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SOFTWARE SERVICE FOR CONTROLLING THE INTENSITY OF ULTRAVIOLET BACTERICIDAL IRRADIATORS

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HIGHLIGHT — 5 KEY SENTENCES

1. This study develops a specialized desktop software service for monitoring and assessing the suitability of UV germicidal lamps in medical institutions, enabling determination of the permissible amount of radiation based on radiometer measurements and current standards.

2. The service is built on a three-tier monolithic architecture (client–business–data layers) using Electron, React, TypeScript, Vite, MUI, and NeDB, ensuring cross-platform operation, local data processing, and network-independent performance.

3. The system implements the MVC (Model-View-Controller) pattern adapted for desktop applications, providing a clear separation of data management, business logic, and user interface components.

4. Each measurement is automatically assigned a status (Good / Warning / Danger) by comparing radiometer data against the established standard threshold of $100 \mu\text{W}/\text{cm}^2$, enabling rapid risk assessment for medical personnel.

5. The developed service is unique in its comprehensive approach — no existing integrated solutions currently provide multifactor monitoring, centralised data storage, and automated suitability assessment for UV germicidal lamps in a single tool.

Abstract

Ultraviolet germicidal lamps are an important tool for disinfecting premises in medical institutions. However, if these lamps do not work properly or do not meet standards, the effectiveness of disinfection may decrease, which creates risks to the health of patients and medical personnel. Therefore, it is critically important to have tools for monitoring the condition of the lamps and their suitability for use. This determines the need to develop a specialized service that can assess the suitability of the lamps using data collected using radiometers and ensure the effective and safe use of ultraviolet germicidal lamps. The purpose of the work is to develop a service for managing and analyzing the condition of ultraviolet lamps in medical institutions, ensuring compliance with standards, and creating a convenient tool for monitoring and managing measurement data. The work identifies the main functional capabilities of the service, describes the process of collecting and processing data from radiometers, as well as the algorithm for determining the suitability of ultraviolet lamps. The choice of system architecture, including the client and server parts, is justified. The database structure, user interface design, and implementation of the main algorithms for calculating the suitability of lamps are described. A detailed analysis of the functionality of dashboards for visualization of measurement analytics is provided. The results of software testing are also presented.

Keywords: software engineering, ultraviolet germicidal irradiators, health, measurement, radiometry, reliability, measurement analytics, react, typescript, node.js, nedb.

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Introduction.

Ultraviolet (UV) germicidal lamps are an important tool for disinfecting premises in healthcare facilities [1]. However, if these lamps do not work properly or do not meet standards, the disinfection efficiency may decrease, which poses risks to the health of patients and medical staff [2]. Therefore, it is critical to have tools to monitor the condition of the lamps and their suitability for use. This determines the need to develop a specialized

service that can assess the suitability of the lamps using data collected using radiometers and ensure the effective and safe use of ultraviolet germicidal lamps. The relevance of the topic lies in the fact that currently there are no integrated services that would allow for multifactor monitoring of the condition of the lamps, store data on their use in one place and automate the suitability assessment process. The developed service is unique, as it will provide a comprehensive approach to the assessment of ultraviolet lamps and allow for the storage and analysis of all measurements to increase the efficiency of irradiation and preserve human health.

The aim of the work is to develop software for monitoring and assessing the suitability of UV germicidal lamps in medical institutions, in particular to determine the permissible amount of radiation based on the results of measurements by radiometers and taking into account current standards. The development includes the creation of algorithms, the choice of system architecture and the provision of opportunities for further development and improvement of the software product.

The established goal entails the following tasks:

- requirements analysis and definition of functional and non-functional requirements for the updated software, in particular, improving the interface and algorithms, as well as adapting the system to new technologies to improve user experience and performance;
- designing the architecture of the updated software product taking into account new functionality, including the integration of new tools and technologies to increase system reliability and scalability;
- developing and improving algorithms for more accurate and effective determination of the permissible amount of radiation based on data collected from radiometers, taking into account current standards and regulations. Updating algorithms for more detailed data analysis and integration of new functions;
- updating and improving the user interface to ensure more convenient data entry, improved display of measurement results, as well as expanding data management and navigation capabilities in the software product;
- implementing and improving the authentication and authorization system for users to increase data security, restrict access to critical system functions, and implement modern information protection standards;
- development and optimization of the database for efficient storage of measurement results, as well as for integration of new functions, such as automatic storage of data from radiometers, analytics and reporting;
- extended testing and debugging of the software to verify its stability, correct operation after updating functions, as well as to ensure compliance with new requirements and standards.

UV germicidal irradiation (UVB irradiation) is a concept described in the ISO 15727:2020 standard UV-C devices — Measurement of the output of a UV-C lamp. Published (Edition 1, 2020) [3] is a disinfection method that uses electromagnetic radiation in the ultraviolet C spectrum to combat microorganisms and prevent the spread of infections. It is a sanitary and anti-epidemic measure aimed at reducing the number of microorganisms in the air and on indoor surfaces using irradiation to improve human health.

The key parameters that determine the effectiveness of UVB irradiation are wavelength (in nm), radiation intensity (in W/m^2 or $\mu\text{W}/\text{cm}^2$) and radiation dose ($\text{W}\cdot\text{s}/\text{m}^2 = \text{J}/\text{m}^2$) [4]. UV radiation covers the range from 200 to 400 nm, which is divided into three main regions by wavelength: UVA, UVB and UVC. The UVC range has the strongest

bactericidal effect, with a peak efficiency at a wavelength of 254 nm. This effect is achieved due to the ability of photons of UV radiation with a wavelength of 254 nm to destroy molecular bonds in the cells of microorganisms. The most vulnerable to UV radiation are the DNA of bacteria, viruses and fungi. It has been experimentally proven that exposure to UV with a wavelength of 254 nm can destroy microorganisms at the level of 90%, 95% or 99.9% [5]. To assess the efficiency of UV germicidal lamps and adjust the optimal operation of UV irradiators, UV radiometers (hereinafter - UV radiometers) are used. These devices are designed to measure the intensity of the bactericidal flux of ultraviolet radiation. The basic units of measurement are Watts per square meter (W/m^2) and microwatts per square centimeter ($\mu\text{W/cm}^2$). Radiometers are calibrated to operate at a wavelength of 254 nm, which is most effective for killing microorganisms.

Architectural solutions for monitoring ultraviolet lamps.

To create an effective and reliable service for determining the suitability of UV lamps in medical institutions, the key was to decide on a desktop implementation of the project with a focus on cross-platform.

This approach has several significant advantages compared to well-known web services [6].

Increased autonomy - the desktop application does not depend on constant access to the Internet, which is important for medical institutions where uninterrupted access to the network may be limited.

Cross-platform - the chosen solution is based on modern technologies, such as Electron, which ensures that the application works on different operating systems (Windows, macOS, Linux) without the need for significant code modifications.

Improved performance - compared to a web application, the desktop application works locally, which allows to reduce delays in data processing and increase the speed of operations.

Enhanced security – data storage and algorithm processing are performed locally, which minimizes the risks associated with data leakage over the network.

The service implementation is based on a three-tier architecture (see Figure 1):

- Client layer – responsible for a user-friendly user interface, data integration from radiometers and display of measurement results.

- Business layer – includes data processing algorithms, calculation of UV lamp suitability and performance of all necessary compliance checks.

- Data layer – centrally stores all measurement data, devices and test history in a local database with backup capability.

The transition to a desktop solution with cross-platform support has become an important factor that has provided the service with greater reliability, network independence and ease of use for medical institutions with different technical capabilities [7].

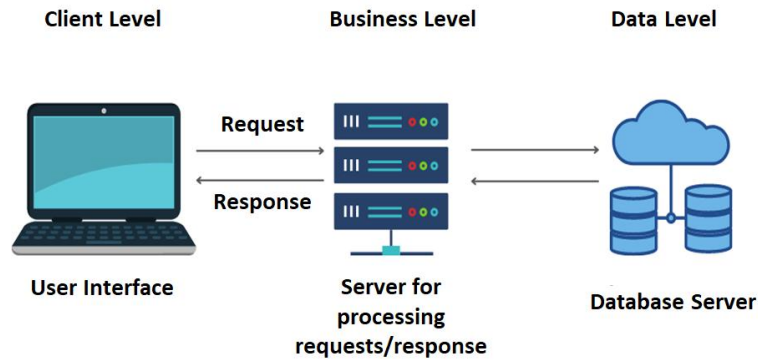


Figure 1. Three-tier service architecture.

One of the key advantages of such an architecture is increased data security and integrity due to a clear distribution of functions between the layers. All data is processed through the application's business logic, which determines how and who can access this data. A desktop architecture with a three-tier structure allows you to effectively manage requests, ensuring protection and correct access to information.

The three-tier model assumes that an intermediate business logic layer acts as an intermediary between the client interface and the data layer. This approach ensures that the user does not have direct access to the database, thereby reducing the risk of unauthorized intervention. Thanks to this, clients can interact with data regardless of the specific database management solution used in the system.

Compared to other architectural models, a desktop implementation using cross-platform technologies provides high security, scalability, performance, and the ability to reuse components. The distribution of functions between levels allows you to make changes to any of them without affecting the others, which greatly facilitates the support and development of the program.

The desktop architecture of this service is implemented according to the Monolithic Architecture principle, where all components are interconnected in a single structure. This approach provides the following advantages.

Ease of deployment – monolithic architecture allows you to quickly deploy the program, because the entire system has a single entry point and simplified integration processes.

Ease of development – all modules and components are in a single repository, which speeds up the introduction of changes and new features.

Simplified debugging – since all program elements are integrated in a single environment, it is easier to track the logic of code execution and detect errors.

The transition to a desktop solution with cross-platform support provided not only increased functionality and convenience, but also significantly improved the autonomy and adaptability of the service compared to the undergraduate web application.

1. To implement a desktop service for managing the state of UV lamps and determining the allowable amount of radiation, an architectural approach was chosen that contains elements of the Model-View-Controller (MVC) pattern [8] (Fig. 2), adapted for cross-platform programs.

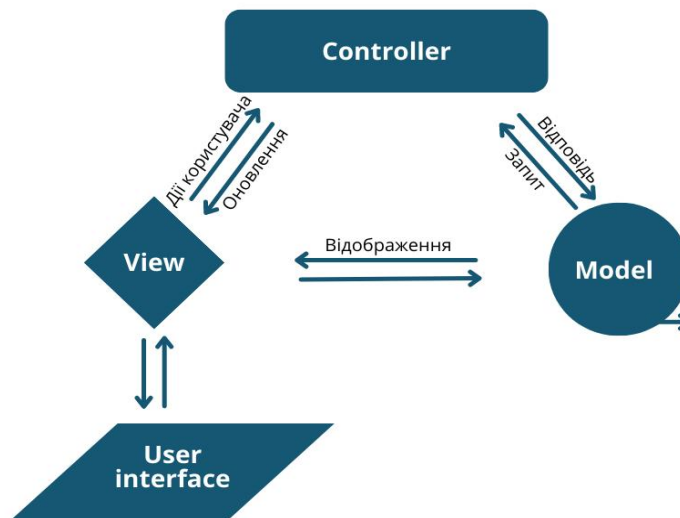


Figure 2. Logical diagram of the MVC pattern.

Using MVC allows you to clearly divide the functionality of the service into three main components, ensuring ease of maintenance and the ability to make changes to each of them independently. In the context of this project, these components perform the following roles.

Model: is responsible for data management, its structure and business logic. In our case, the model implements functions for interacting with the local database (NeDB) and processing information received from radiometers. It defines data analysis algorithms and calculations for assessing the suitability of lamps.

View: provides data display in a convenient user interface developed using Electron [9]. This component is responsible for how the user interacts with the program, including data visualization in the form of tables, graphs and dashboards for analytics. View does not contain business logic, but serves only to present the results obtained from the model.

Controller: manages the interaction between the model and the view. The controller processes user input, calls the appropriate model methods to perform actions such as saving data or running an analysis, and passes the results to the View. It is also responsible for validating the input data, ensuring security through user authorization and authentication, and handling errors.

Thus, the adapted MVC approach allowed for an effective application structure with the distribution of responsibilities between components, which increased its flexibility and reliability.

During the user's interaction with a desktop application for managing the state of UV lamps, all actions pass through the components of the MVC architecture. The user initiates a request through the interface (view), which is passed to the controller. The controller receives the request, processes it, and calls the appropriate model methods to perform business logic or access data.

The model performs the necessary calculations or data operations, in particular, obtaining information about the state of the lamps, analyzing the results of radiometric measurements, or updating the database. After executing the request, the model passes the result to the controller. The controller, in turn, forms a response and passes it to the

presentation. The presentation displays the data to the user in an understandable format, for example, in the form of tables, graphs, or messages about the state of the lamps.

The MVC architecture is an ideal choice for developing such systems due to its reliability, efficiency, and scalability. A clear division of responsibility between components — the model is responsible for the logic, the controller processes requests, and the presentation provides visualization — allows you to easily modify the interface without affecting the main business logic. This is important because the program is cross-platform and must run on different operating systems.

The general structure of the service for determining the permissible amount of UV radiation for disinfection of premises in a desktop application has a multi-level architecture that allows you to effectively organize interaction between parts of the program.

The client part implements the visual user interface. This component is responsible for the user experience with the application:

- 1) The graphical interface allows users to perform basic actions such as entering data, viewing measurements, and interacting with visualization. Implemented in React and Electron.

- 2) Navigation between pages, such as registration/login, viewing measurements, and editing them, is integrated to provide an intuitive user experience.

- 3) The measurement page performs local calculations of the permissible level of UV radiation, using data provided by the user.

- 4) Radiometer accounting page.

- 5) Lamp accounting page.

- 6) Measurement accounting page.

The server part processes the business logic of the application. It performs the following tasks:

- 1) Request processing: receives data from the client part and decides which operations to perform, for example, save the measurement, calculate the result, or retrieve information from the database.

- 2) Business logic: defines the rules and algorithms for data processing, including user input validation, authorization, calculation execution, and accounting.

- 3) Database interaction: manages data storage and retrieval.

Database:

- 1) The application uses a database to centrally store information, including measurement data, calculation results, and user accounts.

The mechanism for interaction between the client and server parts.

In this desktop application, the client part (built as a graphical interface) interacts with the server part via an API: User actions on the client side, such as entering new data or requesting an edit, are sent to the server part in the form of requests. The server part receives these requests, processes them using internal algorithms, and, if necessary, accesses the database to retrieve or store information. After processing, the server returns a response to the client part, which displays the results in the form of tables, graphs, or messages.

Client part and functionality.

The developed software module for determining the permissible amount of ultraviolet radiation is implemented using a structured approach that functionally divides the system into separate components to ensure ease of development, scalability and support. The architectural approach corresponds to the concepts of the MVC (Model-View-

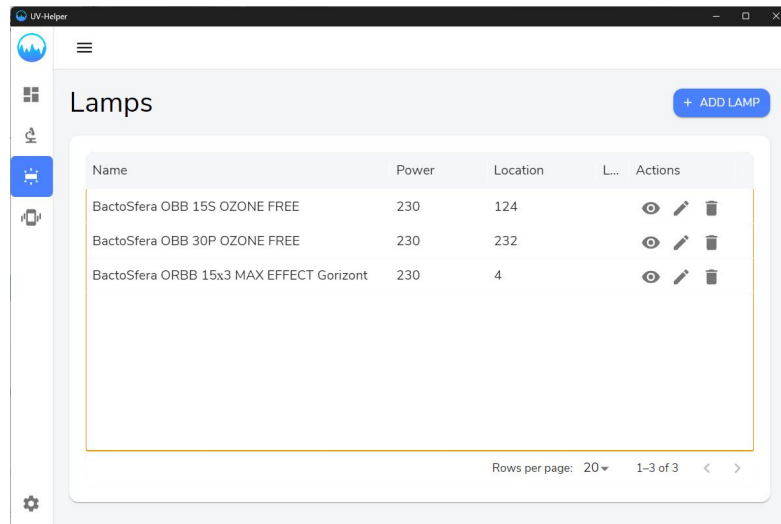
Controller) pattern [10], adapted for use in the context of a desktop application built on Electron, React, Vite, TypeScript, MUI and NeDB technologies.

The client part is implemented using React and built using the Feature-Sliced Design (FSD) methodology [11]. This ensures modularity and ease of scaling of the application. All main pages, such as: Lamp Management, Measurement Overview, Session Management, are located in the corresponding modules and are integrated into the overall architecture. State management is implemented using Effector, which allows for efficient data management between components.

After installation and configuration, the program is ready for use. Users can register in the system or log in if their data has been previously imported. The application provides functionality for:

- Entering new radiometer measurements,
- Saving and viewing sessions,
- Managing information about lamps and their suitability for further operation.

Figure 3 shows the lamp accounting table page to illustrate the service.



Name	Power	Location	L...	Actions
BactoSfera OBB 15S OZONE FREE	230	124		  
BactoSfera OBB 30P OZONE FREE	230	232		  
BactoSfera ORBB 15x3 MAX EFFECT Gorizont	230	4		  

Figure 3. Lamp accounting table page.

On this page you can view detailed information about the lamp and also view information and history of its measurements (see Fig. 4).

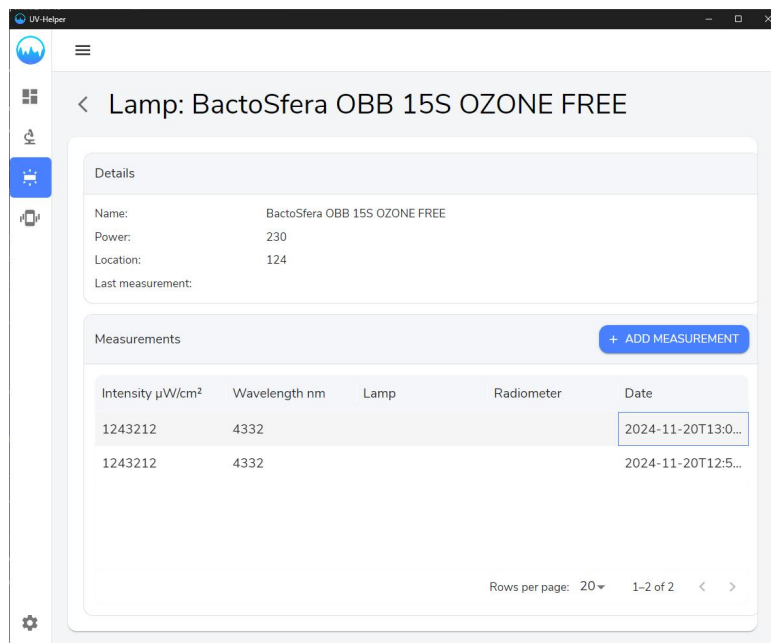


Figure 4. Lamp details page.

The user can then add a new measurement from this page. If the user clicks the “+ Add Measurement” button (see Figure 4), the program will redirect them to the measurement page with the selected lamp from which they came to this page (see Figure 5).

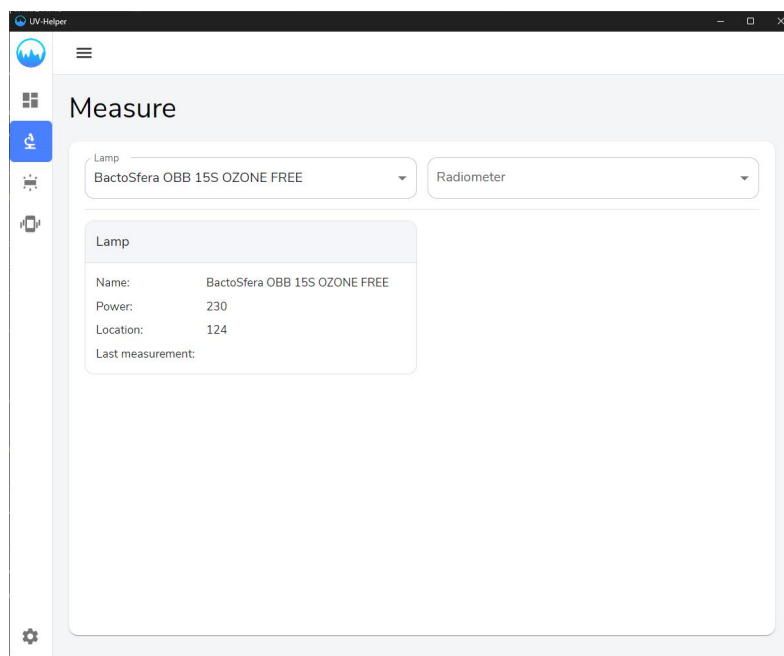


Figure 5. Page of measurements.

On the measurement page, the user can select a lamp and a radiometer and information about them will be displayed. Later, when the user selects both a lamp and a radiometer, he will have the opportunity to enter measurement data and save this data (see Fig. 6).

Figure 6. “Measurements” page.

The user also has access to the radiometer accounting page (see Figure 7). This page is similar to the lamp page, except that there is no button to view detailed information about the lamp.

Name	Manufacturer	Actions
Тензор-71Б	Тензор	
LS125	Linshang	

Figure 7. Filled vertical plane form.

Results.

As part of this work, software was developed to monitor and analyze the condition of UV lamps, as well as determine whether their operation complies with established standards. The service provides extensive functionality that ensures effective storage, analysis and verification of data on ultraviolet radiation levels.

Key functional capabilities of the service:

1. Storage of measurement data. The service allows users to store all measurements in a centralized database. The data is structured according to the lamp model and radiometer type, which ensures the accuracy of their processing. Saved measurements can be viewed at any time for analysis, trend detection and data comparison.

2. Comparison with legislative standards. Using internal algorithms, the service automatically checks whether the measurement data complies with established standards (for example, the level of $100 \mu\text{W}/\text{cm}^2$). Each measurement is assigned a status (Good, Warning or Danger), which allows users to quickly assess the level of risk and take the necessary measures.

3. Data visualization. For the convenience of users, the service provides a graphical display of data. This helps to better understand the measurement results and identify dependencies or potential problems in the operation of the lamps.

4. Authorization capability. A secure access system to the service has been implemented, which allows both authorized users and guests to interact with the program, although the latter have limited access to functionality.

Technological basis.

- Electron, React, TypeScript, Vite and the MUI component library were used to implement the client part, which provides a modern interface and program speed.

- The system is built on the principles of the FSD (Feature-Sliced Design) methodology in combination with the Effector state manager, which provides a logical structure and ease of code maintenance.

- The MongoDB database is used for main data storage, and Keytar provides secure storage of confidential information.

The developed functionality has been thoroughly tested, in particular, the correctness of the operation of the algorithms for determining measurement statuses was checked. Testing has shown accuracy, reliability, and implementation efficiency. The service is a useful tool for medical institutions and professionals working with ultraviolet lamps. It allows you to track the effectiveness of their work, ensure compliance with regulatory requirements, and make informed decisions about replacing or servicing equipment.

Future development.

Prospects for improving the service include adding new parameters to determine the safe level of ultraviolet radiation, expanding monitoring and analytics capabilities, and integrating with other systems for automated maintenance and data management.

Conclusions.

Software has been developed for monitoring and assessing the suitability of UV germicidal lamps in medical institutions, in particular for determining the permissible amount of radiation based on the results of measurements by radiometers and taking into account current standards. In particular, the requirements have been analyzed and functional and non-

functional requirements for the software have been determined. The architecture of the software product has been designed taking into account the integration of new tools and technologies to increase the reliability and scalability of the system.

Algorithms have been developed for more accurate and effective determination of the permissible amount of radiation based on data collected from radiometers, taking into account current standards and regulations. Algorithms have been updated for more detailed data analysis and integration of new functions.

A user interface has been created to ensure more convenient data entry, improved display of measurement results, as well as expanded data management and navigation capabilities in the software product.

A user authentication and authorization system has been implemented to increase data security, restrict access to critical system functions, and implement modern information protection standards.

Databases were developed and optimized for efficient storage of measurement results, as well as for integration of new features such as automatic storage of data from radiometers, analytics and reporting.

Extensive testing and debugging of the software was carried out to verify its stability, correct operation after updating functions, and to ensure compliance with new requirements and standards.

Disclosure

Author Contributions

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Not stated.

Conflicts of Interest

The author declares no conflict of interest.

Abbreviations

Abbreviation Full Term

API Application Programming Interface

DB Database

FSD Feature-Sliced Design

MUI Material UI (component library)

MVC Model-View-Controller

NeDB Node.js Embedded Database

UV Ultraviolet

UVA / UVB / UVC Ultraviolet spectrum regions (A / B / C)

UVB irradiation UV germicidal (bactericidal) irradiation

Reference.

- [1] Andrzej Wiśniewski. Promieniowanie UV-C i promienniki promieniowania UV-C w zastosowaniu bakteriobójczym. PRZEGLĄD ELEKTROTECHNICZNY. R. 97 NR 4/2021. P. 170-174. URL: file:///C:/Users/Admin/Downloads/31_Wi%20niewski_Promieniowanie_4_2021.pdf (Date of application 07.23.2026).
- [2] Oświadczenie dotyczące stanowiska CIE w sprawie promieniowania nadfioletowego (UV) jako środka ograniczającego ryzyko rozprzestrzeniania się COVID-19. 12 maja 2020. URL: [https://cie.co.at/files/CIE%20Position%20Statement%20-%20UV%20radiation%20\(2020\)_PL_0.pdf](https://cie.co.at/files/CIE%20Position%20Statement%20-%20UV%20radiation%20(2020)_PL_0.pdf) (Date of application 07.23.2026).
- [3] ISO 15727:2020 UV-C devices — Measurement of the output of a UV-C lamp. **Published** (Edition 1, 2020). URL: <https://www.iso.org/standard/67815.html> (Date of application 07.23.2026).
- [4] Jolanta Malinowska-Borowska. Czy przypadkowe włączenie lampy bakteriobójczej w poradni podczas przebywania w nim osób może mieć

- niekorzystny wpływ na ich zdrowie? 02-04-2024. URL: <https://translate.google.com/?hl=ru&sl=auto&tl=uk&text=Jolanta%20Malinowska-Borowska%200AZak%C5%82ad%20Medycyny%20i%20Higieny%20Pracy%20Katedry%20Chor%C3%B3b%20Przewlek%C5%82ych%20i%20Zagro%C5%BCe%C5%84%20Cywilizacyjnych%2C%20Wydzia%C5%82%20Zdrowia%20Publicznego%20w%20Bytomiu%20%C5%9A%C4%85skiego%20Uniwersytetu%20Medycznego%20w%20Katowicach%0A&op=translate>. (Date of application 07.23.2026).
- [5] ISO 15727:2020 UV-C devices — Measurement of the output of a UV-C lamp. Published (Edition 1, 2020) [URL: <https://www.iso.org/standard/67815.html>] (Date of application 07.23.2026).
- [6] Yuriy Dobrovolsky, Bohdan Starchuk. Control of the permissible amount of irradiation by ultraviolet bactericidal irradiators using software engineering methods / Current tasks of medical, biological physics and informatics. Materials of reports and speeches of the II All-Ukrainian scientific and practical conference with international participation, April 7, 2023, Vinnytsia. - P. 35-37. URL: <https://ir.lib.vntu.edu.ua/bitstream/handle/123456789/36938/124274.pdf?sequence=2&isAllowed=y> (Date of application 07.23.2026).
- [7] Мартін Роберт С. Чиста архітектура. Фабула, 2019 URL: <https://fabulabook.com/info-chysta-arhitektura-7389?srsId=AfmBOoqF680zJJrcKibzGdP3TWbacMkSOUGNhPres46WuvjfxZdYqe-b> (Date of application 07.23.2026).
- [8] Robert C. Martin Series. The Clean Coder: A Code of Conduct for Professional Programmers. Publisher: Pearson. 2011. 256 pages. URL: https://www.amazon.com/Clean-Coder-Conduct-Professional-Programmers/dp/0137081073#detailBullets_feature_div (Date of application 07.23.2026).
- [9] Electron Documentation. URL: <https://www.electronjs.org/docs>] i React [Документація React. URL: <https://react.dev/>] (Date of application 07.23.2026).
- [10] Eric Evans. Domain-Driven Design: Tackling Complexity in the Heart of Software. Addison-Wesley Professional, 2004.
- [11] Документація Feature-Sliced Design. URL: <https://feature-sliced.design/docs> (Date of application 07.23.2026).