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Optimization of the Fuse Protection System of The BT Electrical Distribution Network in Likasi in Order to Reduce Electric Arcs And Expenses.

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Abstract:
The study on the optimization of the fuse protection system of the BT electrical distribution network in Likasi has identified the main causes of the recurring electric arcs and the high expenses related to this system. The failures of the protection system are mainly due to a lack of coordination of the protections and a suboptimal selectivity of the installed fuses. This results in frequent power outages and significant maintenance costs for the network operator. To address this situation, technical and organizational solutions have been proposed. These include strengthening the coordination of the protections, optimizing the selectivity of the fuses and improving the preventive maintenance of the network. These improvements should significantly reduce the failures of the protection system, thus benefiting consumers in terms of the reliability of the electricity supply, and the operator in terms of controlling operating costs. Beyond these immediate solutions, the optimization of the fuse protection system is part of a continuous improvement perspective, particularly with the emergence of smart monitoring and control technologies. The progressive integration of more efficient protection devices, such as fast-acting fuses or electronic circuit breakers, will also help reduce the risks of electric arcs and optimize network maintenance. In the longer term, this optimization approach will have to adapt to the challenges of the local energy transition. In addition, an innovative solution was considered as part of this study: the recycling of zinc envelopes from used batteries for the manufacture of replacement fuses. This approach would not only reduce electric arcs, but also significantly reduce the costs associated with the purchase of new fuses. The dimensioning of these zinc fuses, based on the characteristics of the battery envelopes, would be an interesting avenue to explore to further optimize the protection system of the BT network in Likasi.

Keywords: optimization, protection system, fuses, network, low voltage, electricity distribution, expense, electric arc.

I. Introduction

In the current context of electricity distribution in Africa, the reliability and performance of low-voltage (BT) networks are major challenges to ensure quality power supply to users. In Likasi, the mining city of the Democratic Republic of Congo, the BT distribution network faces recurring challenges in terms of safety and operating costs. Indeed, the repeated electric arcs and the high expenses related to the frequent replacement of fuses are concerning problems for the national electricity company. To address this situation, a thorough study of the fuse protection system of the BT network in Likasi is necessary. The objective is to identify the main causes of the failures of the system and to propose technical and organizational solutions to reduce electric arcs and associated expenses. The analysis of Here is the English translation of the text:

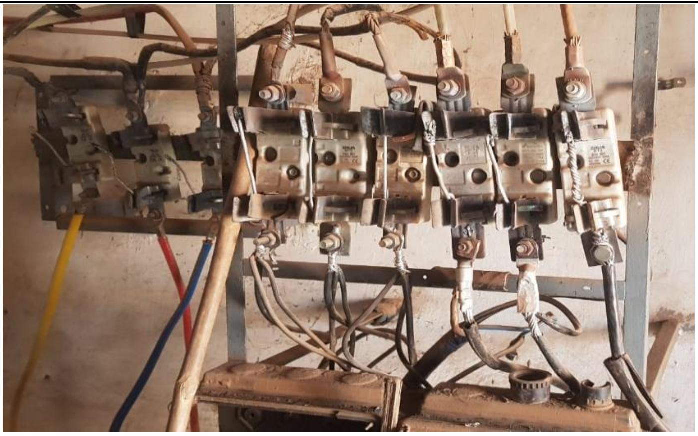
The current operation of the protection system has highlighted gaps in terms of coordination of protections and selectivity of the installed fuses. These weaknesses lead to unwanted tripping of the protections, thus causing frequent power outages and significant maintenance costs for the network operator. Faced with these findings, improvement avenues have been identified, in particular the optimization of protection coordination and fuse selectivity. These adjustments should help limit protection system failures, thus benefiting consumers in terms of electricity supply reliability, and the operator in terms of operational cost control.

II. Comparative Analysis

The study carried out on the LV network of Likasi has highlighted the shortcomings of the current fuse protection system in place. A comparative analysis with recognized practices in the field of power distribution has been carried out in order to identify the most relevant areas for improvement.
From a technical perspective, the comparison showed that the coordination of protections and the selectivity of the installed fuses were suboptimal compared to international standards. Indeed, the lack of consistency in the sizing of the fuses and their distribution on the network led to unwanted tripping, thus causing frequent power outages for users.
From an organizational standpoint, the management of the fuse protection system has also proven to be deficient. Contrary to what is practiced in many mature distribution networks, preventive maintenance and performance monitoring of the system were insufficient in Likasi. This resulted in high maintenance costs and degraded network reliability.
By comparing with more efficient technical solutions implemented elsewhere, the study identified opportunities for improvement. The use of fast-acting fuses or electronic circuit breakers, for example, would more effectively limit electric arcs and optimize network maintenance.
Finally, the analysis emphasized the importance of proactive management of the fuse protection system, based on proven practices in terms of performance monitoring, protection coordination, and device selectivity. These adjustments should significantly reduce electric arcs and expenses related to frequent replacement of fuses on the Likasi LV network.
The visible sectioning boxes offer better visibility and accessibility to the electrical feeders, thus facilitating maintenance and switching operations. However, their installation requires dedicated outdoor space and can incur additional costs. The choice between visible boxes or feeders integrated into cabins will depend on site constraints and project priorities.
1. Presentations of cabins and visible sectioning boxes
To ensure the situation, we went out on the field by taking some data on the operation and use of aluminum-based fuses in different cabins. This representation is accompanied by the location of the site, by the latitude and longitude of the site, followed by explanatory images with the MES Coordinates application.
This study was conducted as part of a project to evaluate the efficiency and reliability of aluminum-based fuses in electrical installations:
- The objective was to collect real field data to better understand the conditions of use of these fuses.
- We have carried out visits in several electrical cabins distributed on different sites.
- For each cabin, the following data was collected:
- Precise location of the site (latitude, longitude)
- Model and technical characteristics of the installed fuses
- Environmental conditions (temperature, humidity, etc.)
- History of failures and maintenance interventions
- Photographs were also taken to illustrate the installations.

Tableau 1 Presentations of cabins and visible sectioning boxes

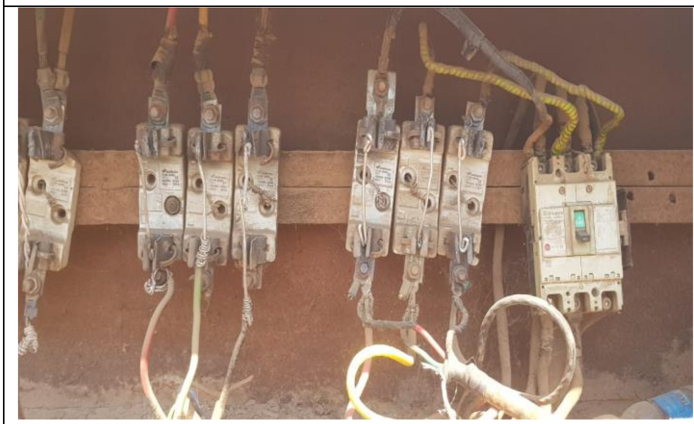
1. CABIN FOYER SOCIALE-KASONGO MICHEL



Localisation (Ma position)

- **Latitude : -10.978511**
  S10°58’42.64068”
- **Longitude : 26.724112**
  E26°43’26.80428”

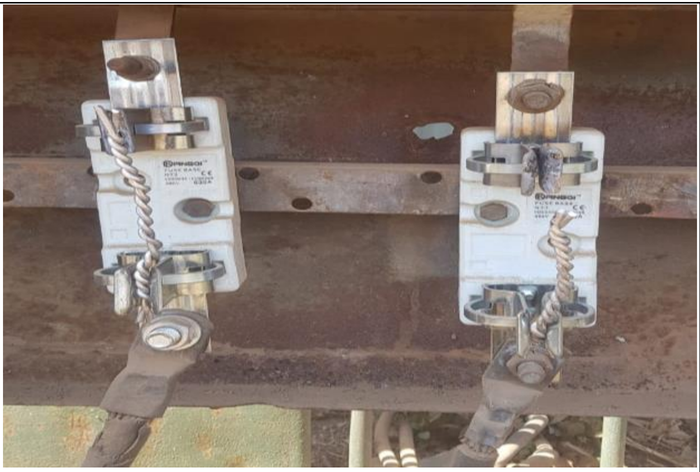
2. APPARENT DISCONNECTION BOX THHHYPER PSARO (A)



Localisation (Ma position)

- **Latitude : -10.979878**
  S10°58’47.5608”
- **Longitude : 26.721867**
  E26°43’18.71976”

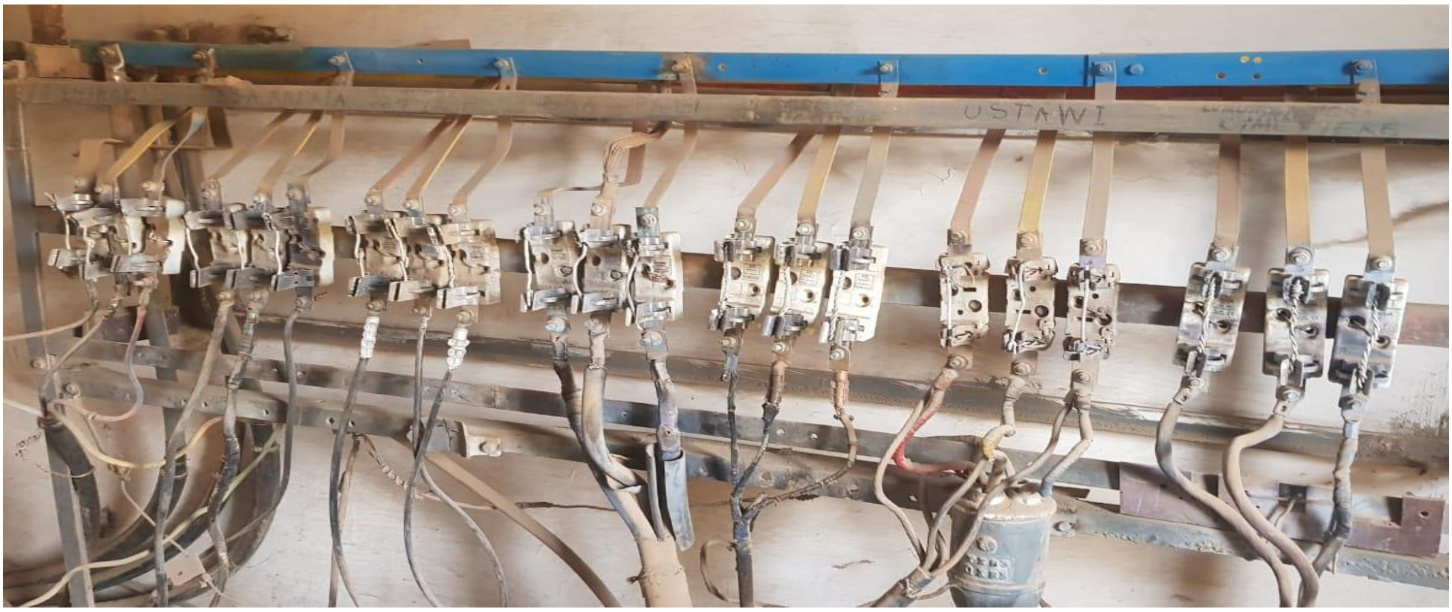
3. CABIN ECOLE OFFICIELLE



Localisation (Ma position)

- **Latitude : -10.979878**
  S10°58’47.5608”
- **Longitude : 26.721867**
  E26°43’18.71976”

4. CABIN LUMUBA(ROUTE KAMPOMPI)



Localisation (Ma position)

- **Latitude : -10.987578**
  S10°59'15.28044"
- **Longitude : 26.732072**
  E26°43'55.4574"

III. Methodology For Analyzing The Current Protection System

The analysis of the fuse protection system generally follows several steps. First, it is necessary to have a good knowledge of the structure of the electrical network, by identifying the power sources, loads, connections and equipment present, as well as their technical specifications. Then, it is necessary to determine the maximum and minimum short-circuit levels at the various critical points of the system, taking into account the elements that impact these short-circuit currents, such as impedances and configurations.

Based on this information, appropriate fuses can be selected and coordinated according to the short-circuit temperatures. The choice of fuse properties, such as nominal current, nominal voltage and type, must ensure selective protection and proper coordination between the various fuses. It is also important to verify that these choices are consistent with the characteristics of the electrical system.

Regarding the materials used in the manufacture of fuses, their properties and prices (al, 2016):

a. Gold:

- Gold is an excellent electrical conductor with very low resistance.
- It is used in very high-quality fuses as it does not oxidize and has an extremely long service life.
- The price of gold in August 2023 was approximately 58,000 euros per kilogram.

b. Copper:

- Copper is a widely used electrical conductor and is less expensive than gold.
- It is corrosion resistant and easily machineable.
- The price of copper in August 2023 was approximately 8,000 euros per ton.

c. Silver:

- Silver has a slightly higher electrical conductivity than copper.
- It is more expensive than copper but less than gold.
- The price of silver in August 2023 was approximately 650 euros per kilogram.

d. Aluminum:

- Aluminum is a lightweight and inexpensive metal with good electrical conductivity.
- It is more corrosion resistant than copper.
- The price of aluminum in August 2023 was approximately 2,200 euros per ton.

Gold offers the best performance but is the most expensive, while aluminum is the most affordable but with slightly lower performance. The choice of material depends on the specific requirements of the fuse and the available budget (Guide and Utilization of Fuses, 2024).

N°	Matter	Advantages	Incontinents	Température de fusion	Intensité de fusion
1.	Gold	- Excellent electrical conductivity - Corrosion resistance - Extremely long lifetime	- Very high cost - Limited availability	- 1 064,18 °C - 1 947,52 °F	- Chaleur latente - Latent heat of fusion: 12.55 kJ/mol - Volumetric heat of fusion: 68.9 kJ/L
2.	Copper	- Good electrical conductivity - Relatively affordable cost - High availability - Easy to machine	- Susceptibility to corrosion - Shorter lifetime than gold	- 1 084,62 °C - 1 984,32 °F	- Latent heat of fusion: 13.26 kJ/mol - Volumetric heat of fusion: 207.8 kJ/L
3.	Silver	- Very good electrical conductivity - Corrosion resistance - High lifetime	- Higher cost than copper - Less abundant availability than copper	- 961,78 °C - 1 763,20 °F	- Latent heat of fusion: 11.30 kJ/mol - Volumetric heat of fusion: 104.7 kJ/L
4.	Aluminium	- Very affordable cost - Lightweight - Good corrosion resistance	- Electrical conductivity slightly lower than copper - Shorter lifetime than noble metals	- 660,32 °C -1220,58 °F	- Latent heat of fusion: 10.79 kJ/mol - Volumetric heat of fusion: 107.2 kJ/L

Tableau 2 Matter of adventages

The choice of material depends on the compromise to be found between electrical performance, durability, cost and availability. For critical applications, gold or silver will be favored despite their higher price.

Copper and gold have very close melting points, around 1,064-1,085°C. Silver melts at a slightly lower temperature, around 962°C. Aluminum has the lowest melting point of these four metals, at 660°C. The latent heat of fusion indicates the amount of energy required to transition a metal from the solid to the liquid state without a change in temperature. The volumetric heat of fusion indicates the amount of energy per unit volume.
Among these metals, copper requires the greatest amount of energy per mole and per liter to melt, followed by gold, silver and finally aluminum which has the lowest melting intensity.

IV. Experimentation, Fuse Melting Sizing And Proposal Of Adapted Fuse Manufacturing Model

1. Experimentation

The overall costs for the fuses and the associated formula, as well as Joule's law applied to fuses (likasi, 2024).

- Calculation of total costs:

- For all the cities of Likasi we have at least 108 cabins and for the most favorable ones, a cabin has at least 150 outgoing lines, hence:
- At each outgoing line, there are about 5 fuses
- The unit cost of a fuse is $7

Therefore, the total cost would be:

$$N_f = d \cdot f \quad (1)$$

Total number of fuses = 150 outgoing lines x 5 fuses per outgoing line = 750 fuses

$$C_t = f \cdot f_1 \ (2)$$

Total cost = 750 fuses x $7 per fuse = $5,250
Formula:

$$C_t = N_d \cdot f \cdot C_u \ (3)$$

Total cost = Number of outgoing lines x Average number of fuses per outgoing line x Unit cost of the fuse

- Joule's law applied to fuses:

Joule's law establishes that the power dissipated in a conductor is proportional to the square of the current flowing through it.
For a fuse, this means that when an excessively high current flows through the fuse, the dissipated power increases significantly, causing the metal to melt and the circuit to open.
The formula for Joule's law is:

$$P = I^2 \times R \quad (4)$$

Where:
- P is the dissipated power (in watts)
- I is the current intensity (in amperes)
- R is the resistance of the conductor (in ohms)

When the current exceeds the rated value of the fuse, the dissipated power becomes too high, causing the metal to melt and the circuit to be interrupted.
This melting mechanism is what allows fuses to protect electrical circuits against overcurrents.

2. Fuse melting sizing and proposal of adapted fuse manufacturing model

Fuses are not considered an investment, but rather a consumable. In this case, we propose an estimate of the overall costs related to fuses. We indicate that we have about 150 outgoing lines and that each of these outgoing lines requires about 5 fuses.
Fuses are seen as consumable items rather than investments, and we estimate that we need about 750 fuses (150 outgoing lines x 5 fuses per outgoing line) to cover our needs.
So, in total, you would need:

- 150 outgoing lines x 5 fuses per outgoing line = 750 fuses And we mentioned that a fuse costs around $7.
So, the total cost for 750 fuses would be:- 750 fuses x $7 per fuse = $5,250
So, our approximate overall cost for the fuses would be $5,250.
Although fuses are not considered investments but rather consumables, their replacement still represents a significant cost in the overall operating budget. It is therefore important to accurately estimate these recurring operational costs when doing budget planning.
The main materials to be recycled in adapted fuses are the conductive metal used in the core, generally copper or silver, which can be recovered and remelted for reuse. The fuse envelope or housing, often made of ceramic, glass or plastic, can also be sorted and recycled through appropriate channels. Finally, the brass or steel connection and fastening elements, such as screws and terminals, can also be recycled.
The fuse recycling process generally takes place in several steps. First, manual or mechanical disassembly allows the different components to be separated. Then, the materials are sorted according to their nature. The metals are then crushed or melted to be purified and reused, while the other materials are recycled through their respective channels.
This process of recycling used fuses allows a significant portion of the raw materials they contain to be recovered and reintroduced into the production cycle. It is an interesting ecological and economic approach, contributing to waste reduction and the circular economy.

Physical Properties	Chemical Properties
- Bluish-gray transition metal - Melting Point: 419.5 °C - Boiling Point: 907 °C - Density: 7.14 g/cm³ - Appearance: Shiny when freshly exposed, but tarnishes quickly in open air	-- Atomic Number: 30 - Electronic Configuration: [Ar] $3d^{10}$ $4s^2$ - Valence: +2 - Reactivity: Reactive, easily oxidizes in air and reacts with many acids to form zinc salts - Common Uses: Galvanization, batteries, alloys, pigments, etc.
Melting Intensities	**Melting Temperature**
- - Latent heat of fusion of zinc: 7.32 kJ/mol - - Volumetric heat of fusion of zinc: 110.4 kJ/LL	The melting temperature of zinc is 419.53 °C (787.15 °F).

Tableau 3 Overview of the main chemical and physical properties of zinc:

The main properties of zinc when subjected to high heat intensity, particularly at its melting point:
- Melting point: 419.5°C
- At temperatures close to its melting point, zinc becomes increasingly soft and ductile, facilitating its shaping.
- During fusion, zinc undergoes a solid-liquid phase transition. Its specific volume increases by nearly 4% during this transition.
- At its melting point, zinc abruptly changes phase, from a crystalline solid state to a homogeneous liquid state.
- When heated beyond its melting point, zinc becomes increasingly fluid, facilitating its casting and molding.
- Zinc has a relatively high latent heat of fusion of 7.32 kJ/mol, which means that a significant amount of thermal energy must be supplied to melt it.

- During fusion, zinc does not undergo significant changes in its chemical properties. Only its physical properties related to the state of matter are affected.
This high sensitivity of zinc to heat and its melting point make it a metal of choice for many industrial applications such as galvanization, die casting, or foundry.
- Zinc is a soft and malleable metal that melts at a lower temperature than harder construction metals like steel or copper.
- The melting temperature of zinc is higher than that of some other light metals such as magnesium (650°C) but lower than that of aluminum (660°C).
- The relatively low melting point of zinc makes it an interesting metal for certain applications where ease of fusion is important, such as in brazing alloys or galvanization.

Figure 1 Presentation of Zinc Battery Envelopes

Since zinc has relatively low melting temperature and melting point compared to other common metals, it makes an interesting material for certain applications. In particular, the envelopes of used batteries often contain zinc as the main component. As a result, it is interesting to recycle these battery envelopes after use, as the zinc they contain can be recovered and reused. The low melting point and lower energy required to melt zinc facilitate this recycling process compared to other more refractory metals.
Therefore, the advantageous melting properties of zinc make it a metal of choice for certain applications, such as battery envelopes, and allow for easier recycling of these materials when they are used up. Finally, the analysis highlighted the potential offered by the recycling of used zinc battery envelopes for the manufacture of replacement fuses. This circular approach, although still uncommon in the electricity sector, could prove particularly suitable in the context of Likasi and could significantly reduce the costs related to the protection system.

V. Results And Discussion On Proposed Improvements

a. Temperature Evaluation

The current flowing through the fuse is far from constant and significant jumps can sometimes occur. The thermal response will therefore result from the equation:

$$\rho \,.\, C \,.\, S \,.\, l \,.\, d\theta = R \,.\, I^2 \,.\, d\theta \qquad (5)$$

Where:
- C: specific heat in [(kcal)/(kg°C)];
- ρ: conductor density in [kg/m³];
- S: conductor cross-section in [m²];
- R: conductor resistance in [Ω];
- l: conductor length.

$$\rho \,.\, C \,.\, S \,.\, l \,.\, d\theta = R \,.\, I^2 \,.\, dt$$

$$d\theta = \frac{R \,.\, I^2}{\rho \,.\, C \,.\, l \,.\, S}\, dt$$

$$\int d\theta = \int \frac{R\ .\ I^2}{\rho\ .\ C\ .\ S} dt$$
$$\int d\theta = \frac{R\ .I^2}{\rho\ .C\ .l\ .S} \int dt$$
$$\theta = \frac{R\ .\ I^2}{\rho\ .\ C\ .\ l\ .\ S}\ .t \quad (6)$$

The resistance is 2.578 Ω, the cross-section is 70 mm², the density of zinc is 7.13 kg/m³, and its specific heat capacity is 0.3851 kcal/(kg°C).

- Under normal operation:

$$\theta = \frac{2{,}578\ .\ (253{,}7)^2}{70\ .10^{-6}\ .\ 7.13\ .\ 0{,}3851.\ 10^3 .1840\ .\ 4{,}185} = 0{,}0011\ ℃$$

- In case of overload:

$$\theta = \frac{2{,}578\ .\ (360{,}3)^2}{70\ .10^{-6}\ .\ 7.13\ .\ 0{,}3851\ .10^3\ .1840\ .4{,}185} = 0{,}0023\ ℃$$

b. Fuse Sizing

1. Calculation of the fuse cross-section:

The formula to calculate the cross-section is:

$$S = \frac{I^2 \cdot L_s}{K \cdot \Delta T} \quad (7)$$

Where:
- I = 25 A (line current)
- L_s = fuse length (to be determined)
- K = 0.3851 kcal/(kg°C) (zinc fusion coefficient)
- ΔT = difference between zinc melting temperature and ambient temperature (to be determined)

To determine ΔT, we can use the melting temperature of zinc, which is around 420°C. Assuming an ambient temperature of 20°C, we get:

ΔT = 420°C - 20°C = 400°C

Therefore, the fuse cross-section would be:

$$S = \frac{25 \cdot L_s}{0.3851 \cdot\ 500} = 1.625 \cdot L_s\ \ mm^2$$

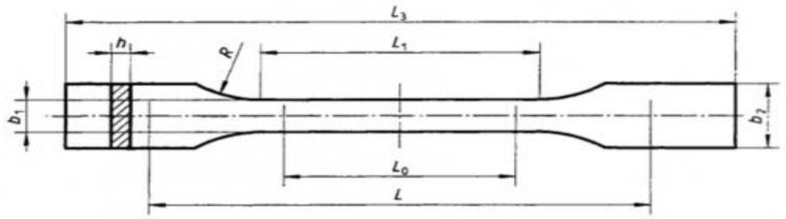


Figure 2 the fuse cross-section would

2. Calculation of the fuse length:

The formula to calculate the length is:

$$\boldsymbol{R} = L_c \frac{\boldsymbol{\rho}}{\boldsymbol{S^2}} \quad \textbf{(8)}$$

$$L_c = \frac{\boldsymbol{R \cdot S^2}}{\boldsymbol{\rho}}$$

Where:
- R = 2.578 Ω (fuse resistance)
- S = fuse cross-section (calculated previously)
- ρ = 5.9 × 10⁻⁸ Ω·m (zinc resistivity at 20°C)

Replacing the value of S, we get:

$$L_c = \frac{\mathbf{2,578 \cdot (1,625\ \times} L_s\mathbf{)^2}}{\mathbf{5.9 \cdot 10^{-8}}}$$

$$L_c = \mathbf{1,066} \times L_s{}^{\mathbf{2}}$$

Solving this quadratic equation to find the length L:

$$L_c - 1.066 \cdot L_s - 0 = 0$$

L_c= **1,033 m**

3. Calculation of the fuse blade thickness:

Since the shape is rectangular, we can note b as the blade width.

The thickness e of the blade would then be:

$$\boldsymbol{e} = \frac{s}{b} \qquad (9)$$

Let's assume the width b is 1 cm (0.01 m), then the thickness e would be:

e = (1,625 × L) / 0,01 = 0,1625 × L = 0,168 cm

So with these calculations, we can determine that for a rectangular zinc fuse with the given characteristics:
- The length L would be around 1.033 m
- The thickness e of the blade would be around 0.168 cm (for a width b of 1 cm)

Figure 3 Presentation of the Experiment

the section in mm²	**length:** (m)	Estimation of Reactive Losses in the Line	Current	Température	Fuse melt normally
$1.625 \cdot L_s$	1,033 m/3 phase	0,168 cm	25 A	400°C	Normally

The experiments that follow in the table were carried out at the SNEL DTS in order to verify the performance of zinc-based fuses while comparing them to copper fuses. The results clearly define that the recycling of used battery casings can be used as fuses in order to reduce the risk and expense.

The key points are:
1. Experiments were conducted at SNEL DTS to evaluate the performance of zinc-based fuses.
2. These zinc-based fuses were compared against traditional copper fuses.
3. The results showed that the used battery casings can be reused and utilized as fuses.
4. Using recycled battery casings as fuses can help reduce the risk and cost compared to standard copper fuses.

The text highlights how recycling and reusing materials, in this case used battery casings, can provide a more cost-effective and safer alternative to conventional fuse materials like copper.

1. Localisation

- Latitude : -10.988531
  S10°59'10.7098''
- Longitude : - 26.739584
  E 26°44'22.5004

2. Current Injector:

- Marque CPC 100 OMICROM
- Fréquence 50Hz
- **Curren**t Max : 800A
- SerNo. XK076F/101367254

Figure 4 ***Current injector***

2. Laser Thermometer: to measure the melting temperature of fuses as a function of current and time.

- The laser thermometer is used to measure the melting temperature of fuses during the tests.
- This temperature measurement allows evaluating the behavior of the fuses as a function of the applied current and duration.
- The objective is to study the thermal response of the fuses, i.e. their ability to open and interrupt the current in case of a fault, as a function of the electrical parameters.
- Temperature measurement using a laser thermometer is a precise and non-invasive way to monitor the thermal evolution of the tested fuse.
- These temperature data, coupled with the electrical parameters controlled by the current injector, allow evaluating the performance and limits of the different types of fuses.

In summary, the laser thermometer plays a key role in the thermal characterization of fuses and the analysis of their behavior under overload or short-circuit conditions.

- 3M DROP
- -30° TO 650° C
- WATER/DUST RESISTANT IP54

Tableau 4 Zinc-Based Fuse Experiments

the section in mm²	**length:** (Cm)	Estimation of Reactive Losses in the Line(Cm)	Current(A)	Température(°C)	Fuse melt normally
2.5	**6**	0,168	40	-	Fuse blows without arc generation
7		0,168	100	99	Fuse blows without arc generation
7.5	6	0,168	98	100	Fuse blows without arc generation

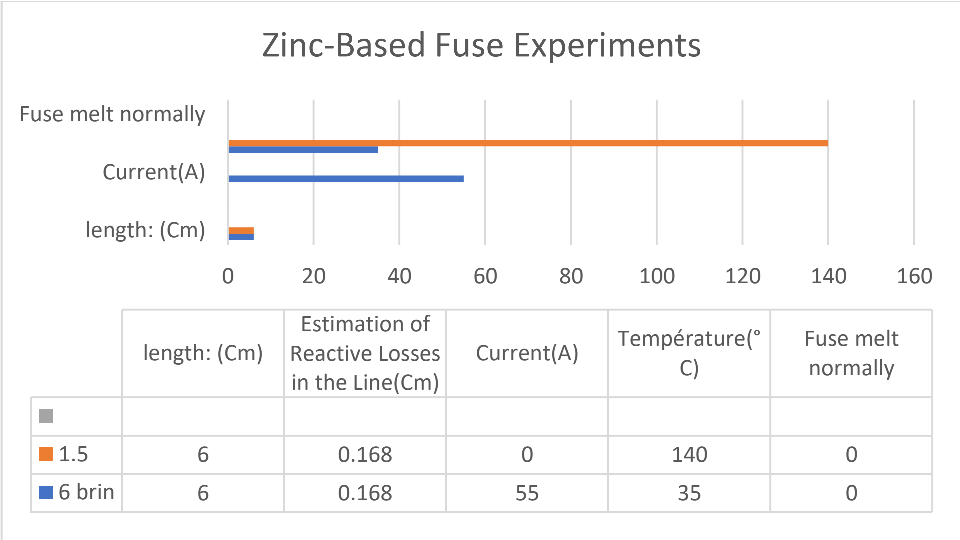
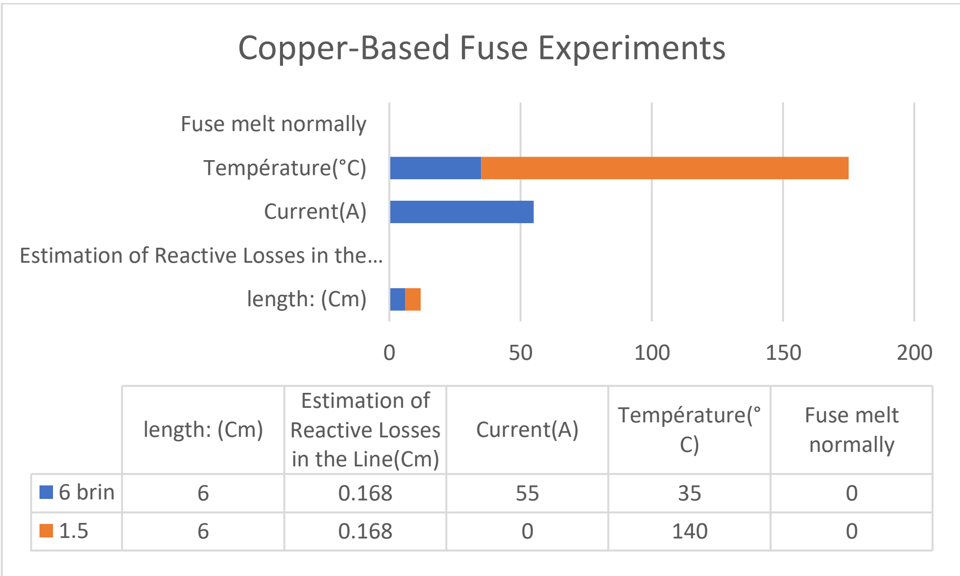


Tableau 5 Copper-Based Fuse Experiments

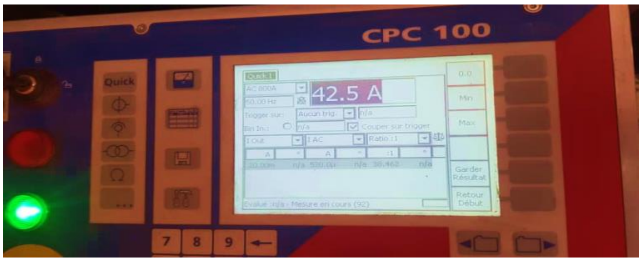
the section in mm²	**length:** (Cm)	Estimation of Reactive Losses in the Line(Cm)	Current(A)	Température(°C)	Fuse melt normally
6 brin	**6**	0,168	55	35	The strand turns red and creates a flame
1.5	6	0,168	25 A	140	The fuse turns red and creates a flame



Practical Experience with the Current Injector

Dimmer

Implementation



Zinc-Based Fuse that Softens without Forming an Arc

Copper-Based Fuse that Softens without Forming an Arc

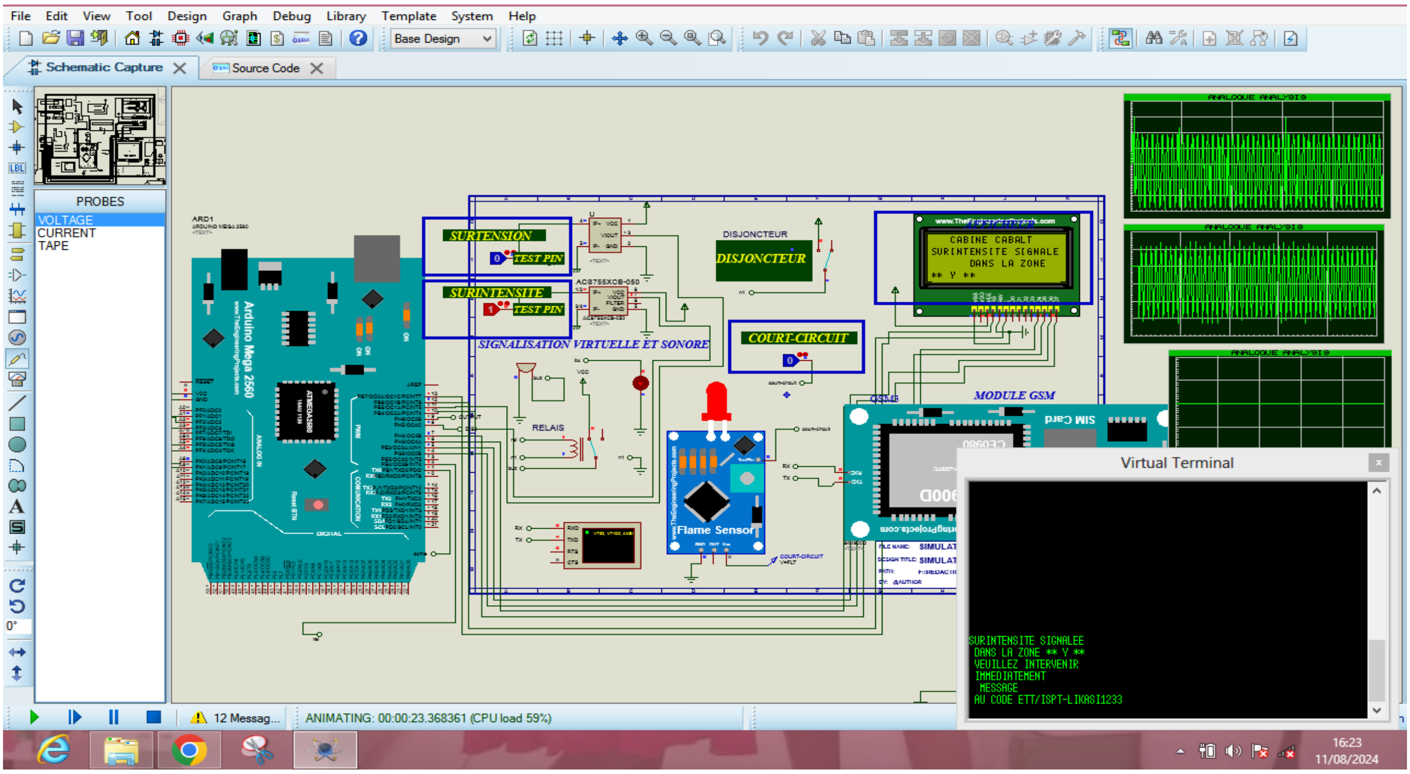


Figure 5: Prototype of Results

Since the simulation is a hypothetical incident aimed at studying the behavior of fuses, we will first present the normal operation of copper-based and zinc-based fuses. Then, we will introduce modifications to simulate a specific incident, in order to analyze the response of these two types of fuses to an overcurrent. Copper-based fuses have the property of softening and deforming at relatively low temperatures, without generating an electric arc. Similarly, zinc-based fuses have this ability to soften without creating an arc. We will therefore be able to compare the performance of these two types of fuses during the simulation of a fault situation. This will allow us to better understand how the metallurgical characteristics of copper and zinc influence the behavior of the fuses and their ability to safely interrupt the current.

This iterative process between modeling, simulation, and analysis of the results is essential to identify the advantages and limitations of each fuse technology, with a view to optimizing their design and use in the targeted applications.

In this simulation, three fault scenarios have been considered:

1. **Short circuit:**

- In the event of a short circuit fault in the low-voltage network supplied by the substation, the detector immediately activates an alarm to alert the maintenance technician.
- The detector also sends a message instantly to report the problem.
- This rapid reaction allows for effective handling of the short-circuit fault.

2. **Overcurrent:**

- If subscribers draw too much current compared to the substation's capacity, it results in an overcurrent fault on the low-voltage network.
- The detector detects this overcurrent and activates an alarm to warn the maintenance technician.
- A message is also sent to quickly report this overload fault.
- This detection and alert allow the identification and resolution of the network overload problem.

3. **Overvoltage:**

- Regardless of its origin, except for transient overvoltages, the detector signals the overvoltage through an alarm.

- A message is also transmitted to inform of the overvoltage problem.
- This rapid notification of overvoltages, except for transient ones, allows taking the necessary measures to protect the network and the subscribers' equipment.

In summary, this simulation sets up effective detection and alert mechanisms for three common types of faults on a low-voltage network: short circuit, overcurrent, and overvoltage. These surveillance and rapid notification systems facilitate the handling and quick resolution of problems, thus contributing to the reliability and quality of the electricity supply.

VI. Conclusion And Future Perspectives

a. Conclusion

The low-voltage (LV) electricity distribution network plays a fundamental role in powering residential and commercial areas. It is the final link in a complex system that must ensure the reliability and quality of the electricity delivered to consumers. However, failures in the fuse protection system can lead to significant problems, such as electrical arcs and high costs for the network operator. In the case of the LV network in Likasi, these malfunctions are particularly concerning and require optimization of the fuse protection system. Indeed, recurring electrical arcs and high maintenance costs negatively impact the quality of service and the profitability of the local electricity network. It is therefore essential to conduct a thorough analysis of the causes of these problems in order to propose technical and organizational solutions to significantly reduce them. This study aims to contribute to improving the reliability and performance of the LV electricity distribution network in Likasi. By identifying the main factors behind the electrical arcs and high expenses, it will make it possible to define a strategy to optimize the fuse protection system. The ultimate goal is to ensure quality electricity supply for consumers while controlling costs for the network operator.

In summary, the recycling of zinc envelopes from used batteries could be an interesting solution to significantly reduce electrical arcs on the LV electricity distribution network in Likasi. This innovative approach would not only secure the personnel of the national electricity company against burns, which have unfortunately become common, but also reduce the burden of expenses related to the cost of purchasing LV fuses.

Indeed, the use of these recycled zinc envelopes as a replacement material for traditional fuses could prove to be a particularly relevant technical and economic solution to optimize the LV network protection system. In addition to the benefits in terms of safety and reduction of operating costs, this initiative would be part of a broader sustainable development approach, by recovering waste and thus contributing to environmental protection. The study of this avenue for improving the fuse protection system therefore deserves to be further explored in order to assess its feasibility and potential impacts on the overall performance of the Likasi electricity network.

b. Future Perspectives

Beyond the technical and organizational solutions proposed in this study, the optimization of the fuse protection system of the LV electricity distribution network in Likasi is part of a perspective of continuous improvement of the network's performance. Technological and regulatory developments indeed offer new opportunities to further increase the reliability and profitability of the protection system.

The emergence of intelligent monitoring and control systems, coupled with data analysis tools, will make it possible to better detect and anticipate network failures. Similarly, the progressive integration of more efficient protection devices, such as fast-acting fuses or electronic circuit breakers, will help reduce the risk of electrical arcs and optimize maintenance. In the longer term, the optimization of the fuse protection system will also have to be articulated with the challenges of the energy transition, by adapting to changes in the local electricity mix. Thus, the continuous improvement of the LV network protection system in Likasi represents an essential lever to ensure the quality and sustainability of the electricity supply for users.

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