MODERNIZATION OF ELECTRICAL INSTALLATIONS FOR LIGHTING AND POWER IN THE ELECTROENERGETICS LABORATORY OF THE UNIVERSITY OF PETROȘANI

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Abstract: Creating an interior electrical installation for lighting and sockets is a rigorous endeavor that must comply with current regulations and standards in the field. For this, it is necessary to draft a technical project that includes the designed situation and calculation briefs to determine the parameters of the installation. This paper succinctly presents the realization of interior electrical installations for lighting and outlets in the Electroenergetics Laboratory ("Laboratory L1") in Building A of the University of Petroșani and its adjacent rooms.

Keywords: electrical installation, modernization, standards, calculations, protections.

1. INTRODUCTION

The discovery of electrical energy and the ways it can be utilized have represented essential turning points in the progress and development of human civilization. Today, electrical energy is indispensable in all aspects of life and human activities, offering a series of advantages compared to other forms of energy [1], [23]:

- production under economically favorable conditions in power plants;
- rapid—practically instantaneous—and economical transmission of energy over long distances through overhead and underground transmission lines;
- economical distribution to a large number of consumers with different power requirements;

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- efficient and advantageous transformation possibilities of electrical energy into other forms of energy (mechanical, thermal, etc.), even at the consumption site, with high efficiency.

Regarding the specific provisions for the design and execution of low voltage electrical installations in Romania, these are generally legislated through the technical regulation ***"Norm for the design, execution, and operation of electrical installations related to buildings"***, indicated as I7. The most recent edition of this norm was approved in 2011 by an Order of the Minister of Regional Development and Tourism, published in the Official Gazette of Romania No. 802 bis on 14.11.2011, and was modified and supplemented by the Order of the Minister of Development, Public Works and Administration No. 959/18.05.2023, published in the Official Gazette of Romania No. 512 on 12.06.2023 [2]. The I7-2011 norm was mainly developed based on the SR HD 60364 series of standards. Additionally, in the design and execution of lighting electrical installations, the provisions of the technical regulation ***"Norm for the design and execution of artificial lighting systems in buildings"***, indicated as NP-061-02, are also taken into account [3], [24], [25], [29].

2. EXISTING SITUATION

The main building of the University of Petroșani, known as "Building A," was constructed between 1949 and 1952. The internal electrical installations were designed and executed according to the technical regulations valid at that time, which are now technically outdated.

Fig. 1. Electrical panel from the years 1949-52, in an open construction

The electrical circuits were made with cables and conductors insulated with rubber and jute, lacking fire-resistant properties, and in some cases, with smaller cross-sections than those specified by current regulations. Most of the electrical panels were built in an open construction on marble supports, equipped with fuses and switches that are also in open construction and unprotected (see fig. 1) [4]. The installations were sized for the electrical energy consumption of that period when the number of electrical devices was much lower than it is today. Considering the need for the electrical installations to support the state-of-the-art laboratory equipment intended to be acquired for the modernization of the educational spaces, the urgency of replacing the old electrical installations of the Laboratory L1 complex becomes fully justified [26], [28].

The L1 Laboratory complex includes the following rooms:

- the main laboratory;
- the office of the teaching staff;
- the office of the laboratory staff;
- the technical annex.

3. PROJECTED SITUATION

3.1. Specifications document

The first step in modernizing the electrical installations of Laboratory L1 and its associated rooms is the preparation of a project for the new electrical installations for lighting and power. For this purpose, a specifications document has been prepared, outlining a series of requirements, such as: determining the number and placement of electrical panels, lighting and power electrical receptors, as well as their installed power and their mode of operation and usage. The main provisions of the specifications document are summarized in the following paragraphs [27], [30].

3.1.1. Electric power supply

For the electric power supply, the two existing electrical panels in the old installation will be used: the main electrical panel (MEP), located in the basement technical hallway, and the secondary electrical panel, located in the laboratory hallway, which will be renamed SEP-1. The two old electrical panels at the mentioned locations will be decommissioned, and new panels equipped with modern protection devices, chosen in accordance with current technical regulations, will be installed in their places. In addition to these two panels, a new secondary electrical panel, named SEP-2, will be installed in the laboratory. The secondary electrical panels SEP-1 and SEP-2 will be powered from the main electrical panel MEP through two three-phase electrical columns with 5 conductors (L1, L2, L3, N, PE), appropriately sized and installed underground in the existing cable ducts [5], [31].

3.1.2. Lighting electrical installations

Both normal and emergency lighting installations will be implemented. For the normal lighting installations, the placement of existing lighting fixtures will be maintained. Within the laboratory room, lighting will be supplemented with 8 wall-mounted sconce-type fixtures, installed on the eastern and western side walls.

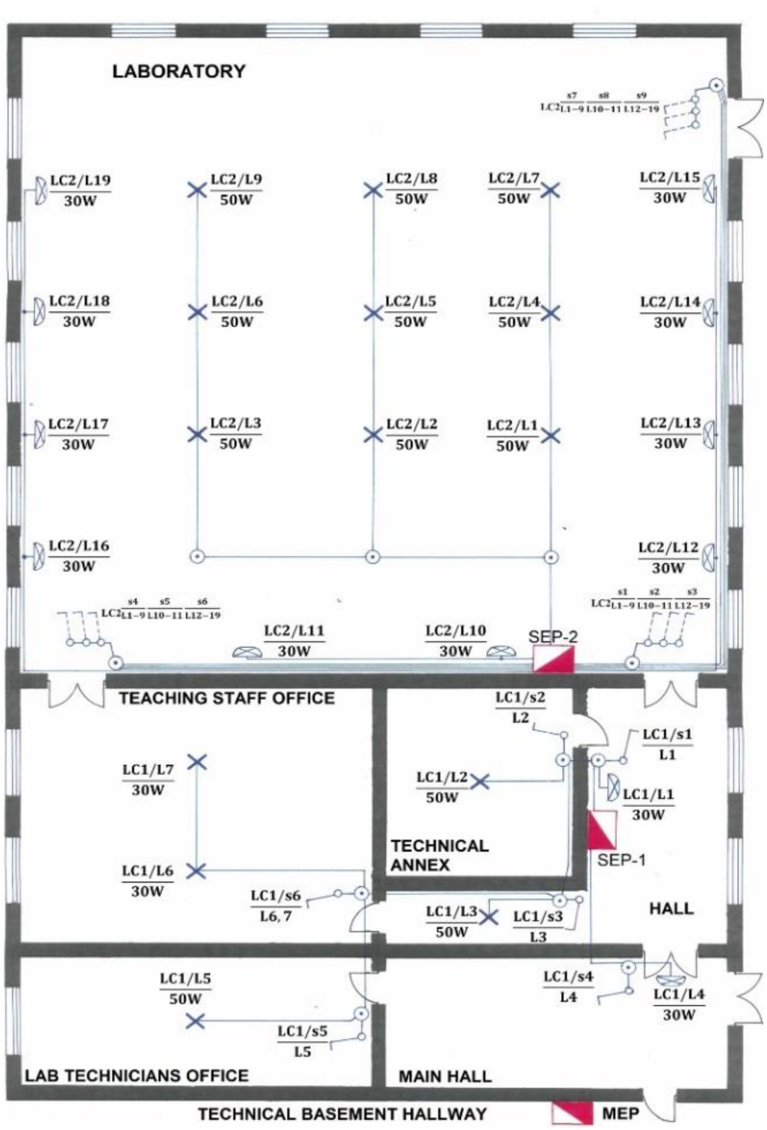


Fig. 2. The electrical plan for normal lighting installations

The normal lighting installation will consist of two circuits:

- lighting circuit LC-1, containing the lighting fixtures in the laboratory's annex rooms;
- lighting circuit LC-2, containing the lighting fixtures in the laboratory.

The lighting fixtures will be LED, point-type, chandelier and/or sconce-type, mounted on ceilings and/or walls.

The emergency lighting installation will consist of one emergency lighting circuit LC-3 and will include emergency lighting fixtures with local battery for evacuation, signaling, and panic [6].

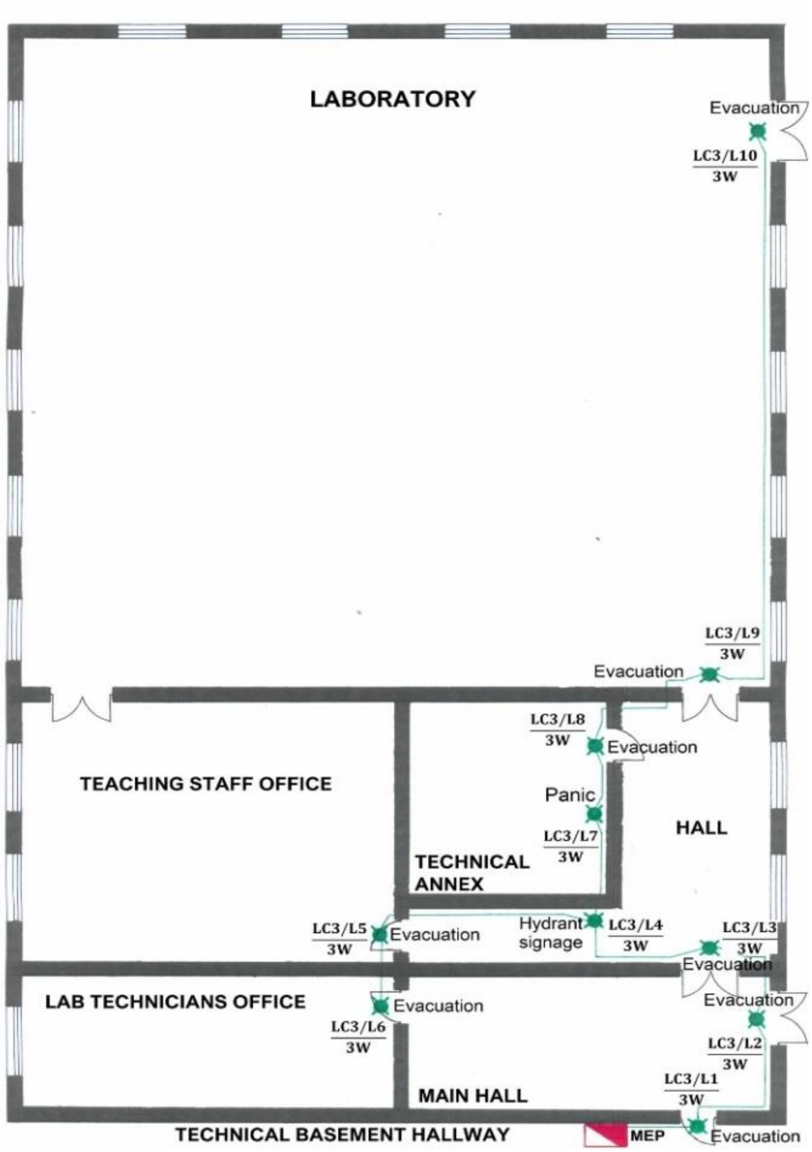


Fig. 3. The electric plan for emergency lighting installation

3.1.3. Electrical installations for single-phase sockets

To supply power to the electrical appliances and devices, several socket outlet circuits will be implemented as follows:

- circuit SC-1 in the laboratory staff office;
- circuit SC-2 in the technical annex;
- circuit SC-3 in the teaching staff office;
- circuits SC-4 and SC-5 in the laboratory.

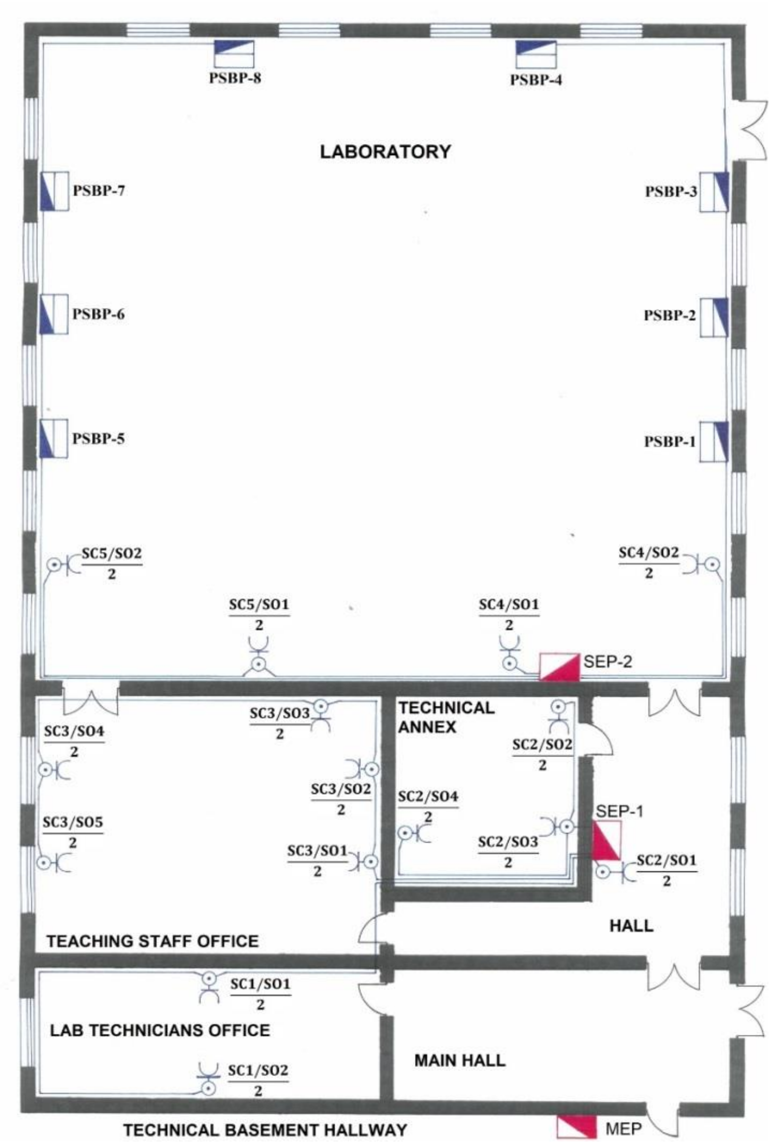


Fig. 4. The electrical plan for single-phase socket outlets installations

3.1.4. Electrical installations for powering specific teaching equipment in the Electroenergetics Laboratory

In order to power the educational apparatus and equipment that will be acquired and installed in Laboratory L1, a total of 8 power supply blocks with protection (PSBPs) will be provided. These will essentially function as capsulated type electrical panels, each equipped with two three-phase sockets outlets and three single-phase sockets outlets. Each socket outlet will be locally protected by miniature circuit breakers (MCBs).

3.2. Preparations for electrical plans

The preliminary stage for preparing the electrical plans consisted of creating the survey drawing. The electrical plans were developed by tracing the electrical circuits and positioning the distribution boards, lighting fixtures, and terminal equipment on the survey drawing. Three electrical plans were prepared [7]:

- electrical plan for normal lighting installations (Fig. 2);
- electrical plan for emergency lighting installation [8] (Fig. 3);
- electrical plan for single-phase socket outlets installations (Fig. 4).

The symbols used in the electrical plans are explained in Fig. 5, and the legend of abbreviations used in the electrical plans and the purpose of each circuit are detailed in Table 1 [9].

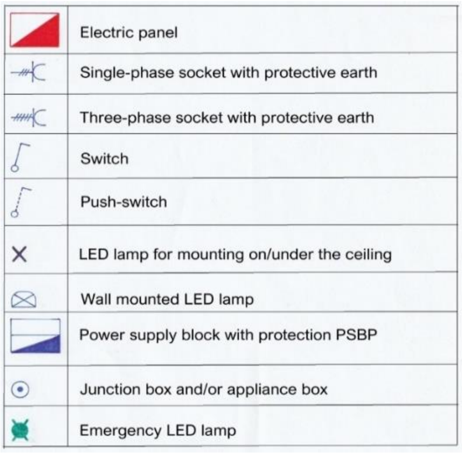


Fig. 5. Symbols used in the preparation of electrical plans

Table 1. ***Legend of abbreviations and the purpose of electrical circuit destinations***

Abreviation	Component element of the electrical installation
MEP	Main Electric Panel
SEP-1	Secondary electric panel no. 1
SEP-2	Secondary electric panel no. 2
$\frac{\mathrm{SC3/SO4}}{2}$	Example notation: unit of 2 modular socket outlets no.4, mounted in a common device box, connected in socket circuit SC-3
$\frac{\mathrm{LC3/L8}}{\mathrm{3W}}$ Evacuation	Example notation: Emergency evacuation lighting fixture no. 8 from emergency lighting circuit LC-3, with a nominal power of 3W
$\frac{\mathrm{LC3/L7}}{\mathrm{3W}}$ Panic	Example notation: Emergency panic lighting fixture no. 7 from emergency lighting circuit LC-3, with a nominal power of 3W
$\frac{\mathrm{LC3/L4}}{\mathrm{3W}}$ Hydrant signage	Example notation: Emergency hydrant signage lighting fixture no. 4 from emergency lighting circuit LC-3, with a nominal power of 3W

$LC2\frac{s1}{L1-9}\frac{s2}{L10-11}\frac{s3}{L12-19}$	Example notation: unit of 3 modular push-button switches, mounted in a common device box, connected in lighting circuit LC-2: - s1, for controlling lighting fixtures L1…L9 - s2, for controlling lighting fixtures L10-L11 - s3, for controlling lighting fixtures L12…L19
$\frac{LC1/L7}{30W}$	Example notation: Lighting fixture number 7 from normal lighting circuit LC-2, with a nominal power of 30W.
$\frac{LC1/s5}{L6,7}$	Example notation: Modular toggle switch no. s5, for controlling lighting fixtures L6 and L7, mounted in normal lighting circuit LC-1.
PSBP-2	Three-phase power supply block with protection no. 2

4. TECHNICAL MEMORANDUM

4.1. Preparing the calculation summary and configuring the electrical Installation

4.1.1. Normal Lighting Installation

In the case of lighting installations, the illumination level on the work plane is determined by NP-061-02 [3].

To determine the characteristics of lighting installations, the following data will be used:

- h_a - height of suspension of lighting fixtures (m);
- h_u - height of the working plane (m);
- H - room height (m);
- h - free height (m);
- L - room length (m);
- l - room width (m);
- i - room index;
- Φ - luminous flux falling on a reflecting surface (walls or ceiling) (lm);
- Φ_r - reflected luminous flux inside the room (lm);
- ρ - reflection factor;
- u - utilization factor, provided in the technical sheets of lighting fixtures;
- M_F - maintenance factor;
- E_m - average illuminance of the room;
- Φ_{req} – luminous flux required for a room;
- Φ_{lamp} - luminous flux of a lighting fixture. In the case of LED fixtures with a matte cover, if the value of Φ_{lamp} is not provided in the product's technical specifications, it is determined by multiplying the nominal power of the lamp by 80;
- s – area of the room (m^2);
- n – number of light sources;

Free height is calculated using the equation (1):

$$h = H - h_u - h_a \tag{1}$$

Room index is calculated using the equation (2):

$$i = \frac{L*l}{h(L+l)} \tag{2}$$

Reflected luminous flux inside the room is calculated using the equation (3):

$$\Phi_r = \Phi * \rho \tag{3}$$

Luminous flux required for a room is calculated using the equation (4):

$$\Phi_{req} = \frac{Em*s}{MF*u} \tag{4}$$

Number of light sources is calculated using the equation (5):

$$n = \frac{\Phi req}{\Phi lamp} \tag{5}$$

For this project, a working plane height of h_u=0.7 m was adopted, specific to room where intellectual activities are conducted.

The reflection factors considered for this project are:

- for educational rooms: $\rho_{ceiling}$ = 0.7; ρ_{walls} = 0.5;
- for the technical annex: $\rho_{ceiling}$ = 0.5; ρ_{walls} = 0.3.

The maintenance factors considered for this project are:

- for educational rooms: M_F = 0,8;
- for the technical annex: M_F = 0,7.

Regarding the average illuminance level Em, the rooms in this project are considered to have visual tasks with specific visual requirements, and the Em value considered is 1000 lx, according to Table 7.1 of NP-061-02 [3].

The light sources used will be LED technology, requiring the selection of a light color appropriate to the type of activities performed. In terms of emitted color, there are three groups of light sources [10, 11]:

- the group of light sources that emit warm light, with a yellowish-white hue, having a color temperature of less than 3000K (typically Tk= 2700K);
- the group of light sources that emit neutral light (sometimes called "natural light"), with a white hue, having a color temperature between 3000-4000K;
- the group of light sources that emit cool light, with a bluish-white hue, having a color temperature of Tk= 6000K.

For the educational activities specific to the spaces covered by this project, it is recommended to use lighting fixtures with a color temperature of T_k=4000K. Additionally, these lighting fixtures must ensure visual protection for the users.

The data resulting from the calculations are synthesized in Table 2 [12, 13].

Table 2. ***Calculation of normal lighting installation***

Circuit abrevia-tion	Room	Lighting fixtures					
		Ceiling-mounted			Wall-mounted		
		Number	Nominal power	Total nominal power	Number	Nominal power	Total nominal power
LC-1	Main hall	-	-	-	1	30	30
LC-1	Hol	1	50	50	1	30	30
LC-1	Technical annex	1	50	50	-	-	-
LC-1	Lab technicians office	1	50	50	-	-	-
LC-1	Teaching staff office	2	30	60	-	-	-
LC-2	Laboratory	9	50	450	10	30	300

4.1.2. Emergency lighting installation

For emergency lighting, the option chosen is to use LED luminous block-type fixtures with continuous operation, equipped with local batteries and having a nominal power of 3W. The lighting fixtures will be intended for:

- emergency evacuation lighting, for fixtures installed above access ways and/or evacuation routes;
- panic emergency lighting, in the technical annex, which lacks natural lighting;
- emergency lighting for the interior fire hydrant signage, located in the hallway.

Connection to the network and protection of the lighting fixtures will be done in the MEP.

4.1.3. Determining the electrical parameters of the installation

Within the calculation summary, the following data were used [12]:

- U_l - line voltage = 400 V AC;
- U_f - phase voltage = 230 V AC;
- cos φ - power factor; for this project, a value of cosφ = 0.92 was considered [13];
- L - circuit length (m);
- s - conductor cross-section (mm²);
- P_i - installed power (W);
- k_s - simultaneity coefficient;
- k_u- utilization coefficient;
- P_r - instantaneous absorbed (required) power (W);
- I_n - nominal current of the circuit breaker;
- I_r - instantaneous absorbed (required) current (A);
- I_z - permissible current according to the chosen reference mounting method (B2) (from Annex 5.10 of I7-2011) [2];

- k_1 - ambient temperature factor, from Annex 5.18 of I7-2011 [2]. For this project, an ambient temperature of 25°C was considered, which corresponds to a value of $k_1 = 1.06$;
- k_2 - group reduction factor, from Annex 5.19 of I7-2011 [2]. In this project, the most unfavorable situation is with 3 grouped circuits, which corresponds to a k_2 factor value of 0.7;
- I_a - maximum permissible current in continuous operation (A);
- Δ_U - voltage drop expressed as a percentage;
- ρ_{Cu} - electrical resistivity of copper = 0.0175 Ωmm²/m;
- Z_{L-N} - direct fault loop impedance phase-neutral L-N (Ω);
- Z_{L-PE} - direct fault loop impedance phase-earth L-PE (Ω);
- Isc_{L-N} - direct short-circuit current phase-neutral L-N (A);
- Isc_{L-PE} - direct short-circuit current phase-earth L-PE (A);
- Rp - dispersion resistance of the local ground electrode, presumed to be 4Ω.

The requested power P_r was determined using the equation (6):

$$P_r = P_i * k_s * k_u \tag{6}$$

The sizing of the circuits was done based on the required current Ir, ensuring that the equation (7) is satisfied:

$$I_r \leq I_n \leq I_a \tag{7}$$

The maximum permissible current in continuous operation was determined using the equation (8):

$$I_a = I_z * k_1 * k_2 \tag{8}$$

The minimum cross-section of copper conductors is 1.5 mm² for lighting circuits and 2.5 mm² for socket circuits, even if calculations suggest the possibility of choosing smaller cross-sections [2]. The reference installation method for the circuits in this project, determined from Annex 5.6 of I7-2011, is B2. From Annex 5.10, the values of the maximum permissible currents were determined, taking into account the most unfavorable conditions [2].

The required current Ir was determined for each circuit using equation (9) and (10):

For one-phase circuits:

$$I_r = \frac{Pr}{Uf \cdot \cos\varphi} \tag{9}$$

For three-phase circuits:

$$I_r = \frac{P_r}{\sqrt{3} \cdot U_l \cdot \cos\varphi} \tag{10}$$

For the protection of the circuits were selected circuit breakers with standardized nominal current values In, each immediately higher than the corresponding Ir values, ensuring that these values satisfy equation (7) for each circuit [14].

The voltage drops expressed as a percentage were calculated for the longest circuits. For single-phase socket circuits, circuit SC-3 has the biggest length of 15 m, between panel SEP-1 and socket outlet SC3/SO5. For normal lighting circuits, the section with the biggest length of 20 m is in circuit LC-2, between panel SEP-2 and lamp LC2/L19. Regarding three-phase circuits, the section between panel SEP-2 and PSBP-8 is the longest, measuring 19 m.

The maximum permissible voltage drops expressed as a percentage are 3% for lighting circuits and 5% for socket circuits [2, 15, 16]. The calculation of the voltage drops expressed as a percentage was carried out using equations (11) and (12):

For one-phase circuits:

$$\Delta U_f = \frac{2 \cdot 100 \cdot I_n \cdot L \cdot cos\varphi \cdot \rho_{Cu}}{U_f \cdot s} \tag{11}$$

For three-phase circuits:

$$\Delta U_l = \frac{\sqrt{3} \cdot 100 \cdot I_n \cdot L \cdot cos\varphi \cdot \rho_{Cu}}{U_l \cdot s} \tag{12}$$

The values determined by calculations using equations (11) and (12) for voltage drops are: 1.87% for the lighting circuit; 1.3% for single-phase socket circuits and 0.93% for three-phase socket circuits. These values are below the maximum limits provided by I7-2011 [2, 17].

For the correct selection of the type of miniature circuit breakers (MCBs) in the electrical panels, in addition to their nominal current, it is necessary to determine the time-current characteristics of each circuit breaker. These characteristics, also known as tripping curves, show the time in which a circuit breaker trips depending on the value of the overload current it is subjected to. The most common tripping curves of circuit breakers used in residential areas are as follows (fig. 6) [10, 18, 19]:

- curve B, where the circuit breaker trips when a current between (3-5) * I_n passes;
- curve C, where the circuit breaker trips when a current between (5-10) * I_n passes;
- curve D, where the circuit breaker trips when a current between (10-20) * I_n passes.

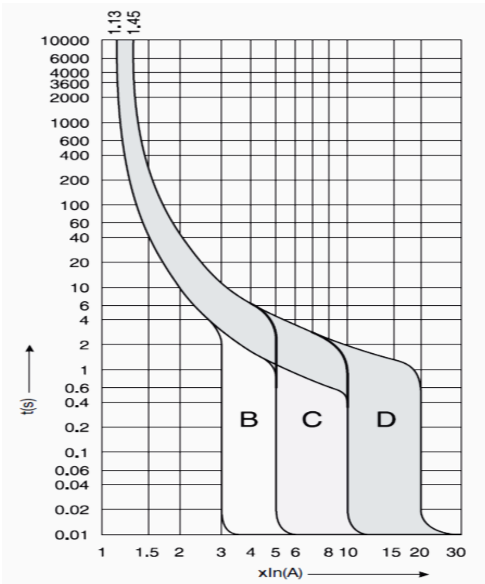


Fig. 6. Tripping curves of the MCBs

Manufacturers generally recommend using circuit breakers with tripping curve B for the protection of circuits with long lengths (which implicitly have a higher fault loop impedance), those with tripping curve C for the protection of general-purpose circuits in all types of installations, and those with tripping curve D for the protection of circuits supplying devices that draw high currents upon connection to the network (e.g., electric motors or high-power lighting installations equipped with LED luminaires that switch on simultaneously, where the inrush current has a high value for a very short period) [14, 20].

In order to correctly determine the fault currents and make the appropriate choice of circuit breaker type, it is necessary to know the values of the phase-neutral and phase-earth fault loop impedances, calculated for the longest circuits or circuit sections. These impedances are calculated using equations (13) and (14) [15, 21]:

$$Z_{L\text{-}N} = 2 \cdot \frac{\rho_{Cu} \cdot L}{s} \tag{13}$$

$$Z_{L\text{-}PE} = \frac{(\rho_{Cu} \cdot L) + R_p}{s} \tag{14}$$

Knowing the values of the fault loop impedances, the presumed values of short-circuit currents were determined using equations (15) and (16):

$$Isc_{L\text{-}N} = \frac{U_f}{Z_{L-N}} \tag{15}$$

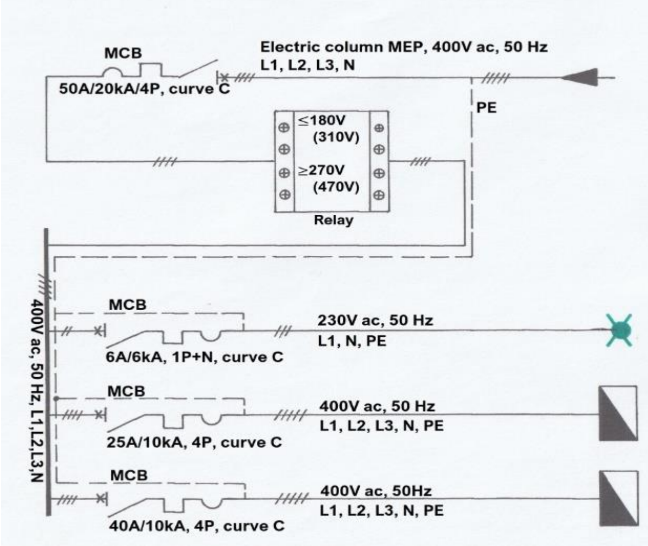
$$Isc_{L\text{-}PE} = \frac{U_f}{Z_{L-PE}} \tag{16}$$

The results of the calculations have been summarized in Table 3.

The next step in designing the electrical installation involves configuring the electrical panels based on the previously calculated data and parameters. Figure 7 depicts the single-line diagram of the main electrical panel MEP.

Table 3. ***Electrical installation parameters***

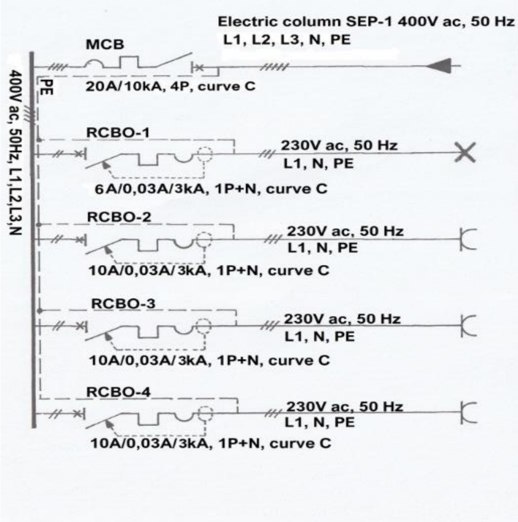
Circuit Simbol	Destination	P_r (W)	I_r (A)	Mate-rial	I_n (A)	S (mm^2)	I_z (A)	I_a (A)	$Z_{L\text{-}N}$ (Ω)	$Z_{L\text{-}PE}$ (Ω)	$Isc_{L\text{-}N}$ (A)	$Isc_{L\text{-}PE}$ (A)	Tripp. curve	k_s	k_u
LC-1	Normal lighting circuit	270	1,28	Cu	6	1,5	16,5	12,99	0,47	2,90	489,36	79,30	C	1	1
LC-2	Normal lighting circuit	750	3,54	Cu	6	1,5	16,5	12,99	0,47	2,90	489,36	79,30	C	1	1
LC-3	Emergency lighting circuit	30	0,14	Cu	6	1,5	16,5	12,99	0,47	2,90	489,36	79,30	C	1	1
SC-1	One-phase socket outlets in laboratory staff office	2000	9,45	Cu	10	2,5	23	17,89	0,21	1,70	1095	135,30	C	1	1
SC-2	One-phase socket outlets in technical annex	2000	9,45	Cu	10	2,5	23	17,89	0,21	1,70	1095	135,30	C	1	1
SC-3	One-phase socket outlets in teaching staff office	2000	9,45	Cu	10	2,5	23	17,98	0,21	1,70	1095	135,30	C	1	1
SC-4	One-phase socket outlets in laboratory	2000	6,05	Cu	10	2,5	23	17,98	0,21	1,70	1095	135,30	C	0,8	0,8
SC-5	One-phase socket outlets in laboratory	2000	6,05	Cu	10	2,5	23	17,98	0,21	1,70	1095	135,30	C	0,8	0,8
PSBP 1…4	Three-phase Power Supply Block with Protection	12000	12,06	Cu	20	6	34	25,23	0,11	0,72	3636	555,56	C	0,6	0,6
PSBP 5…8	Three-phase Power Supply Block with Protection	12000	12,06	Cu	20	6	34	25,23	0,11	0,72	3636	555,56	C	0,6	0,6



Destination	Pi (kW)	Phase
General protection	24,25	L1 L2 L3
Monitoring and protection against under and over-voltage	24,25	L1 L2 L3
Security lighting circuit LC-3	0,03	L1
Three-phase electric column SEP-1	6,21	L1 L2 L3
Three-phase electric column SEP-2	18,05	L1 L2 L3

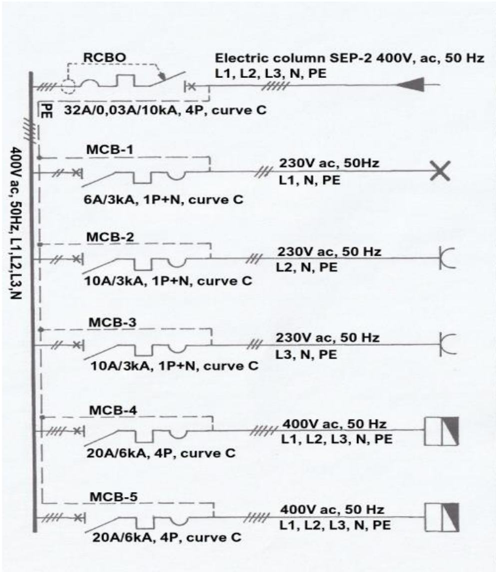
Fig. 7. The single-line electrical diagram of the main electric panel MEP

For monitoring and protecting the entire electrical installation against network over/undervoltages, a three-phase monitoring and protection relay with a nominal current of 63A will be installed in the MEP (main electrical panel) (see figure 7).



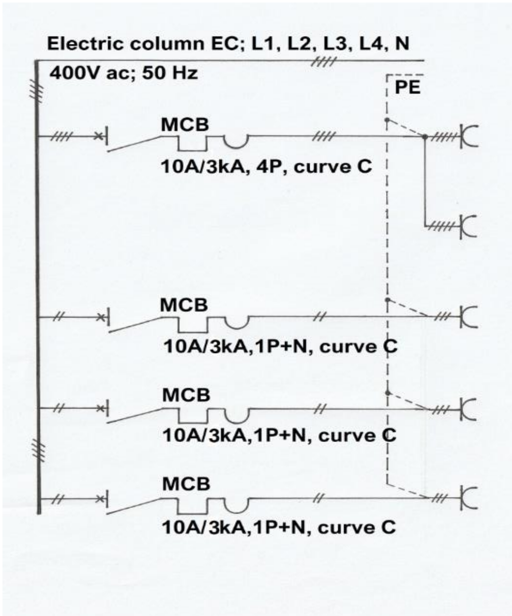
Destination	Installed Power Pi (kW)	Simultaneity factor ks	Requested Power Pr (kW)	Phase	Utilization factor ku
Main protection	6,21	1	6,21	L1 L2 L3	1
Lighting circuit LC-1	0,21	1	0,21	L1	1
One-phase socket circuit SC-1	2	1	2	L2	1
One-phase socket circuit SC-2	2	1	2	L3	1
One-phase socket circuit SC-3	2	1	2	L1	1
TOTAL	6,21		6,21		

Fig. 8. The single-line electrical diagram of the secondary electric panel SEP-1



Destination	Pi (kW)	ks	Pr (kW)	Phase	ku
Main protection	66,19	0,5	18,05	L1 L2 L3	0,545
Lighting circuit LC-2	0,75	1	0,75	L1	1
One-phase socket circuit SC-4	2	0,8	1,28	L2	0,8
One-phase socket circuit SC-5	2	0,8	1,28	L3	0,8
Three-phase electric column for PSBP-1 to PSBP-4	30,72	0,8	7,37	L1 L2 L3	0,3
Three-phase electric column for PSBP-5 to PSBP-8	30,72	0,8	7,37	L1 L2 L3	0,3

Fig. 9. The single-line electrical diagram of the secondary electric panel SEP-2



Socket outlet type	Installed Power Pi (kW)	Simultaneity factor ks	Requested Power Pr (kW)	Phase	Utilization factor ku
Three-phase, 5 poles	6	0,9	5,4	L1 L2 L3	0,6
Three-phase, 5 poles					
Single-phase, 3 poles	2	1	2	L1	0,6
Single-phase, 3 poles	2	1	2	L2	0,6
Single-phase, 3 poles	2	1	2	L3	0,6
Total requested power= (5,4+2+2+2)x ku = 6,84 kW					

Fig. 10. The single-line electric diagram of the power supply block with protection PSBP

Upon analyzing the single-line diagrams in figures 8-10, it is observed that all final circuits of the installation are protected against residual currents by bipolar (1P+N) or four-pole (4P) high-sensitivity RCBO (Residual Current Breaker with Overcurrent protection) devices, with a nominal residual current of 30 mA. These are installed either as the main protection for the entire panel or as individual protections for the final circuits [16].

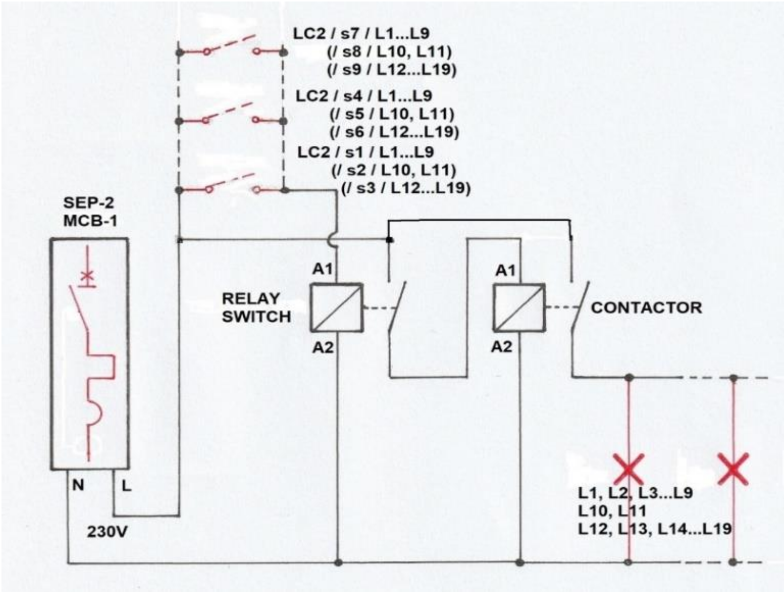


Fig. 11. The electrical control diagram for the lighting in the laboratory, utilizing a 3-point control system with step relays and contactor setup

Regarding the lighting fixtures in the laboratory, it is necessary that these can be controlled from each of the 3 access points into the laboratory. Control needs to be distinct for the ceiling lights, the lights on the side walls, and the lights on the front wall above the smart board. To achieve this, in the secondary panel SEP-2, 3 relay switches (step relays) and 3 contactors have been installed, one for each grouping of lights. Each of the 3 step relays is controlled from the 3 control points via a momentary push-button switch (see figure 11).

The operation of the control scheme is as follows: when one of the momentary push-button switches S1...S3, S4...S6, or S7...S9 is pressed, the corresponding step relay coil receives a voltage pulse, causing the internal cam-driven mechanism to rotate one step and close the corresponding contact. This energizes the coil of the corresponding contactor. By closing the normally open (NO) contact of the contactor, the power circuit to the corresponding lighting line is completed [9, 10].

Upon pressing the corresponding push-button switches again, the step relay coil receives a new pulse and rotates the cam-driven mechanism again, opening the relay contact. This interrupts the coil circuit of the contactor, causing it to de-energize and thereby stopping the power supply to the lighting line.

5. THE PRACTICAL IMPLEMENTATION OF THE ELECTRICAL INSTALLATION

After completing the project, the next steps in the practical implementation of the interior electrical installations in laboratory L1 and its annexes involved selecting materials and equipment, and executing the installation.

a) b)

c) d)

e) f)

g)

Fig. 12. Examples of the electrical equipment and devices used in the installation:
a) Bipolar RCBO; b) Four-pole RCBO; c) DIN rail-mounted contactor; d) Step relay; e) Three-phase monitoring and protection relay; f) PSBP; g) Unit of 2 modular socket outlets installed in surface-mounted box

The electrical columns supplying the secondary panels SEP-1 and SEP-2 were executed using multi-strand copper conductors with PVC insulation having enhanced resistance to flame propagation, type HO7V-K, of flexibility class 5, with a cross-section of 16 mm². These were protected in corrugated flexible PVC conduit type FK15 with a diameter of 40 mm, capable of withstanding a compression resistance of 750 N [5, 22].

For equipping the electrical panels, protective and control equipment from renowned European manufacturers such as Schneider Electric, Legrand, and Finder was used. Regarding terminal equipment (single-phase socket outlets, toggle-switches and push-button switches), we opted for products from the Italian manufacturer Gewiss - modular equipment from the System range installed in surface-mounted boxes from the 27 Combi series. From the same manufacturer, Gewiss, we also selected the power supply blocks with protection PSBPs which are to be installed in the laboratory [14, 17].

The lighting fixtures are LED, wall or ceiling-mounted sconces with a matte diffuser, featuring a color temperature of 4000K. The electrical circuits were installed with PVC-insulated single-core copper conductors and flame-retardant sheathing type CYY-F, with cross-sections of 1.5, 2.5, and 6 mm², surface-mounted on the non-combustible structural elements of the building (masonry walls) and protected in 40 x 60 mm PVC ducts. Penetrations between rooms for routing electrical circuits were made through masonry walls, without compromising the structural integrity of the building. Within-room transitions were protected with PVC conduits. Minimum distances from other installations (water, gas) as per Norm I7-2011 were adhered to.

In Figure 12 are some photographs and illustrations of various types of equipment used in the installation.

6. CONCLUSIONS

Over its 75 years of existence, the University of Petroșani has earned a well-deserved reputation within the scientific and technical community of Romania and beyond. The university's educational facilities have primarily served the training of specialists in the field of mining, equipped specifically for this purpose. With the evolution of society and the gradual shift away from coal for electricity generation, the University is now facing the necessity to "reinvent" itself in order to remain a significant player in today's competitive university environment, where attracting new students at all academic levels is crucial.

With the gradual disappearance of strictly mining-related specializations and the emergence of new fields of study, it is natural to consider the discontinuation of many of the old equipment and facilities in the university laboratories that no longer serve their purpose in the current context. Over the coming years, there is a plan to replace these outdated facilities with state-of-the-art teaching materials and equipment.

It is obvious that the electrical installations that have served the university's educational spaces for seven decades no longer meet the requirements to support modern laboratory equipment. Additionally, they do not align with the safety and operational standards mandated by current regulations and industry standards. Therefore, there is a need to upgrade these installations to ensure they can support the new laboratory equipment effectively and comply with the latest safety regulations.

In the context outlined above, the initiative to design and implement modern and safe electrical installations to serve the entirety of the rooms comprising Laboratory of Electrical Engineering (Laboratory No. 1) in Building A of the university, as the subject of this project, is entirely normal. Its culmination can only be positive, with the aim to extend similar initiatives to other educational spaces across the campus.

Furthermore, this project underscores once again that the design and implementation of internal electrical installations must be approached professionally by specialists and industry professionals. Not only is this a legal requirement, but it also ensures rigorous handling of all issues and aspects, leading to excellent results.

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