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A Pedagogical Proposal: Some Fundamentals and Concepts for Fire Protection System Design

Oscar D. Flórez C.[1], Julián R. Camargo L.[2], César A. Perdomo Ch.[3]
[1] Engineering Faculty, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia
[2] Engineering Faculty, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia
[3] Engineering Faculty, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia

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ABSTRACT

This paper presents the basic concepts and fundamentals for designing fire protection systems in Colombia. In the courses of electrical installations and basic electricity, some risks related to the handling of electrical energy are mentioned. Still, there is no specific course at the level of professional electrical and electronic engineering training that identifies and prepares the future engineer in the design and approval of these systems. Some regulations that must be considered for the design and construction of these systems are mentioned. Many international laws apply to equipment and give recommendations but do not establish the professional or the procedures for explicit approval of an installation. It is crucial to make students aware of this problem and generate job opportunities in the medium and long future responsible for promoting technological and social integration for the benefit of users of buildings and other infrastructure.

Keywords: Basic electricity, Electrical installations, Fire protection system, NFPA 70, UL 864

1. INTRODUCTION

Fire is a chemical combustion reaction based on strongly exothermic "oxidation-reduction" phenomena, manifested by a significant release of light and heat. Fire is an uncontrolled fire. Its effects are generally undesirable, producing personal injuries due to smoke, toxic gases and high temperatures, and material damage to installations, manufactured products and buildings [1].

The fire is produced when the following factors exist simultaneously in time and space: fuel, carburant, usually the oxygen in the air, and heat, which provides the energy necessary to activate the reaction".

Generally, urban-type fires are mainly caused by short circuits due to faulty installations, overloads or because electrical installations are not maintained, faulty electrical appliances, wrong handling of hazardous substances and human error [2]-[7]. A fire can be transmitted in three ways, as shown in Figure 1.

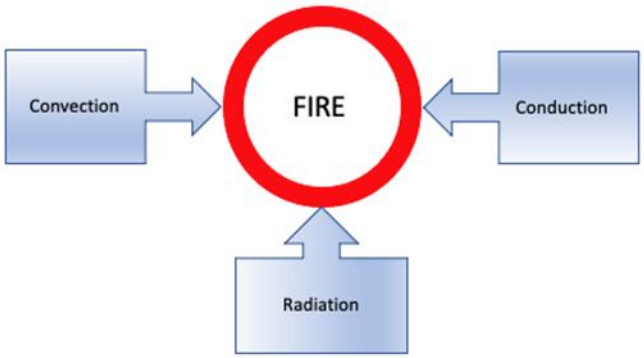

Figure 1: Fire propagation

Fire Protection is the set of provisions arranged in buildings to protect them against the action of fire, which can be active or passive. It is intended to warn users of fire and act on it. Active Fire Protection (AFP) is the set of elements, equipment, and systems installed to warn of a possible fire and prevent it from spreading. Fire detection and alarm systems, fire extinguishers, fire water supply systems, hoses, equipment and other fire protection accessories make up the active protection equipment. See Figure 2.

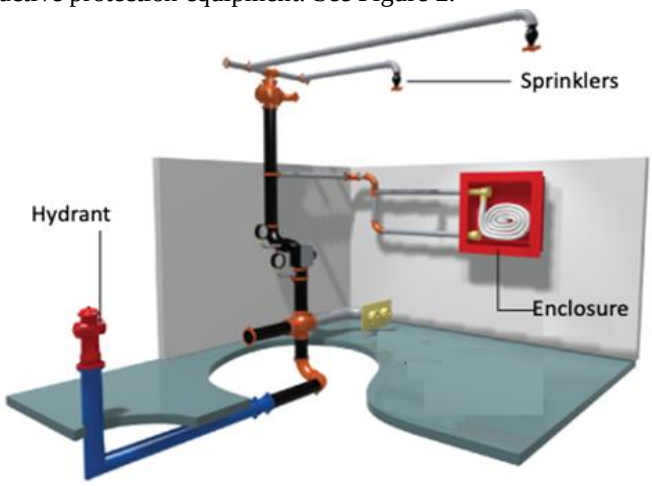

Figure 2: Active protection equipment [8]

There are three categories in active protection: detection, suppression and ventilation. Detection using smoke, flame and heat detectors and other sensors, detects the fire, the signals sent to start the emergency evacuation protocol fire suppression includes all processes and activities focused on extinguishing the fire by direct action [9]-[11]. Mechanical ventilation consists of all procedures carried out to keep evacuation routes and other specific areas free of smoke through fire-resistant mechanical fans.

Figure 3 shows an example of a primary fire detection system with the different elements that make it up. The available technology will replace some of them in the medium and long term and the communication protocols that allow information to be known as quickly as possible [12]-[15].

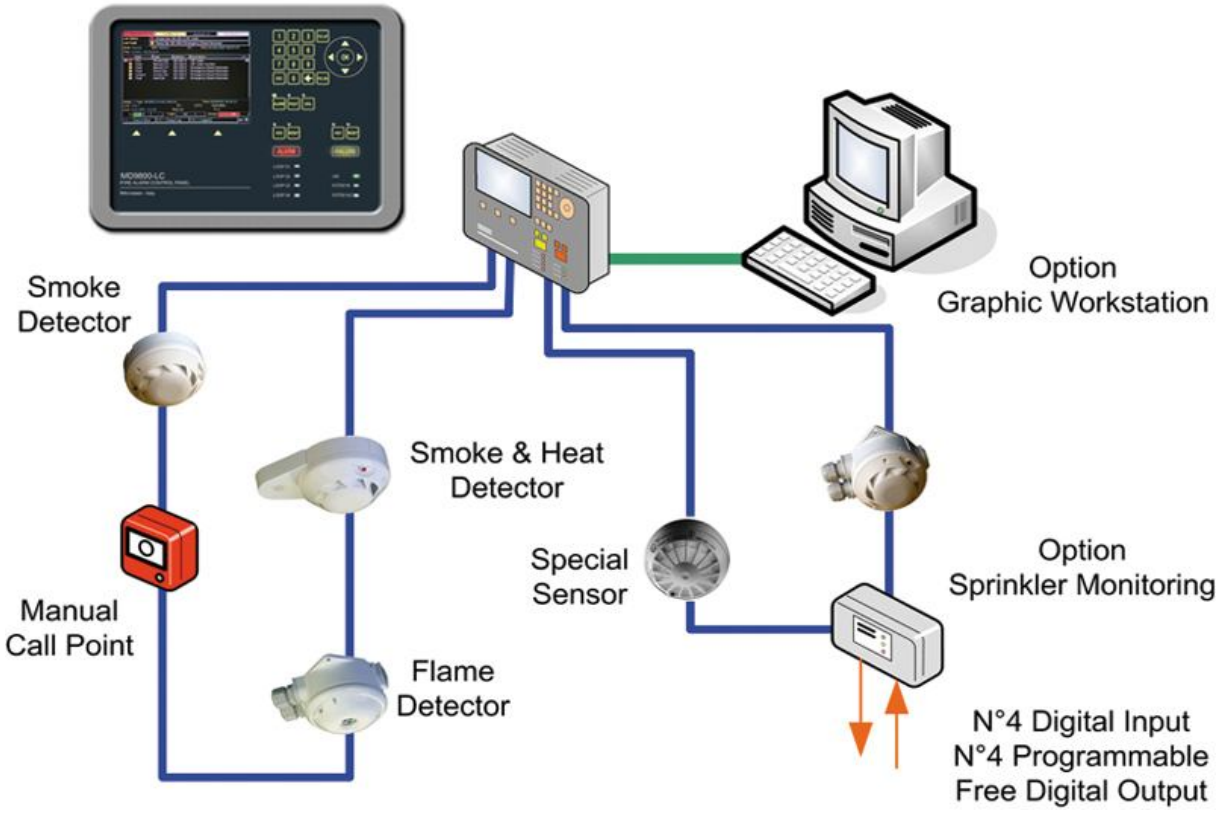

Figure 3: Fire detection system [16]

Passive fire protection (PFA) has a preventive role. It relates all the installed systems to mitigate the consequences of a fire. It is considered passive protection because it works without human intervention to allow the evacuation of people and the intervention of emergency services.

Depending on the regulations related to the type of building, these constructive measures are intended to prevent the spread of flames, stop the progression of smoke and contain the thermal effects in the disaster area [17]-[19].

Passive fire protection has three categories as follows:

- Structural protection: measures to ensure the fire resistance of structural elements.
- Compartmentation: Measures to close the passages that connect the area where the fire started to the adjacent areas.
- Fireproofing treatments: This is the technique used to enhance the correct insulation of the structures of a building to prevent the spread of fire.

2. PROBLEM FORMULATION

The following are the regulatory requirements required in Colombia for fire protection system designs.

Short circuits mainly cause urban fires due to faulty installations, overloading or lack of maintenance of electrical installations, faulty electrical appliances, mishandling of hazardous substances and human error are also classified as residential, industrial or commercial.

Decree 926 of 2006 of the Colombian Association of Earthquake Engineering establishes where fire detection and alarm systems are mandatory and provides guidelines for their implementation.

Makes mandatory the adoption of the first seven chapters of the Colombian Electrical Code Standard NTC 2050. The Technical Regulation of Electrical Installations (RETIE)

indicates the requirements to ensure safe electrical installations.
The Technical Regulations for Telecommunications (RITEL) also applies to residential fires taking into account the scope of an application contemplated and updated according to Resolution 5993 of 2020.

The RETIE and RITEL are issued by the Ministry of Mines and Energy and are constantly being revised and adjusted to protect people and equipment at all times.

The Colombian Institute of Technical Standards (ICONTEC), through the Colombian electrical code, establishes specific requirements for the wiring of fire detection and alarm systems in its section 760. Based on NFPA 70 [20].

The "National Fire Alarm and Signaling Code" defines the performance standards that fire detection and alarm systems must meet for their correct installation and operation.

It imposes the use of products certified by independent laboratories and "The Human Safety Code" determines requirements to guarantee life safety, classifies occupancies and their needs. It establishes where detection and alarm systems are required, determines minimum conditions for evacuation, prevention, etc. of the NFPA, respectively [21].

The European Standard EN54 of 2016 "Fire Detection and Alarm Systems" by the European Committee for Standardization is mandatory in the European Union (EU). It specifies minimum requirements and laboratory tests that ensure safety for all Fire Alarm System components to guarantee quality and functionality standards [22], [23].

The "ISO 7240 Fire Detection and Alarm Systems" International Organization for Standardization specifies all fire detection and alarm system components and defines performance requirements for their installation and interconnection. Prescribes requirements for their testing and maintenance [24], [25].

3. FIRE SYSTEM DESIGN CONDITIONS AND DESCRIPTION

1. To cover, whenever possible, the entire risk unit, understood as the building or group of buildings that may be affected by the same fire.

2. The protected area should be divided into zones to identify where the activated detector is located easily. The floor area of a single zone must not exceed 1,600m^2.

3. Where a zone extends beyond a single fire compartment, the zone's boundaries should be the boundaries of the fire compartments and the floor area of the location should not exceed 400m^2.

4. Each zone shall be confined to a single floor of the building, except in the case of stairways, light courts or elevator shafts or similar enclosures which constitute fire compartments or where the total floor area of the building is less than 300m^2.

5. Detectors should be of a type appropriate to how the fire is likely to develop, bearing in mind that no single type of detector is most suitable for all applications. The final choice will depend on the circumstances of each case. It will often be helpful to use a mixture of different detectors.

6. Detectors will be selected according to their effectiveness depending on the room's height, among other factors that condition the response time.

7. Air velocities greater than 5m/s may cause false alarms emitted by ionization chamber smoke detectors.

8. Detectors should not be installed in air currents from air conditioning, ventilation or air conditioning installations.

9. The location of the detectors should be made, taking into account direct solar radiation. All materials, machines and similar that emits or may emit thermal radiation, hot air, or hot vapors must also be taken into account and considered.

4. CERTIFICATION

It is essential to be permanently updated through specific courses and training organizations like NFPA [26]. The certification processes cover the equipment and materials used that comply with current regulations and the design procedures of qualified professional personnel for this purpose. Table 1 shows some conformity certifiers in the industry.

Table 1: Some conformity certifiers in the industry

Underwriter Laboratories	**Factory Mutual**	**European Compliance**
UL 864 Control Units and Accessories for Fire Alarm System Underwriters laboratories UL's test standard is to ensure compliance with	**FM Approvals** Specific for each type of product determines the requirements and test protocols that must be	In the European system, certification is not issued directly to the market by the certifying body since it is the manufacturer who assumes responsibility for ensuring that when using the CE mark of conformity, all the

the performance requirements established by NFPA 72 for fire detection and alarm systems.	carried out to obtain certification.	requirements are met, including, among others, having carried out the necessary certification tests with an external laboratory.

The fire departments are the competent bodies to carry out the work of inspections and technical reviews regarding fire prevention and human safety according to Article 42. Inspections and safety certificates of Law 1575 of 2012.

These inspections will contemplate the following aspects:

1. Current regulations review the designs of fire protection and human safety systems of new construction and/or renovation projects.
2. Annual inspection and testing of fire protection systems by the regulations in force.
3. He is carrying out planned technical inspections related to fire and human safety.

The above applies to the hydraulic piping network and its control systems. To date, there is no official endorsement or review of the design of the fire protection system for electrical and/or electronic components, although NFPA 70 standards are being followed.

5. CONCLUSIONS

It is essential to highlight the responsibilities and possible risks of electrical energy accidents in the training of electrical and electronic engineers. In this way, they will in the future implement systems against fire and other eventualities that can affect the life and property of the residents of a building according to the conditions of each country or specific area.

Work must be done in a unified manner with architects, engineers, etc., to establish protocols and final regulations for validating designs and implementing fire protection systems to guarantee the best conditions and safety for all users.

REFERENCES

1. P. Rai, S. Rai, R. Sharma, S. Rai, M. Pradhan, B. H. Subba and T. Sherpa. **Smart Fire Detection System with Water Head Sprinkler**, *International Journal of Recent Advances in Multidisciplinary Topics*, vol. 2, no. 7, pp.253-254, 2021.
2. A. Gaur, A. Singh, A. Kumar, A. Kumar and K. Kapoor. **Video flame and smoke based fire detection algorithms: A literature review**, *Fire Technology*, vol. 56, no. 5, pp. 1943-1980, 2020.
3. K. Poobalan and S.-C. Liew. **Fire detection algorithm using image processing techniques**, *Conference: International Conference on Artificial Intelligence and Computer Science*, Penang, Malaysia, 2015.
4. P. Li and W. Zhao. **Image fire detection algorithms based on convolutional neural networks**, *Case Studies in Thermal Engineering*, vol. 19, 2020.
5. K. Muhammad, J. Ahmad and S.W. Baik. **Early fire detection using convolutional neural networks during surveillance for effective disaster management**, *Neurocomputing*, vol. 288, pp. 30–42, 2018.
6. R. P. Sadewa, B. Irawan and C. Setianingsih. **Fire Detection Using Image Processing Techniques with Convolutional Neural Networks**, *2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*, 2019, pp. 290-295.
7. Y. Luo, L. Zhao, P. Liu and D. Huang. **Fire smoke detection algorithm based on motion characteristic and convolutional neural networks**, *Multimedia Tools and Applications*, vol. 77, pp. 15075-15092, 2018.
8. Quindiaguas, **Redes contra Incendio**, [Online]. Available: https://quindiaguas.com/contenido-index-id-23.htm
9. J. Fonollosa, A. Solórzano and S. Marco. **Chemical sensor systems and associated algorithms for fire detection: A review**, *Sensors*, vol. 18, no. 2, 553, 2018.
10. R. Yadav and P. Rani. **Sensor based smart fire detection and fire alarm system**, *Proceedings of the International Conference on Advances in Chemical Engineering (AdChE)*, 2020.
11. G. Suhas, K. Chetan, B. S. Abhishek, K. A. Digvijay Gowda and R. Prajwal. **Fire Detection Using Deep Learning**, *International Journal of Progressive Research in Science and Engineering*, vol. 1, no. 5, 2020.
12. A. Kashikar, P. More, R. Ulman and K. S. Guide. ***Fire Detection System***, ST. Francis Institute of Technology, 2017.
13. Q. Zhang, J. Xu, L. Xu and H. Gu. **Deep Convolutional Neural Networks for Forest Fire Detection**, *International Forum on Management, Education and Information Technology Application (IFMEITA)*, 2016.
14. T. Çelik, H. Özkaramanlı and H. Demirel. **Fire and Smoke Detection without Sensors: Image Processing Based Approach**, *15th European Signal Processing Conference (EUSIPCO 2007)*, Poznan, Poland, 2007.
15. N. Prabhu Ram, R. Gokul Kannan, V. Gowdham and R. Arul Vignesh. **Fire Detection Using Cnn Approach**, *International Journal of Scientific & Technology Research*, vol. 9, no. 4, 2020.
16. MarTec (Marine & Technologies) Integrtated Safety Solutions, **FDS (Fire Detection System)**, [Online]. Available: https://www.martec.it/?page_id=12
17. J. Yim, H. Park, W. Lee, S. Kim and Y. T. Lee. **Deep Learning-Based CCTV Fire Detection System**, In Proceedings of the Korean Society of Broadcast Engineers Conference (pp. 139-141). The Korean Institute of Broadcast and Media Engineers. 2017.

18. R. Xu, H. Lin, K. Lu, L. Cao and Y. Liu. A Forest **Fire Detection System Based on Ensemble Learning**, *Forests*, vol. 12, no. 2, 2021.
19. P. Barmpoutis, P. Papaioannou, K. Dimitropoulos and N. Grammalidis. **A Review on Early Forest Fire Detection Systems Using Optical Remote Sensing**, *Sensors*, vol. 20, no. 22: 6442, 2020.
20. Icontec**.** ***Norma Técnica Colombiana. NTC 2050. Código eléctrico colombiano. Segunda Actualización***. Icontec, 2020.
21. K. Keller. ***Electrical Safety Code Manual: A Plain Language Guide to National Electrical Code, OSHA and NFPA 70E.*** Butterworth-Heinemann, 2010.
22. R. B. Jevtić. **Differences between standards related to fire protection systems design**, *Tehnika*, vol. 76, no. 3, pp. 386-392, 2021.
23. A. Kumar, K. B. Deve and G. Hancke. **Smart fire detection system based on the IEEE 802.15.4 standard for smart buildings**, *Conference: ICAITA 2014, Hong Kong*, 2014.
24. A. Solórzano, J. Eichmann, L. Fernandez, B. Ziems, J. M. Jiménez-Soto, S. Marco and J. Fonollosa. **Early fire detection based on gas sensor arrays: Multivariate calibration and validation**, *Sensors and Actuators B: Chemical*, vol. 352, part 1, 2022.
25. L. Wu, L. Chen and X. Hao. **Multi-Sensor Data Fusion Algorithm for Indoor Fire Early Warning Based on BP Neural Network**, *Information*, vol. 12, no. 59, 2021.
26. National Fire Protection Association (NFPA). **Certified Fire Protection Specialis**t - **Candidate Handbook**, ANSI - CFPS, 2021. [Online]. Available: https://www.nfpa.org/-/media/Files/Training/certification/CFPS/CFPSHandbook.ashx