standard were transmitted by radio and television throughout the USSR. The time and frequency service of the Kharkiv Institute of Metrology was a part of the corresponding service of the USSR, and the secondary standard of the Institute was a part of the state group standard of time and frequency units of the USSR [9, p. 6–13].

Advanced scientific research related to new directions in science, such as quantum electronics and laser technology, were initiated in the mid-1960s. Experimental work on the development of lasers was also started at KhSIMMI. Further research on the frequency characteristics of lasers was carried out at this institute. These directions on the basis of KhSIMMI were consistently developed [9, p. 18–24].

In the late 1960s, a unique research laboratory was established at KhSIMMI to provide hydrophysical measurements. The Institute's staff created a modern instrumental base and mastered the methodology and technique of conducting research work on stands and in the actual sea conditions. As a result, an oceanological installation of several types of hydroacoustic wave recorders of vertical sounding was developed and put into practice for conducting oceanological work [11, p. 16–24].

In early 1978, in KhSIMMI on the basis of two laboratories the research department of hydrodynamic parameters of liquid mediums measurements and measurements of hydrophysical parameters was opened. Main tasks of the department were metrological support of aerospace research of the ocean. In the following years, the team of KhSNIIM created a unique equipment complex. Modern equipment of those years was protected by copyright certificates of the USSR. Since 1982, the main tasks of the department have been expeditionary works in the open ocean conditions. The specialists of the laboratory conducted research on the development and manufacture of active elements for lasers used in gravimetry and ranging, on the creation of absolute ballistic gravimeters [8, p. 3–15, 172–177].

The problem of improving the accuracy of construction and reproduction of the temperature scale is one of the fundamental problems in metrology. Since the late 80s of the twentieth century, in UkrCSM there were new directions of work, which were associated with the construction of thermodynamic temperature scale by radiometric method. It should be noted that the main development of temperature metrology was a significant increase in the accuracy of radiometric methods of temperature measurements [13, p. 9–18].

Creation of national standard base of Ukraine. In the early 1990s, most of the technical means, including a mobile laboratory equipped with quantum clocks, methods of frequency and time standard signals transmission by radio, television, ground and satellite radio navigation systems, most part of the measurement standards of different kinds of measurements remained in the Russian Federation. In the first years Ukrainian metrologists used the Russian standard base, and that limited and hampered the work on measurement uniformity organization in the country. It should be noted that at the end of 1992, the perspective programme of the development of the national measurement standard base was established to solve such problems. A commission was set up, consisting of the leading metrologists of the country, in particular the standard measuring specialists. The programme approved at its sessions stipulated the development of the measurement standards, which should have worldwide metrological characteristics, within a short period of time. The programme's formation and development was very difficult.

At the end of 1990, optical and optical–physical measurements were restructured. After 1991, work was carried out at the institute with the aim of developing measurement standards both for providing measurements of laser radiation parameters and for other fields of measurements, in which laser measurement systems are used. Development of the measurement standards started at the end of 1992 and were in the progress for 4 years. At

the end of 1996, 4 measurement standards were created for these types of measurements, including the state primary standard of average power of continuous and pulsed laser radiation energy. The main purpose of the standard is reproduction, storage and transmission of a unit of power parameters of laser radiation. Additionally, the standard of unit of power of weak light signals has been created. This standard is required for metrological maintenance of fibre optic information transmission systems. Creation of these standards helped to form the basis for metrological support of measurements of power and frequency parameters of laser radiation. This standard complex has been improved over the years by the latest developments and advances in the industry. With the advent of lasers, the range of optical–physical measurements has expanded considerably. The successful development of laser technology at the NSC "Institute of Metrology" made it possible to create standard lasers awarded in international comparisons.

During the period from 1994 to 1999, lasers, which were included in the state standard of length units, participated four times in international comparisons of standards. Two comparisons took place in Kharkiv and two in Bratislava. Such countries as France, Germany, Russia and Slovakia took part in these comparisons. These international comparisons resulted in clarification of the absolute value of the frequency [15, p. 38–40].

By the decision of the Cabinet of Ministers of Ukraine, dated 16 March 1993 No 191 to the State Commission of unified time and reference frequencies the State Service of Time and Reference Frequencies of Ukraine was created. The State Programme «Creation and Development of the State Service of Unified Time and Standard Frequencies» was developed with the participation of scientists and specialists during 1994. During 4 years, the development of standard was carried out at KhSIMMI. On April 18, 1997 the State Standard of Ukraine approved the state primary standard of time and frequency units by the order No. 220 [7, p. 17–19].

It is worth noting that the standard activities at UkrCSM started in independent Ukraine. UkrCSM began to work in the direction of measuring the physical–chemical composition and substances properties in the late 1980s. However, the standard was developed only in 1995. This standard is necessary for the gas industry. Thanks to the appearance of the installation a number of questions in this industry were solved [11, p. 47–51].

Wide measurement of flow parameters, flow rate, level, volume of substances is carried out in those branches where measuring instruments are submitted to the state metrological supervision and control. The main branches where it is necessary to apply this type of measurements are: metallurgy, fuel and energy complex (including nuclear energy), chemical industry, medicine, municipal and agriculture services, trade, economic monitoring, etc. Since the end of 1993, the development of national measurement standards has started. During 3 years the work was under the process and in 1996 Ivano–Frankivsk enterprise "Prompribor" launched into operation the state primary measurement standards. Since the introduction of the measurement standards the calibration and metrological attestation of a large number of standard and working measuring instruments have been conducted on them. The tests of the working and standard means of measuring technique were carried out in Ukraine [16, p. 7–9].

Conclusion. Therefore, the formation of the standard base of Ukraine can be divided into 3 main stages of development. The first stage (1901–1952) was characterized as the initial stage of the standard base development. Despite the disorder in the national economy in the early 1920s, the establishment of the Kharkiv Verification Tent, and later the Ukrainian General Chamber of Weights and Measures, had a positive impact on the development of industry in the region. The first scientific research in the field of applied metrology was carried out which created the basis for the uniformity of measurements and uniformity of measuring instruments. Thus, at this stage the preparations for the development of the first national measurement standards took place. The second stage of the formation and development of the national standard base (1952–1991) is the period of the development of the standard complex system. During this stage, 8 measurement standards were developed. A wide range of laboratories had been established, which made it possible to carry out profound theoretical development and practical research in various fields of measurements.

The leading metrological institutions of Ukraine were engaged in realization of different state programmes. The third stage began in 1991. It was the main stage of the modern national measurement standard base formation. The Ukrainian metrologists had an important task – to develop the programmes of restoration and modernization of the standard base of Ukraine. As a result a series of standards were created in various kinds of measurements. Totally 69 primary measurement standards were developed for 12 kinds of measurements. Now 52 primary national measurement standards are stored in NSC "Institute of Metrology", 15 primary national measurement standards are kept in UkrCSM (Kyiv). In Lviv and Ivano–Frankivsk Centres of Metrology there is 1 primary national measurement standard per each city. Nowadays every Ukrainian city has metrological institutions, which perform state metrological control and supervision of standards, norms and rules observance in accordance with the Ukrainian legislation requirements.

REFERENCES

1. *Pavlenko, Yu. F.* (ed.), et al. (2011). Etalony [Standarts]. Kharkiv: Publishing House NSC "Metrology Institute". Kharkiv, 71 p. (in Russian)
2. *Lyashuga, I. Yu.* (2018). Osnovni metrolohichni tsentry zi stvorennia derzhavnykh etaloniv v Ukraini [The main metrological centers for the creation of state standards in Ukraine. *Actual issues of the history of science and technology*. Kyiv, pp. 150–153 (in Ukrainian)
3. *Tverytnykova, O. E.* (2002). Metrolohichna sluzhba Ukrainy naprykintsi 19 st.– 40 rr. 20 st. [The Metrological Service of Ukraine at the end of the 19th – 40 yeas of the 20th century]. *The history of science on the threshold of millennia*. Kyiv: Academy of Sciences of the Higher School, vol. 10, pp. 14–19 (in Ukrainian)
4. State archive of Kharkiv region. F. R-6183. Descr. 1. Case 428. P. 95.
5. State archive of Kharkiv region. F. R-6183. Descr. 1. Case 14. P. 25.
6. State archive of Kharkiv region. F. R-6183. Descr. 1. Case 3. P. 14.
7. *Bohdan, Hrytsko.* (2005). Narysy z istorii metrolohii na terenakh Ukrainy [Essays on the history of metrology in the territory of Ukraine]. Lviv: Afisha, 267 p. (in Ukrainian)
8. *Pavlenko, Yu. F.* (ed.), et al. (2001). 100 let HGNIIM: ot poverochnoy palatki do Glavnogo metrologicheskogo tsentra Ukrainy [100 years of Kharkiv State Institute of Measures and Measuring Instruments (KhSIMMI): from the verification tent to the Main metrological center of Ukraine]. Kharkiv: KhSIMMI, 216 p. (in Russian)
9. State archive of Kharkiv region. F. R-6183. Descr. 1. Case 415. P. 61.
10. State archive of Kharkiv region. F. R-6183. Descr. 3. Case 25. P. 210.
11. State archive of Kharkiv region. F. R-6183. Descr. 3. Case 26. P. 210.
12. Central State Archive of the Supreme Authorities of Ukraine. F. 1254. Descr. 6. Case 62. P. 17.
13. Central State Archive of the Supreme Authorities of Ukraine. F. 1254. Descr. 6. Case 55. P. 165.
14. *Velychko, O. M., Markov, B. F., Sydorenko, V. S.* (1999). Kontseptsiia Derzhavnoi naukovo-tekhnichnoi prohramy stvorennia ta udoskonalennia etalonnoi bazy Ukrainy na 2000–2004 rr. [The concept of the State scientific and technical program for the creation and improvement of the standart base of Ukraine for 2000–2004]. *Ukrainian Metrological Journal,* no. 1, pp. 23–25 (in Ukrainian)
15. *Markov, B. F.* (2014). Natsionalnaya etalonnaya baza. Sostoyanie i perspektivyi [National standart base. Status and prospects]. *Ukrainian metrological journal,* no. 4, pp. 7–11 (in Ukrainian)

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