M^ed Boudiaf M'sila University

Electrical Engineering Department

Specialty: renewable energy and environment

Level : 2^end level license

Title :

Electric safety

Realised by :

GHADBANE Ismail

University year : 2023/2024

رقم:...421.../ق هـ ك /2024

المسيلة في : 24 نوفمبر 2024

شهادة إدارية

بخصوص مطبوعة الدروس الخاصة بالأستاذ

غضبان إسماعيل

بناءً على محضر اللجنة العلمية لقسم الهندسة الكهربائية تحت رقم: 107/ ق.هـ.ك/2024المنعقد بتاريخ 04مارس2024 والمتضمن تعين الخبراء:الأستاذ بلخيري صالح أستاذ محاضر –أ- بجامعة المسيلة الأستاذ بوزيدي رياض أستاذ محاضر –أ- بجامعة المسيلة، والأستاذ سعدوني رضوان أستاذ بجامعة غرداية وذلك لتقييم مطبوعة الدروس الخاصة بالأستاذ غضبان إسماعيل أستاذ محاضر "أ" بقسم الهندسة الكهربائية لجامعة المسيلة تحت عنوان "**Sécurité Electrique**" مطبوعة دروس مكتوبة باللغة الإنجليزية تحت عنوان "**Electrical Safety**" وبعد إطلاع رئيس اللجنة العلمية ورئيس القسم على التقارير الواردة و التي كانت كلها ايجابية، وعليه فإن اللجنة لا ترى مانعا أن تتخذه سندا في تدريس طلبة السنة الثانية ليسانس طاقات متجددة وبيئة، شعبةطاقات متجددة ميدان علوم و تكنولوجيا و أن تعتمد في أي تقييم للمسار العلمي للأستاذ المعني.

رئيس اللجنة العلمية
أ .د بوقرة عبد الرحمان

رئيس القسم
دفداف المبروك

ملاحظة: سلمت هذه الشهادة للمعني(ة) لاستعمالها في حدود ما يسمح به القانون

Summary:

Electrical safety refers to the set of practices and measures implemented to prevent risks associated with the use of electricity, ensuring the protection of people, property, and electrical installations. It is essential in all environments where electricity is used, whether in residential, industrial, or commercial buildings. The main aspects of electrical safety include protection against electrical shocks. An electrical shock occurs when the human body comes into contact with a live electrical conductor. Safety is achieved through the use of protective devices such as circuit breakers, grounding systems, and residual current devices, which help prevent this type of risk. Electrical installations must be carried out in accordance with current standards and regulations, such as the NF C 15-100 standard. A poorly installed system can lead to short circuits, fires, or electrocutions. Electrical systems should be regularly inspected and maintained to detect any abnormalities (e.g., exposed wires, damaged equipment). Equipment must comply with safety certifications. Personal protective equipment (PPE)**:** People working on or near electrical installations must wear suitable protective gear, such as insulated gloves, safety shoes, and protective eyewear. Training and awareness**:** Prevention also involves training workers and the general public in proper safety practices, such as never touching damaged electrical devices or cables and avoiding the use of faulty equipment. Fire risk**:** A short circuit or insulation failure can cause a fire. It is therefore crucial to install safety devices that disconnect the power in case of failure.

In summary, electrical safety aims to prevent electrical accidents through proper design, installation, and maintenance of equipment, as well as by training users and ensuring the use of appropriate protective devices. The goal of this field is to inform future professionals about the nature of electrical accidents, methods for rescuing electrical accident victims, and to provide sufficient knowledge for properly sizing protection systems for both equipment and personnel working in industrial and other sectors that use electrical equipment.

Keywords: electrical risk, electrical accident, protective equipment, NFC standards, maintenance.

Résume :
La **sécurité électrique** désigne l'ensemble des pratiques et des mesures mises en place pour prévenir les risques liés à l'utilisation de l'électricité, afin d'assurer la protection des personnes, des biens et des installations électriques. Elle est essentielle dans tous les environnements où l'électricité est utilisée, que ce soit dans les bâtiments résidentiels, industriels, ou commerciaux. les principaux aspects de la sécurité électrique **Protection contre les chocs électriques** , Un choc électrique se produit lorsque le corps humain entre en contact avec un conducteur électrique sous tension. La sécurité passe par l'utilisation de dispositifs de protection tels que les disjoncteurs, les prises de terre, les interrupteurs différentiels, qui permettent d'éviter ce type de risque. Les installations électriques doivent être réalisées en suivant les normes et réglementations en vigueur, telles que la norme NF C 15-100. Une installation mal réalisée peut entraîner des courts-circuits, des incendies ou des électrocutions. les systèmes électriques doivent être régulièrement inspectés et entretenus pour détecter toute anomalie (fils dénudés, équipements endommagés, etc.). Les équipements doivent être conformes aux certifications de sécurité**.** Équipements de protection individuelle (EPI) **:** Les personnes travaillant sur ou à proximité d'installations électriques doivent porter des équipements adaptés, comme des gants isolants, des chaussures de sécurité, des lunettes de protection, etc. Formation et sensibilisation : La prévention passe également par la formation des travailleurs et du grand public aux bonnes pratiques de sécurité, comme ne jamais toucher un appareil ou un câble électrique endommagé, ou éviter d'utiliser des appareils défectueux. Risque d'incendie : Un court-circuit ou un défaut d'isolation peut provoquer un incendie. Il est donc crucial d'installer des dispositifs de sécurité qui coupent le courant en cas de défaillance. En résumé, la sécurité électrique vise à prévenir les accidents électriques grâce à une bonne conception, installation, maintenance des équipements et à la formation des utilisateurs, tout en garantissant des équipements de protection adaptés. La matière a pour objectif d'informer le futur licencié sur la nature des accidents électriques, les méthodes de secours des accidentés électriques et de lui donner les connaissances suffisantes pour lui permettre de dimensionner au mieux les dispositifs de protection du matériel et du personnel intervenant dans l'industrie et autres domaines d'utilisation de ces équipements.

Mots clés :risque électrique, accident électrique , équipement de protection , Norme NFC , Entretien

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UE	Méthodologique	32 h cours 32 h TD
Crédit=3	Sécurité électrique	Semestre 3

Objectifs : informer le futur licencié sur la nature des accidents électriques, les méthodes de secours des accidentés électriques et de lui donner les connaissances suffisantes pour lui permettre de dimensionner au mieux les dispositifs de protection du matériel et du personnel intervenant dans l'industrie et autres domaines d'utilisation de ces équipements.

Enseignant responsable du module : CHOUDER Aissa

Compétences visées :

- ✓ Être capable de choisir et mettre en œuvre un transformateur monophasé, triphasé,
- ✓ Être capable de mettre en œuvre une inductance
- ✓ Être capable de faire des mesures sur un système de distribution électrique, en particulier de type triphasé,
- ✓ Être préparé à l'habilitation électrique.
- ✓ Être capable de choisir et mettre en œuvre un transformateur monophasé, triphasé,
- ✓ Être capable de mettre en œuvre une inductance.

Prérequis :

Contenus et compétences associées	Niveau d'acquisition
Chap1 Risques électriques: Définition et but de la sécurité du travail, Légende et historique du risque électrique, Organisme de normalisation, Statistiques sur les accidents électriques. **Chap2 Nature des accidents électriques et dangers du courant électrique:** Classement (actions directe et indirecte du courant électrique), Impédance du corps humain, Paramètres d'influence du courant humain, Effets pathophysiologiques du passage du courant électrique, Electrisation sans perte de connaissance, Electrisation avec perte de connaissance (fibrillation ventriculaire). **Chap3 Mesures de protection:** Introduction, Protection de personnes, Réglementation, Mesures de sécurité, Travaux hors tension, Travaux au voisinage des installations électriques, Protections individuelles et collectives, Protection contre les courants direct et indirect, Tension de sécurité, Schéma de liaison à la terre (SLT), Effets du champ électrique et magnétique, Protection du matériel, Dispositifs de protection (types et fiabilité des dispositifs), Installations intérieures BT, MT et HT, Appareils mobiles BT, Vérifications et contrôles. **Chap4 Mesures de sécurité contre les effets indirects du courant électrique:** Les incendies, Les matières nuisibles, Les explosions, Les bruits et les vibrations (Définition, normes et techniques de luttes contre le bruit). **Chap5 Mesures de secours et soins:** Attitude à observer en cas d'accidents électriques, Premiers soins, Ventilation assistée (méthodes du bouche à bouche et de Sylvester), Massage cardiaque externe, Soins aux brûlés.	

Modalités de mise en œuvre :

Références :

1- V. Semeneko, Prescriptions Générale de Sécurité Technique dans une Entreprise,Université de Annaba, 1979.

2- A.Novikov, Cahier de Cours de Protection de Travail, Université de Annaba, 1983

Edgar Gillon, Cours d'Electrotechnique, Dunod, Paris 19664-

Mots clés :

Teaching objectives

The purpose of the course is to inform the future graduate about the nature of electrical accidents, the methods for rescuing victims of electrical accidents, and to provide them with sufficient knowledge to effectively size the protection devices for equipment and personnel working in industry and other areas where such equipment is used

List of contents

Chapter I: Electrical risks

The histories of science refer to a complacency in biblical texts and historical texts. The electrical history does not include any investigations or other electrical hazards.

1.Purpose of work safety

In every workplace, employers are generally responsible for to ensure the safety and health of workers in all aspects related to their work

1.1. The objective of a risk assessment is:

Enable the employer to take the necessary measures to ensure the protection of worker safety and health.

Work safety is the set of methods aimed at eliminate, or at least minimize, the consequences of failures or incidents in a device or installation. The consequences of these failures have a destructive effect on personnel, equipment or the environment or any the other. The employer is the person who, directly or indirectly by delegation, assumes legal responsibility within the framework of the Labor Code of an establishment or business.

1.2. What is worker health and safety ?

The study of worker health and safety is a very broad discipline that covers many specialized areas. In its most general sense, it must aim to:

- Promote and maintain the highest possible degree of physical, mental and social well-being of workers in all occupations
- Prevent adverse effects on the health of workers due to their working conditions;
- Protect workers against dangers that threaten their health;
- Place and maintain workers in a work environment adapted to their physical and mental needs; Adapt work to men.

In other words, worker health and safety addresses all aspects of workers' social, psychological and physical well-being.

2- History of electrical risk

Accidents linked to natural electricity have been observed since Antiquity. Lightning is the best known form and also the most dangerous. Certain animals can also produce electricity: this is the case of the gym note, a bony fish equipped with two electrical devices, which produces discharges sufficient to paralyze the fish on which it feeds.

• In 1650, the invention of various electrostatic machines gave rise to the first accidents linked to electricity produced by man.

• In 1774, an electric shock applied to a young man in an apparent state of death was followed by a resumption of spontaneous ventilation. Discoveries followed quickly during the 19th century, laying the foundations of knowledge. current information about electricity.

• In 1879, the first fatal occupational accident due to electrification with an alternating current of 250 volts (V) occurred among a theater stagehand inLyon.

• In 1890 the first execution by electric chair took place. D'Arsonval, then Prevost and Batelli studied at the end of the 19th century the physiological effects of electric current and the cause of deaths by electrification. Electrical accidents (AE) increased with the development of domestic and industrial use of electricity in the 20thcentury

3.statistics on electrical accidents

The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. For example, 1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death. The amount of internal current a person can withstand and still be able to control the muscles of the arm and hand can be less than 10 milliamperes (milliamps or mA). Currents above 10 mA can paralyze or “freeze” muscles. When this “freezing” happens, a person is no longer able to release a tool, wire, or other object. In fact, the electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, handheld tools that give a shock can be very dangerous. If you can’t let go of the tool, current continues through your body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). You stop breathing for a period of time. People have stopped breathing when shocked with currents from voltages as low as 49 volts. Usually, it takes about 30 mA of current to cause respiratory paralysis. Currents greater than 75 mA cause ventricular fibrillation (very rapid, ineffective heartbeat). This condition will cause death within a few minutes unless a special device called a defibrillator is used to save the victim. Heart paralysis occurs at 4 amps, which means the heart does not pump at all. Tissue is burned with currents greater than 5 amps.2

The table shows what usually happens for a range of currents (lasting one second) at typical household voltages. Longer exposure times increase the danger to the shock victim. For example, a current of 100 mA applied for 3 seconds is as dangerous as a current of 900 mA applied for a fraction of a second (0.03 seconds). The muscle structure of the person also makes a difference. People with less muscle tissue are typically affected at lower current levels. Even low voltages can be extremely dangerous because the degree of injury depends not only on the amount of current but also on the length of time the body is in contact with the circuit.

3.1 Electrical accident in Algeria

The risks linked to its misuse are therefore poorly perceived, which unfortunately results in numerous more or less serious accidents among people.

whether or not they are aware of these dangers. Victims of electric current aredefined by the so-called “4 I” rule:

- Incompetence,
- Ignorance,
- Irresponsibility
- Imprudence.

Statistics of electrical accidents in Algeria, estimated per year: In the professional environment

- 10 Electrocutions
- 60 Very serious electric shocks

In a domestic environment

- 200 Electrocutions
- 180 Very serious electric shocks

The number of fatal accidents relating to gas, declared by operators, fell significantly in 2010 compared to 2009, unlike accidents of electrical origin where the trend was upwards.

Most of the accidents, he said, were recorded in the building and public works(BTP) and electricity and gas sectors, as workers failed to respect safety measures N(combination safety equipment, gloves, noise-canceling helmet). The average age of workers most exposed to work accidents is less than 34 years old with a rate greater than 34%, followed by the category of workers with no experience in the field (27%).

4.Domestic accidents

year in Algeria, several deaths due to the improper use of electricity or gas are recorded. The causes are careless behavior, dilapidated installations and lack of maintenance of devices. For electricity:

• Intervention on interior electrical installations

• Work near the electricity network

The situation remains worrying given the number of accidents and victims recorded each year (Fig.I.2)

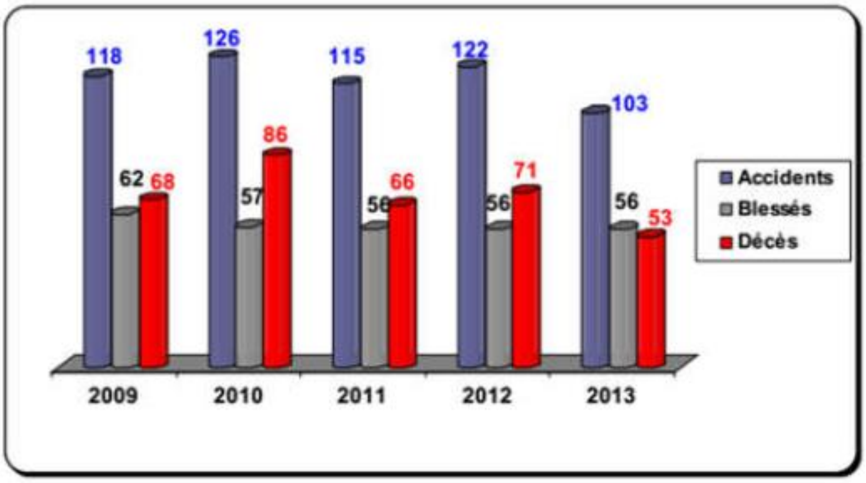


Fig.I.2 Statistics of electrical accidents in Algeria

Most recurring causes (Consequences Electrocution/Electrification):

• Work near the electrical network (direct or indirect contact with live electrical lines / Construction near electrical lines)

• DIY on indoor electrical installations (meters, fraud, etc.)

• Climbing electric supports (especially children)

• Contact with bare or fallen conductors

• Access to electrical stations for flights

Fig.2. Electrical accident

Electrical accidents are more common than you might think. For various reasons, each year in France we deplore several thousand personal injury accidents, including 200 fatalities on average and more than 20,000 fires. There are more than 1,000 accidents of electrical origin in the world of work, around twenty of which are fatal. In a domestic environment, these figures must be widely multiplied by 4 or 5.

The natural phenomenon of lightning also has something to do with it; it causes a lot of damage every year and kills many people. Lightning strikes an average of 30times per second worldwide. Workplace and domestic accidents reinforce these figures. Even if the number of employees is increasing, occupational accidents of electrical origin are decreasing from year to year (by 72% from 1962 to 1993).And if there is one area where rigor and caution are required, it is that of electrical installation, because although work accidents of electrical origin represented only0.14% of the total number of work accidents (in 1995), they still represent 1.7% off at al accidents. This means that the (reported) accident of electrical origin, even rare, often turns out to be very serious.

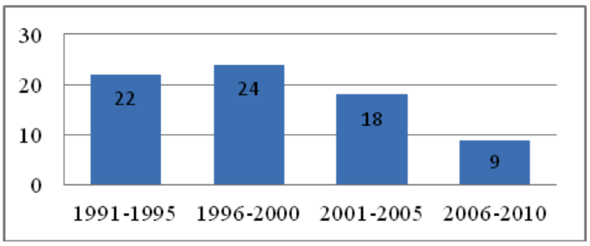


Figure 3: Evolution of electrical accidents from 1991-2010

Figure 4: The severity triangle

The analysis of work accidents of electrical origin produced by INRS is:

The location of the injuries due to the electrical accident is illustrated in the graph below.

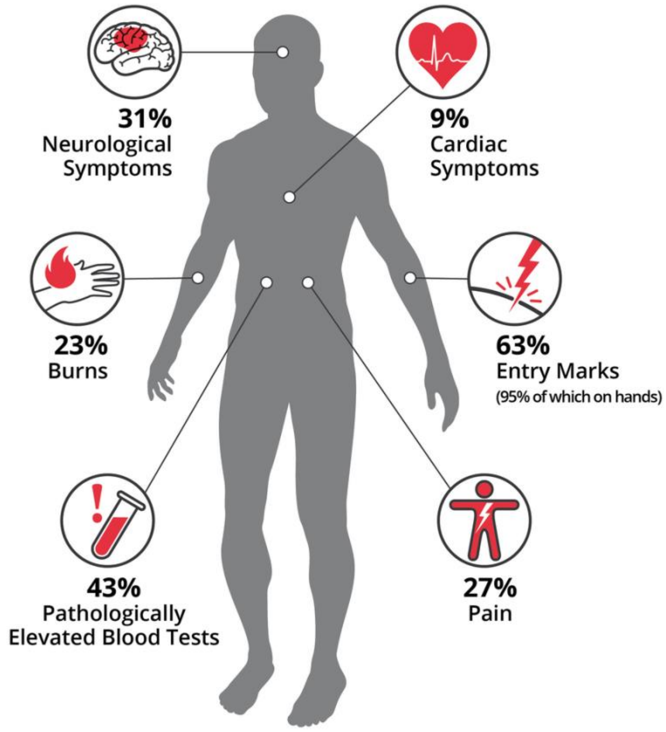


Figure 5: Location of lesions due to the electrical accident

4- Standardization body

The regulatory texts relating to the labor code are drawn up from decrees issued by the responsible minister in order to ensure the hygiene and protection of workers. Legislative texts respond to a hierarchy:

The Law: It is voted by the national assembly, it defines objectives to be achieved.

The Decree: It comes from a law signed by the government minister concerned, it specifies the goals to be achieved.

The decree: It is signed by the government minister concerned, it specifies the means.

The Circular: It is issued by the technical or administrative services of the ministries, and intended for civil servants, it analyzes the texts and determines a line of action.

The Technical Note: It is issued by the technical services of the ministries, and intended for civil servants, it gives a technical interpretation of a particular point.

4.1 Standardization

There are several levels of standardization for electricity(international, continental or national) represented by approved organizations which develop various types of documents, in particular STANDARDS. The publications issued are recommendations aimed at international harmonization of the standards in force in the different countries concerned.

The main standardization organizations are:

* **The IEC** which is the International Electrotechnical Commission (IEC standards, etc.). * CENELEC which is the European Committee for Electrotechnical Standardization (EN standards...)

AFNOR which is the French Standardization Association (NFstandards, etc.) UTE, which is the Technical Union of Electricity, an office associated with AFNOR (UTE standards, etc.).

Fig.6 European standard

Alongside which we can find:

* The CEF which is the French Electrotechnical Committee.

***** The EEC which is the International Regulatory Commission for the approval of electrical equipment**.**

* The CECC which is the Specialized Committee for electrical components. The standards developed by these organizations are classified into four categories:

* The approved standard: it must be applied to contracts awarded by the state ,public establishments and services. It is the subject of an order from the Minister of Industry published in the official journal.

The registered standard: it has an established technical value but not approved.

The experimental standard: it is put to the test before transforming it into a registered or approved standard.

Documentation Booklets: they include practical guides and prescriptions ,and are not subject to any official procedure.

The electricity STANDARDS which fall into class C, are collections of rules, requirements and methods intended for manufacturers of electrical equipment, professional electricians, or non-electricians exposed to electrical risks. The French standard marked "NFC..." or "UTEC..." is divided into two large families of standards which aim on the one hand at the construction of electrical equipment and on the other hand at the construction of electrical installations, and of which the main standards are:

French NFC standards for implementation: NF C 15 100- low voltage electrical installations. NFC 42020 (or IEC1010 or EN61010) - measuring devices. NF C 13 100 - delivery stations.

NF C 14 100 - low voltage connection installations. French NFC design standards:

NF C 15 100 and NF EN 60-529 - classification of degrees of protection. NF C 20 030 - protection against electric shock.

NF C 71 008 - portable lamps. The French master standard of the UTE is the UTE C 15-100 which covers the standards for the construction and design of electrical installations, and which calls on other standards, among others, the following standards:

UTE C 15-211- Medical premises UTE C15-107 - Prefabricated pipelines UTE C15-411 - Alarms

UTE C 15-531 - TT surge arresters UTE C15-103 - External influences UTE C 15-476 - Sectioning and control UTE C 15-106 - PE section

UTE C 15-105 - Practical guide UTE C15-520 - Pipes: installation method

UTE C 15-801 - Electrical installations in furniture UTE C 15-150 - Discharge lamps

UTE C 15-421 - Frequencies 100 to400 Hz UTE C 15-201 - Large kitchens

UTE C 15-401 - Thermal groups UTEC 15-103 - Protection index

The “NFC...”, “UTEC...”, “CEI...” or “EN” conformity mark engraved on the devices certifies that the equipment has been tested in an approved laboratory. and complies with safety standards.

5. Electrical authorization

5.1 Definition:

Authorization is recognition by an employer of a person's ability to safely carry out the assigned tasks. To be authorized, staff must have acquired training:

- the prevention of electrical risks,
- personal safety.

5.1.1 Scope of use:

Authorization is necessary in particular for:

- Access premises reserved for electricians without supervision,
- Carry out electrical work or interventions,
- Direct electrical work or interventions,
- Carry out electrical instructions,
- Carry out electrical tests, measurements or checks,
- Perform the function of security supervisor.

5.2. Authorization conditions

The employer must ensure that the people to be authorized have sufficient knowledge of:

• Prevention of electrical risks,

• The necessary instructions to enable him to ensure his own safety and that of personnel who may be placed under his orders,

• What to do in the event of an accident,

• Preventive measures with respect to other risks linked to the company's activity and environment.

It must also ensure that these people:

• Have the skills necessary to carry out the tasks covered by the authorization,

• Exhibit behavior compatible with the proper execution of these operations.

5.3. The qualification title

The authorization title is awarded by the employer only to people in his company who have the required security knowledge and have the skills and behavior necessary to carry out the requested operations.

The issuance of an authorization by the employer does not necessarily release the latter's responsibility.

5.3.1 Objectives:

• Learn practical tools and methods allowing:

• Electrical risk assessment

• Improving staff safety against electrical risks

• Carry out simple safety interventions on low voltage electrical installations

• Learn the effects of an electrical fault on the human body

• Learn methods to improve electrical safety

5.3.2 Symbols

	DOMAINES DE TENSION	OPÉRATIONS D'ORDRE NON ÉLECTRIQUE	TRAVAUX D'ORDRE ÉLECTRIQUE		AUTRES OPÉRATIONS				
			Exécutant	Chargé de travaux	Chargé de consignation	Chargé d'intervention BT	Chargé d'intervention d'opération spécifique	Chargé d'opérations élémentaires chaîne PV	Spéciales
Hors tension	BT	B0	B1	B2	BC	BR, BS	BE		B1X, B2X
	HT	H0	H1	H2	HC		HE		H1X H2X
Voisinage simple	BT	B0	B1	B2	BC	BR, BS	BE	BP	B1X, B2X
	HT	H0	H1	H2	HC		HE		H1X H2X
Voisinage renforcé	BT		B1V	B2V	BC	BR	BE	BP	B1X, B2X
	HT	H0V	H1V	H2V	HC		HE		H1X H2X
Sous tension	BT		B1T, B1N	B2T, B2N					
	HT		H1T, H1N	H2T, H2N					

Table 1 Empowerment symbol

The first letter indicates the voltage range of the electrical works• B: work in the Low Voltage domain • H: work in the High Voltage domain

The second letter specifies the nature of the operations • C: the holder can carryout lockouts, • T: the holder can work under voltage • N: the holder can carry out cleaning work under voltage, • R: the holder can carry out trouble shooting interventions for connections, measurements, tests, verifications.

V: the holder can work near installations in the indicated area. The numerical index indicates:

• 0: Personnel carrying out exclusively non-electrical work and/or permitted maneuvers,

• 1: Personnel carrying out electrical work and/or maneuvers,

• 2: Personnel responsible for electrical work.

5.3.3 Authorization title (example)

Figure 5: Example of authorization title

Electrical accreditation is essential and essential in the field of electricity. It is recognition by an employer of a person's ability to perform the tasks set incomplete safety.

Chapter 2: Nature of electrical accidents and dangers of electric current

2.Danger of electric current

2.1.Why is electric current dangerous?

Electric current is dangerous because it constitutes a relatively frequent cause of work accidents in the field of electrical engineering which, moreover, results in a significant severity factor. These accidents appear due to exposure, more or less prolonged, to the risk of electrical origin which finds its source in the notion of proximity to one or more bare parts under voltage. Accidental contact of body parts with these live conductors can cause electrical shocks which can be fatal. The danger is constituted by the intensity of the current which passes through the human body when it is subjected to an electrical voltage.

Electrical accidents can also result from the flashing of an electric arc. This current is called “contact current”.

Electric current is dangerous from 10 mA. This comes from the fact that the frequency used (50Hz) causes violent muscular excitations which can lead to tetanization.

Contact with bare live parts can be direct or indirect, which involves more or less serious damage and effects on the human body. The effects of the electric current depend on the parameters acting as aggravating factors and depend on the path of the electric current in the human body. Some organs suffer more severely from electric shocks than others. The brain, lungs, heart, liver and kidneys are 40 times less resistant than the skin.

2.2 Electric current danger thresholds

The current acts on the body in three different ways:

By blocking the muscles or “tetanization”, whether those of the limbs or the rib cage.

By burns: depending on the value of the current, electricity produces more or less serious tissue damage through its thermal effects.

By action on the heart: electricity causes a complete disorganization of the functioning of the heart, known as “ventricular fibrillation”.

The effect caused by the electric current on the human body depends mainly on its intensity and other parameters linked to the human body (resistance, contact surface, etc.) and its environment (humidity) during the electrical accident .

The threshold for perception of electric current varies greatly from one person to another, 0.5 mA can be considered as an average value.

~1mA / Excitation of sensitive nerve endings

-Stinging or mild shock sensation

>3 mA / Feeling of pain

The tetanization threshold corresponds to muscle contractions which starts from 10 mA. This value depends on age, sex, state of health, level of attention, etc. Tetanization has the effect of preventing the person from letting go of the driver, which can lead to more serious consequences. serious depending on the duration of the current flow. As a result, the body's resistance weakens and the intensity of the current increases accordingly, which can cause the situation to evolve towards tetanization of the respiratory muscles, hence difficulties and respiratory arrest due to ventilatory asphyxia which occurs. for currents of 20 to30 mA.

~10mA

Contraction of the muscles passed through by the current

Unable to let go (forearm flexors)

Projection (extenders)

~25 mA

Tetanization of the respiratory muscles

More than 3 minutes = ventilatory asphyxia

The threshold for ventricular fibrillation occurs from 75 mA

~75 mA / Ventricular fibrillation

Leads to electrocution unless defibrillated (and kept alive until then)

Burn Thresholds starts at 100 mA

~100 mA (danger)

- Joule effect: $E_{thermal} = RI^2 t$
- Skin destruction
- Deep tissue destruction: muscles, nerves, blood vessels and viscera

- Amputation
- Combustion waste can lead to fatal kidney failure
- The threshold for cardiac arrest is around 1 A.

~1 A (danger)

Heart failure

The threshold for inhibition of the nerve centers is at 2 A.

~2 A (danger)

- Inhibition of nerve centers
- Other risks and damages may be suffered by the human body.

Thus, a short circuit can in particular cause:

- burns by projection of molten material

- intense ultraviolet radiation

- a release of toxic gas

- a fire, an explosion

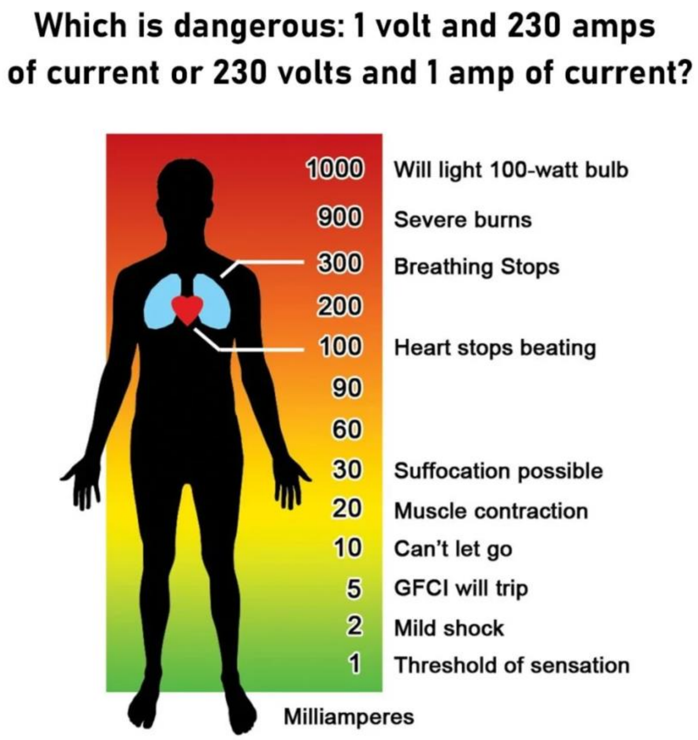


Figure II.1: Danger thresholds for alternating electric current

The danger thresholds for direct current are slightly shifted compared to alternating current and for others undetermined. Although the risk of cardiac fibrillation is 3.75 times smaller, burns are more

deep. The moments of switching on and switching off the power are the most dangerous. In addition, the passage of direct current in the human body causes a phenomenon of electrolysis.

2.3 Effect of the action of electric current on humans

Depending on the direct and indirect action of the electric current, the nature of contact (direct or indirect) and the field of activity in which the accident occurs(domestic environment, work, leisure, etc.),

The effects of the action of electric current on man are either immediate or secondary.

2.3.1 Immediate effects

2.3.1.1 Excito-motor effects

They only come from a variation in current, causing the muscles and nerves to be excited;

II.3.1.1 Electrical shock:

Result of muscle contraction caused by a single and brief excitation, produced following the application of a current (direct or alternating 50Hz)to a muscle. This can lead to secondary dangers such as the reflex to drop a tool or grab something which could represent a danger to the victim.

2.3.1.1.2 Muscle contraction:

If we rhythmically interrupt the passage of direct current in a muscle, we observe a series of successive jerks which become closer together when the frequency of the interruptions increases.

When the muscle no longer has time to relax (for example with 50 Hz current),it is the phenomenon of contracture.

Depending on whether the current path involves the flexors (forearm) or extensors (arms), we will have different consequences.

2.3.1.1.3 Tetanization of the respiratory muscles:

Tetanization can only be observed when the path of the current affects the respiratory muscles(intercostals, pectorals and diaphragm).

The flowchart in Figure II.3 schematizes the effects of tetanization of there spiratory muscles.

Can be observed when the current path passes through the heart muscle. It is a disorganization of the perfect synchronization of contractions of the muscle fibers(myocardium) which ensures the functioning of the heart.

In ventricular fibrillation, each fiber contracts on its own account, which results in total inefficiency, therefore the equivalent of circulatory arrest and anoxic lesions downstream, more particularly at the level of the brain (extremely sensitive to lack oxygen). Irreversible damage appears if the duration of anoxia (decrease or suppression of oxygen in the blood) reaches or exceeds approximately 3 minutes. The flowchart in Figure II.4 schematizes the effects of ventricular fibrillation.

II.3.1.2 Inhibition of nerve centers:

Can only take place if a very strong current passes through the medulla oblongata, which is very rare.

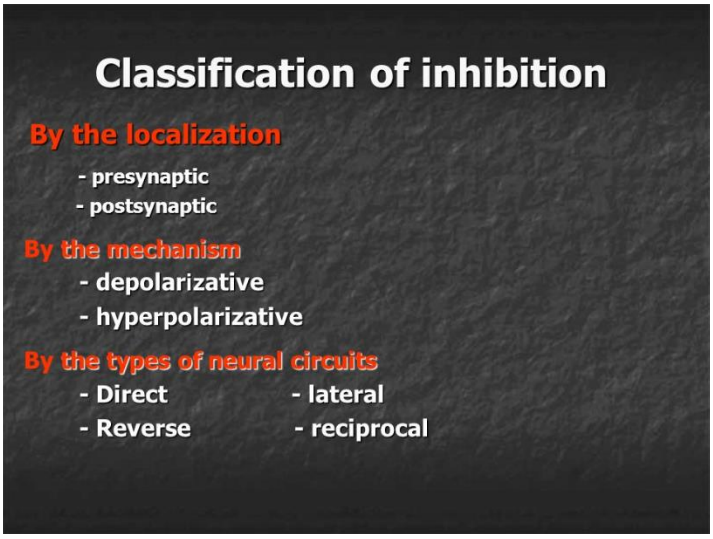


Fig.2.3. Classification of inhibition

2.3.1. 3 Thermal effects

2.3.1. 3.1 Electrothermal burns:

Are caused by the energy dissipated by the Joule effect along the current path.

These burns lead to internal necrosis (death of a cell or mortification) located more particularly at the level of the muscles, thus resulting in blockage of the kidneys which are unable to eliminate the large quantities of my oglobin and hemoglobin(pigment of red blood cells ensuring the transfer of oxygen and CO2 between there spiratory system and the cells of the body) which invade them after leaving the affected muscles.

2.3.1.3.2 Arc burns:

Are thermal burns due to the intense heat released by the Joule effect during the production of the electric arc. They are superficial (cutaneous) located on exposed parts (face, hands).

2.4. Influential parameters on the effects of electric current

Different factors influence the sensitivity and effects of the passage of electric current in the human body. These are the characteristics specific to the individual, the nature and duration of the passage of current and the contact conditions that can be specified as follows

- the intensity of the current,
- human body impedance,
- the current voltage,

- the frequency of the current,
- contact time,
- the path of the contact.
- Added to this:
- the age of the person,
- its weight
- his sex,
- their personal physiological characteristics

According to Dr. FOLLIOT, the quantity of energy passing through the body is reflected by the equation (I.1) of the electrical risk:

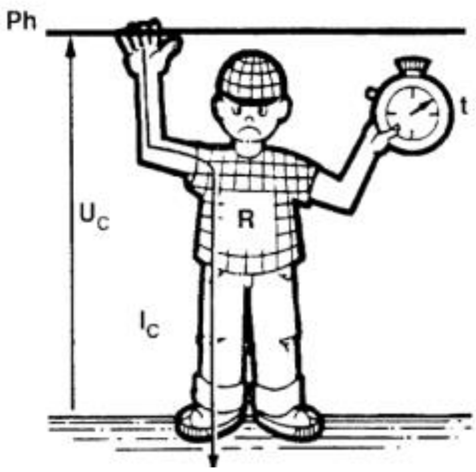


Figure I. 3: Illustration of the four parameters directly influencing the level of risks

The results of experiments from researchers around the world have enabled the International Electrotechnical Commission (IEC) to establish curves specifying, a function of time, the zones corresponding to the different physio pathological effects resulting from the passage of current and, in particular, indicating dangerous current thresholds. The curves below, taken from the IEC 479 standard, illustrate the relationship t=f(Ic) and determine four zones.

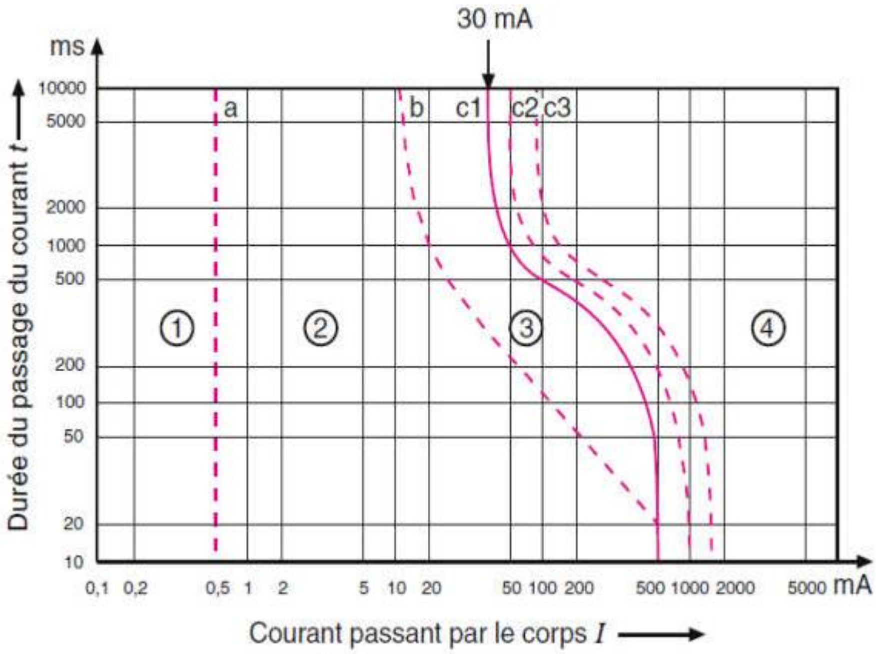


Figure II.4: Curves, taken from the IEC 479 standard, illustrating the relationship t=f(Ic)

Zone 1: The shock current is below the perception threshold (Ic < 0.5 mA). There is no perception of the passage of current in the body: no risk.

Zone 2: The current is perceived without reaction from the person: usually, no dangerous physiological effects.

Zone 3: The current causes a reaction: the person can no longer release the faulty device. The power must be cut off by a third party in order to put the person out of danger: usually without organic damage, but probability of muscular contractions and breathing difficulties.

Zone 4: In addition to the effects of zone 3, ventricular fibrillation increases by 5%of cases for curve C2, 50% of cases for curve C3, and more than 50% beyond this last curve, where significant pathophysiological effects such as heart failure, cessation of breathing, severe burns.

2.4.1 Resistance of the human body

The body's resistance is not a constant; it varies, for the same individual, depending on physical and biophysical factors, while distinguishing between the resistance of the body itself and skin resistance. Figure II5 is a model of the resistance of the human body.

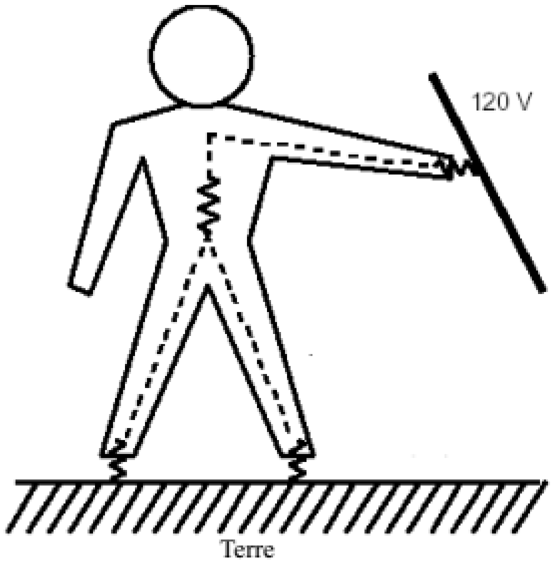


Figure II.5: Modeling the resistance of the human body

The body's own resistance varies depending on the distance of the two points of contact. It is approximately:

* 750 Ω for hand-foot contact,

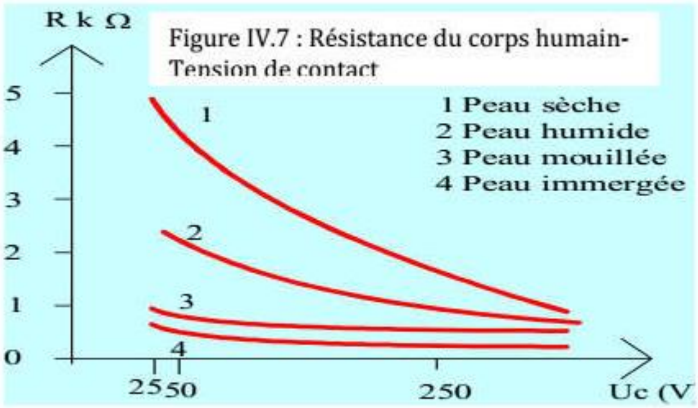
500 Ω for hand-to-hand contact.

The body's own resistance decreases as the two points of contact become closer. I ttends to become negligible compared to the resistance of the skin which then intervenes alone when the two points are very close.

- Coetaneous resistance (skin resistance) is a function of several factors. It depends on:
- the state of coating of the contact surface,
- the contact surface,
- contact pressure,
- the state of hydration,
- contact duration
- the contact voltage of the current.

There resistance skin increase with the thickness of their layer cornea and decreases with contact surface, pressure, hydration, duration and tension. The resistance of the human body varies depending on whether the skin is dry or humid, wet or submerged. The minimum resistance value of the human body is 325 Ω when the body is submerged, for example in bathrooms or swimming pools.

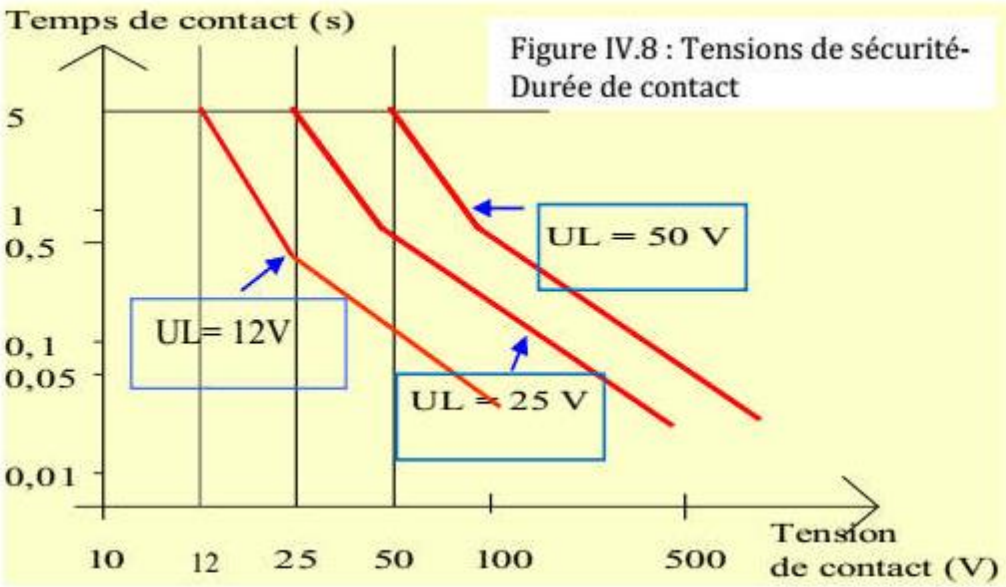
Figure (II.6) gives the curves giving the relationship R = f(Uc) between the resistance of the human body and the contact voltage. The personal safety rules imposed by the NFC 15-100 standard are established from the three relationships t = f(Ic), t = f(Uc) and R = f(Uc).



2.1.3 Current voltage When the voltage rises, the protective power of the skin decreases. The skin behaves like a dielectric envelope from 1500 V and the body's resistance is reduced to 500Ω. This aggravates the genesis of electrothermal burns due to the increase in the amount of heat released with increasing voltage.

For environmental conditions relating to humidity and the nature of the current, limit voltages not to be exceeded at maximum times bearable by the human body are defined;

Figure (II.7) summarizes the safety rules that are taken depending on the alternating voltage to be supported in a given case; the curves in this figure illustrate the relationship t = f(Uc).



These curves make it possible to define, depending on the humidity condition, the conventional U_L limit voltages which can be maintained without danger on people, in other words, a contact voltage U_c lower than U_L does not require cutting, but on the other hand any voltage contact greater than UL requires the elimination of the fault in a time at most equal to that fixed by the corresponding curve.

2.1.5 Contact time

Increasing the contact time weakens the resistance of the human body, which, as a result, gradually increases the intensity of the current, and thereby increases the consequences.

Ventricular fibrillation varies as a function of $\sqrt{t}$ (according to the Dalziel relation), then

that the burn depends on the quantity of heat released in the body, which is directly proportional to the contact time t.

2. 6 Path of the current in the body

The path of the current in the body decides the consequences of this passage for the affected organs. Ventricular fibrillation is triggered as soon as the current lines of force pass through the heart. Sensory disorders, mainly ocular and auditory, are observed when the path of current in the body affects the head. It is the same for the phenomena of nervous inhibition which only occur when the path of the current interests the nervous centers .

Chapter 3: Protective measures

3. Protection of people

What Must Be Done to Be Safe?

Use the three-stage ***safety model***: recognize, evaluate, and control hazards. To be safe, you must think about your job and plan for hazards. To avoid injury or death, you must understand and recognize hazards. You need to evaluate the situation you are in and assess your risks. You need to control hazards by creating a safe work environment, by using safe work practices, and by reporting hazards to a supervisor or teacher. If you do not recognize, evaluate, and control hazards, you may be injured or killed by the electricity itself, electrical fires, or falls. If you use the safety model to recognize, evaluate, and control hazards,you are much safer.

Report hazards to your supervisor or teacher.

3.1 Recognize hazards

The first part of the safety model is recognizing the hazards around you. Only then can you avoid or control the hazards. It is best to discuss and plan hazard recognition tasks with your co-workers. Sometimes we take risks ourselves, but when we are responsible for others, we are more careful. Sometimes others see hazards that we overlook. Of course, it is possible to be talked out of our concerns

by someone who is reckless or dangerous. Don’t take a chance. Careful planning of safety procedures reduces the risk of injury. Decisions to lock out and tag out circuits and equipment need to be made during this part of the safety model. Plans for action must be made now.

OSHA regulations, the NEC, and the National

Electrical Safety Code (NESC) provide a wide range of safety information. Although these sources may be difficult to read and understand at first, with practice they can become very useful tools to help you recognize unsafe conditions and practices. Knowledge of OSHA standards is an important part of training for electrical apprentices.

Always lock out and tag out circuits.

3.2. Evaluate hazards

When evaluating hazards, it is best to identify all possible hazards first, then evaluate the risk of injury from each hazard. Do not assume the risk is low until you evaluate the hazard. It is dangerous to overlook hazards. Job sites are especially dangerous because they are always changing. Many people are working at different tasks. Job sites are frequently exposed to bad weather. A reasonable place to work on a bright, sunny day might be very hazardous in the rain. The risks in your work environment need to be evaluated all the time. Then, whatever hazards are present need to be controlled.

3.3. Control hazards

Once electrical hazards have been recognized and evaluated, they must be controlled. You control electrical hazards in two main ways:

(1) create a safe work environment and

(2) use safe work practices. Controlling electrical hazards (as well as other hazards) reduces the risk of injury or death.

Use the safety model to recognize, evaluate, and control workplace hazards like those in this picture.

Safety Model Stage 1—

Recognizing Hazards

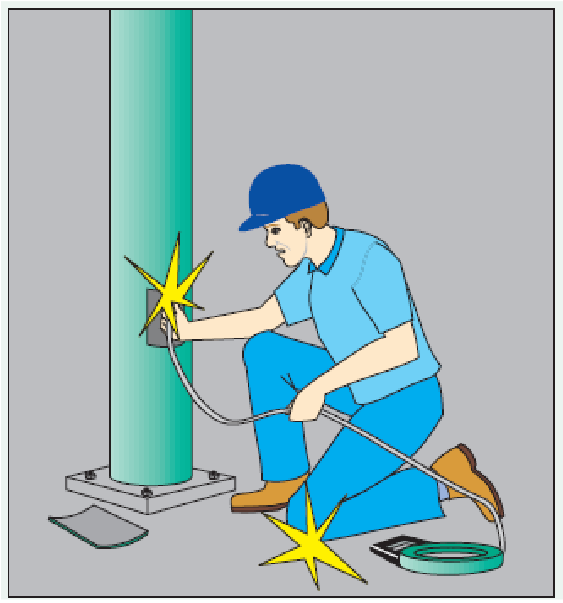
How Do You Recognize Hazards?

The first step toward protecting yourself is recognizing the many hazards you face on the job. To do this, you must know which situations can place you in danger. Knowing where to look helps you to recognize hazards.

- Inadequate wiring is dangerous.
- Exposed electrical parts are dangerous.
- Overhead powerlines are dangerous.
- Wires with bad insulation can give you a shock.
- Electrical systems and tools that are not grounded or double-insulated

  are dangerous.
- Overloaded circuits are dangerous.
- Damaged power tools and equipment are electrical hazards.

- Using the wrong PPE is dangerous.
- Using the wrong tool is dangerous.
- Some on-site chemicals are harmful.
- Defective ladders and scaffolding are dangerous.
- Ladders that conduct electricity are dangerous.
- Electrical hazards can be made worse if the worker, location, or equipment is wet.



Worker was electrocuted while removing energized fish tape.

3. 2. Principles

The different protections that may be implemented meet the following requirements:

- prevent contact with a live part;
- make this contact non-dangerous.

The live parts referred to are:

conductive parts intended to be normally under voltage (conductors, terminals, etc.), called active parts;

the conductive parts of electrical equipment not normally under voltage, but likely to become so in the event of an insulation fault for example, and called masses.

Contacts can be of two types:

- with bare active parts: direct contacts;
- with masses energized following an insulation fault: indirect contacts.

For dangerous contact to occur and for a current to flow through the body, it must be subjected to a potential difference. This can be:

- either simultaneous contact with conductors with different potentials;
- or simultaneous contact between a live conductor or a faulty mass and the earth potential (ground or conductive element at the earth potential or at a neighboring potential).

III.3. Direct contact

It is the physical contact of a person with one (or more) bare active conductor under tension. Direct contact is established when the body is subjected to a potential difference:

- Between two phases;
- Between a phase and the earth or a metallic mass;
- Between neutral and earth or a metallic mass.
- The most exposed parts are the hands, head, ankles, or legs...

III.4. Indirect contact

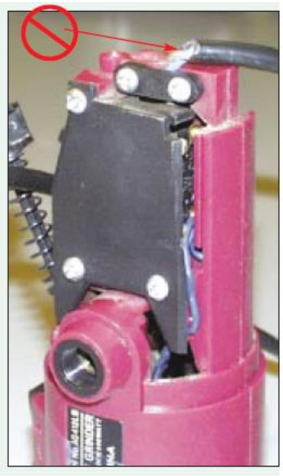
It is the physical contact of a person with a metal mass accidentally brought to a dangerous potential. Indirect contact is particularly sneaky, because there is nothing to predict the presence of voltage on a metal part normally de-energized.

Inadequate wiring hazards

An electrical hazard exists when the wire is too small a gauge for the current it will carry. Normally, the circuit breaker in a circuit is matched to the wire size. However, in older wiring, branch lines to permanent ceiling light fixtures could be wired with a smaller gauge than the supply cable. Let’s say a light fixture is replaced with another device that uses more current. The current capacity (ampacity) of the branch wire could be exceeded. When a wire is too small for the current it is supposed to carry, the wire will heat up. The heated wire could cause a fire.

When you use an extension cord, the size of the wire you are placing into the circuit may be too small for the equipment. The circuit breaker could be the right size for the circuit but not right for the smaller-gauge extension cord. A tool plugged into the extension cord may use more current than the cord can handle without tripping the circuit breaker. The wire will overheat and could cause a fire. The kind of metal used as a conductor can cause an electrical hazard. Special care needs to be taken with aluminum wire. Since it is more brittle than copper, aluminum wire can crack and break more easily.

Connections with aluminum wire can become loose and oxidize if not made properly, creating heat or arcing. *You need to recognize that inadequate wiring is a hazard*.



This hand-held sander has exposed wires and should not be used.

Exposed electrical parts hazards

Electrical hazards exist when wires or other electrical parts are exposed. Wires and parts can be exposed if a cover is removed from a wiring or breaker box. The overhead wires coming into a home may be exposed. Electrical terminals in motors, appliances, and electronic equipment may be exposed. Older equipment may have exposed electrical parts. If you contact exposed live electrical parts, you will be shocked. ***You need to recognize that an exposed electrical component is a hazard*.**

Overhead powerline hazards

Most people do not realize that overhead powerlines are usually not insulated. More than half of all electrocutions are caused by direct worker contact with energized powerlines. Powerline workers must be especially aware of the dangers of overhead lines. In the past, 80% of all lineman deaths were caused by contacting a live wire with a bare hand. Due to such incidents, all linemen now wear special rubber gloves that protect them up to 34,500 volts. Today, most electrocutions involving overhead powerlines are caused by failure to maintain proper work distances.

Overhead powerlines kill many workers!

Electrical line workers need special training and equipment to work safely.

Shocks and electrocutions occur where physical barriers are not in place to prevent contact with the wires. When dump trucks, cranes, work platforms, or other conductive materials (such as pipes and ladders) contact overhead wires, the equipment operator or other workers can be killed. If you do not maintain required clearance distances from powerlines, you can be shocked and killed. (The minimum distance for voltages up to 50kV is 10 feet. For voltages over 50kV, the minimum distance is 10 feet plus 4 inche for every 10 kV over 50kV.) Never store materials and equipment under or near overhead powerlines. ***You need to recognize that overhead powerlines are a hazard***.

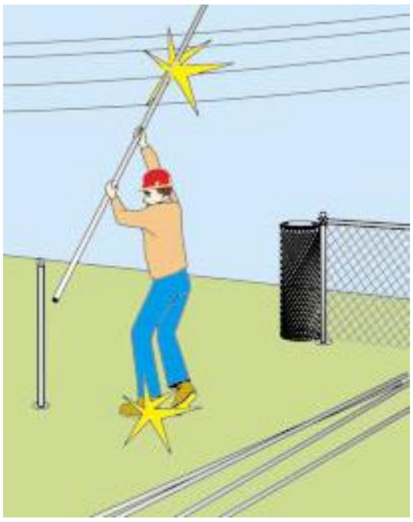
Operating a crane near overhead wires is very hazardous.

five workers were constructing a chain-link fence in front of a house, directly below a 7,200-volt energized powerline. As they prepared to install 21-foot sections of metal top rail on the fence, one of the workers picked up a section of rail and held it up vertically. The rail contacted the 7,200-volt line, and the worker was electrocuted. Following inspection, OSHA determined that the employee who was killed had never received any safety training from his employer and no specific instruction on how to avoid the hazards associated with overhead powerlines. In this case, the company failed to obey these regulations:

• Employers must train their workers to recognize and avoid unsafe conditions on the job.

• Employers must not allow their workers to work near any part of an electrical circuit **UNLESS** the circuit is de-energized (shut off) and grounded, or guarded in such a way that it cannot be contacted.

• Ground-fault protection must be provided at construction sites to guard against electrical shock.



insulation—material that does not conduct electricity easily

Defective insulation hazards

Insulation that is defective or inadequate is an electrical hazard. Usually, a plastic or rubber covering insulates wires. Insulation prevents conductors from coming in contact with each other. Insulation also prevents conductors from coming in contact with people.

Extension cords may have damaged insulation. Sometimes the insulation inside an electrical tool or appliance is damaged. When insulation is damaged, exposed metal parts may become energized if a live wire inside touches them. Electric hand tools that are old, damaged, or misused may have damaged insulation inside. If you touch damaged power tools or other equipment, you will receive a shock. You are more likely to receive a shock if the tool is not grounded or double insulated. (Double-insulated tools have two insulation barriers and no exposed metal parts.) ***You need to recognize that defective insulation is a hazard***.

This extension cord is damaged and should not be used.

Improper grounding hazards

When an electrical system is not grounded properly, a hazard exists. The most common OSHA electrical violation is improper grounding of equipment and circuitry. The metal parts of an electrical wiring system that we touch (switch plates, ceiling light fixtures, conduit, etc.) should be grounded and at 0 volts. If the system is not grounded properly, these parts may become energized. Metal parts of motors, appliances, or electronics that are plugged into improperly grounde circuits may be energized. When a circuit is not grounded properly, a hazard exists because unwanted voltage cannot be safely eliminated. If there is no safe path to ground for fault currents, exposed metal parts in damaged appliances can become energized. Extension cords may not provide a continuous path to ground because of a broken ground wire or plug. If you contact a defective

III. 5 Contactless electrification

An electric arc can be initiated when approaching a high voltage conductor (THline) and a grounded conductive element (earthed foot). Figure (V.1) summarizes the five ways to get electrified.

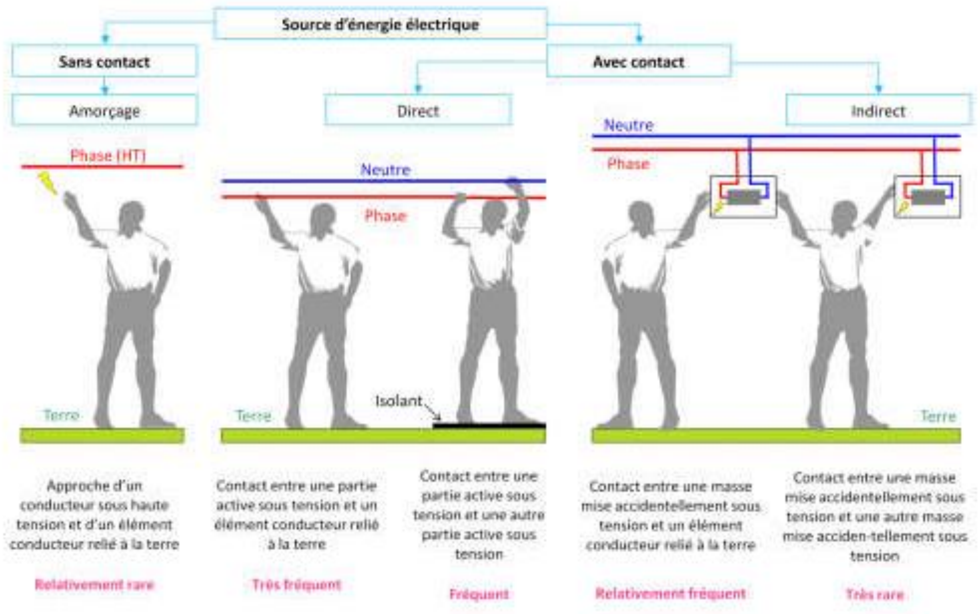


Figure III.1: The five ways to get electrified

V.6. Protection against direct contact

Protection against direct contact is ensured by placing live conductive parts out of reach:

1. Distance from bare conductors (overhead lines);

2. Conductor insulation;

3. Use of cabinet, cabinet and enclosure;

4. Installation of obstacles (mesh, insulating plate, insulating sheet, etc.);

5. Use of very low voltage;

6. Use a high sensitivity DDR residual current device (In≤ 30 mA)

III.7.Protection against indirect contact

Protection against indirect contact is ensured by:

Automatic cut-off: automatic opening of the protection device placed upstream of the ground fault. This automatic opening is ensured by the Residual Differential Device(RDD) associated with the circuit breaker. This protection requires permanent monitoring of leakage currents in the metal masses and the earthing of the masses and device.

automatic power cutoff (DDR). The earthing of the metal masses is ensured by one or more earth connections;

1. The use of double insulation or reinforced insulation (class II equipment);

2. The use of very low voltage (TBTS, TBTP, TBTF)

3. Separation of circuits: separation transformer supplying only one device not connected to earth;

4. The equipotential connection between the metal masses, ensured by the protective conductor (green and yellow);

5. By the choice of the degree of protection: We consider that a live part becomes directly accessible when its protection index is lower than IP2xin LV and IP3x in MV.

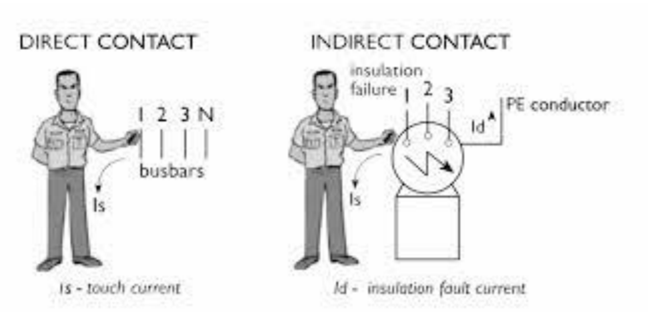


Figure III.6: Protection against indirect contact by automatic cut-off

CLASSE	SYMBOLE	UTILISATION
0	Pas de symbole	Interdite dans l'industrie
I	⏚	Matériel devant être relié obligatoirement à la terre
II	⧈	Matériel à double isolation, *jamais relié à la terre*
III	⟨III⟩	Lampe baladeuse alimentée en TBTS, *non reliée à la terre*

Figure III.7. Protection against indirect contact by using class II equipment

Figure III.8. Protection against indirect contact By choosing the degree of protection

III.7. Insulation classes of electrical appliances

Low voltage equipment is listed, from the point of view of protection against indirect contact, in four classes, the numbering of which does not imply any hierarchy of values (Table III.1). Safety is ensured by two complementary measures (Table III.2).

III.7.1 Class 0 devices

The equipment has main insulation but no earth terminal (1st protection).

Safety is ensured by the floor which must be insulating (2nd protection).

There is no symbol for this class which tends to disappear.

Example: Metal desk lamp powered by a 2-conductor flexible cable with a 2-conductor pin plug.

This material, which does not comply with safety standards, is prohibited in the world of work.

III.7.2 Class I devices

The equipment has an earth terminal and main insulation (1st protection).

The earth terminal is connected to a protective conductor (PE), safety is ensured by a cutting device which will act upon the appearance of the first fault (2nd protection).

This class is represented by the earthing symbol.

Examples: domestic household appliance whose accessible metal parts are connected to a green-yellow protective conductor.

V.7.3 Class II devices

The equipment has no earth terminal with main insulation (1st protection).

Safety is ensured by a second insulation (2nd protection)

The symbol for class II devices is a double interlocking square.

Examples: portable tools.

III.7.4 Class III devices

Protection is provided by the very low voltage supply (< 50 V)

The power transformer has reinforced main insulation without earth connection.

The symbol for Class III devices is a mocked diamond.

Examples: electric train.

The transformer must be a safety transformer complying with standard NF C 52-742; the windings are insulated from each other and safely isolated from the magnetic circuit and the masses.

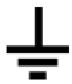
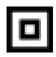
Classes	Caractéristiques	Symboles
0	Isolation fonctionnelle sans mise à la terre	
I	Isolation fonctionnelle avec mise à la terre	
II	Double isolation	
III	TBT	

Table III.1: Classes of low voltage equipment

Stade de protection	Classe de matériel			
	0	I	II	III
premier	Isolation principale	Isolation principale	Isolation principale	Tension inférieure à 50 V
deuxième	Isolation par le sol (local sec et non conducteur)	Mise à la terre et dispositif de coupure associé	Isolation supplémentaire ou renforcée	Alimentation de sécurité

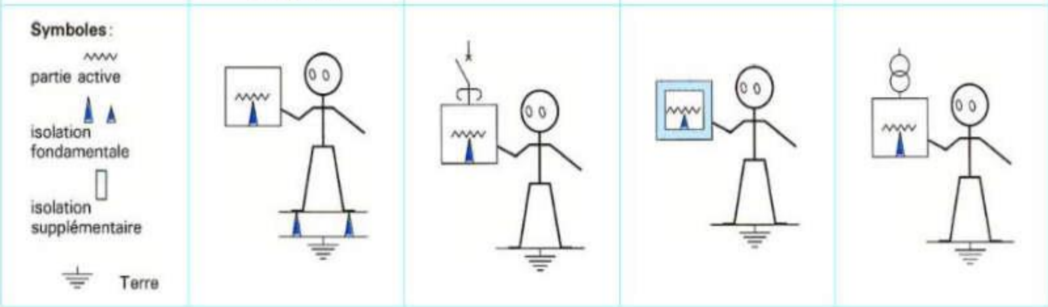


Table III.2: Protection of people against electric shocks

III.8. Protection Indexes

The IP (International Protection) code specifies the degree of protection of equipment for:

- Protection of people against direct contact;
- Protection of materials against certain external influences.

It contains the letters IP followed by two independent numbers (Table III.3):

- The first number characterizes the degree of protection of people against access to dangerous parts and the degree of protection of equipment against the penetration of foreign bodies.
- The second number indicates the degree of protection against the harmful effects of fresh water penetration. The IP code may contain additional letters (A, B, C or D).

IP	1er chiffre	2e chiffre
matériel protégé contre les :		
-	corps solides	corps liquides
0	non protégé	non protégé
1	supérieurs à 50 mm de diamètre	gouttes d'eau verticales
2	supérieurs à 12,5 mm de diamètre	gouttes d'eau à 15° de la verticale
3	supérieurs à 2,5 mm de diamètre	eau en pluie
4	supérieurs à 1 mm de diamètre	projections d'eau
5	poussières sans dépôt nuisible	jets d'eau
6	poussières	paquets de mer
7	-	immersions temporaires
8	-	immersions prolongées

Table III.3: IP code codifying protection against the penetration of solid and liquid bodies.

Example: IP20; material protected against solid bodies greater than 12.5mm, no protection against liquids.

III.9. Electrical work procedures

III.9.1 Introduction

Inadequate behavior of operators and stakeholders during electrical operations are, most of the time, the causes of electrical accidents. To ensure the safety of personnel, it is appropriate to adopt, during electrical operations, a behavior consistent with situations likely to arise, which must begin with:

- information,
- training,
- authorization,
- compliance with procedures adapted to the cases to be treated,

the use of protective tools and specific equipment standardized and approved by the designated organization, a previously carried out analysis of all the risks likely to occurac companied by preventive measures, ensuring protection making the risk impossible or not dangerous.

III.9.2 Organization of work

Publication UTE 18-510 sets out all the necessary, even mandatory, regulations to be respected before starting work, in order to avoid the occurrence of dangerous conditions:

- by forgetting,
- by ignorance,
- by inversion of operations, etc.

It is appropriate to:

- Clearly define the work,
- Carry out a precise study,
- Carry out an analysis of all possible risks,
- Familiarize yourself with the material,

Become familiar with the electrical environment in which the operation will be carried out. Carry out the verification:

Plans and diagrams,

- The conformity of the equipment and its good condition,
- The presence of individual and collective safety devices
- The ability of the work team. III.9.3Electrical work procedures

The execution of electrical tasks must be carried out in accordance with the rules of the work:

- powered off,
- under voltage
- or in the neighborhood,

the rules for using tools and equipment. As a general rule, interventions and work on electrical installations and equipment

In three exceptional cases, these interventions can be carried out under voltage:

1. Turning off the power may endanger people's lives or health.

Ex: switching off the fan motor ensuring the ventilation of confined spaceswhere people are staying.

2. Imperative operating requirements preventing the installation or equipment from being turned off.

Ex: switching off the circulation of fluid ensuring the cooling of a heat treatment oven (safeguarding the equipment).

3. The very nature of the work or interventions requires the presence of tension.

Ex: checking circuits, searching and locating faults, measuring electrical quantities.

III.9.3.1 Work without voltage

Electrical lockout

All work or interventions on a structure in operation carried out without power must be carried out on the basis of a consignment operation; that is to say carry out the following four operations in order:

1- Separating the work from voltage sources (opening a switch, a circuit breaker, a disconnector, etc.). The separation must concern all active conductors.

Figure III.9: Breaking by circuit breaker

2- Locking the separation devices in the open position (sign prohibiting operation, padlock, etc.).

Figure III.10: Lockout by padlock or by sign prohibiting maneuvering

Lockdown by immobilization of the separation device is mandatory in BTB and HT. In other cases, the condemnation can be carried out by signage (sign)

Figure III.11: Locking by signaling

The removal of a conviction is made by the person who made the conviction or by a designated replacement.

3- Identification of the structure deenergized. The aim of this operation is to be certain that the work area is well located on the de-energized structure (study of diagrams, plans, etc.). It must be materialized, on site, by marking, banners, delimiting the recorded area, or by direct and unambiguous vision of possible earthing and short-circuiting;

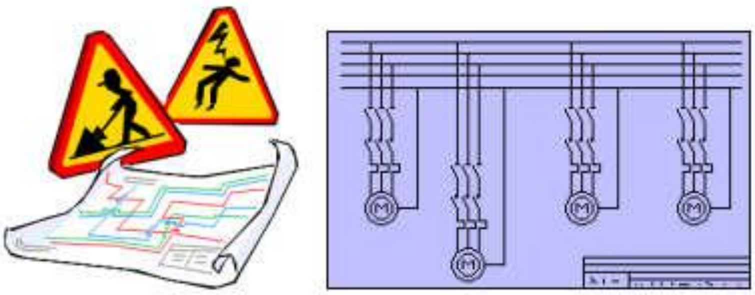


Figure III.12: Identification of the de-energized structure on diagram and plan

4- Verification of the absence of voltage (VAT) then grounding and short circuit(MALT-CCT).

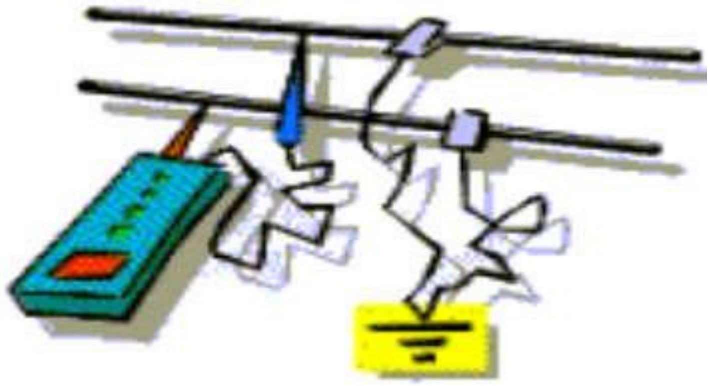


Figure III.13: VAT and MALT-CCT

The proper functioning of a voltage absence tester (VAT) must be checked before and after use.

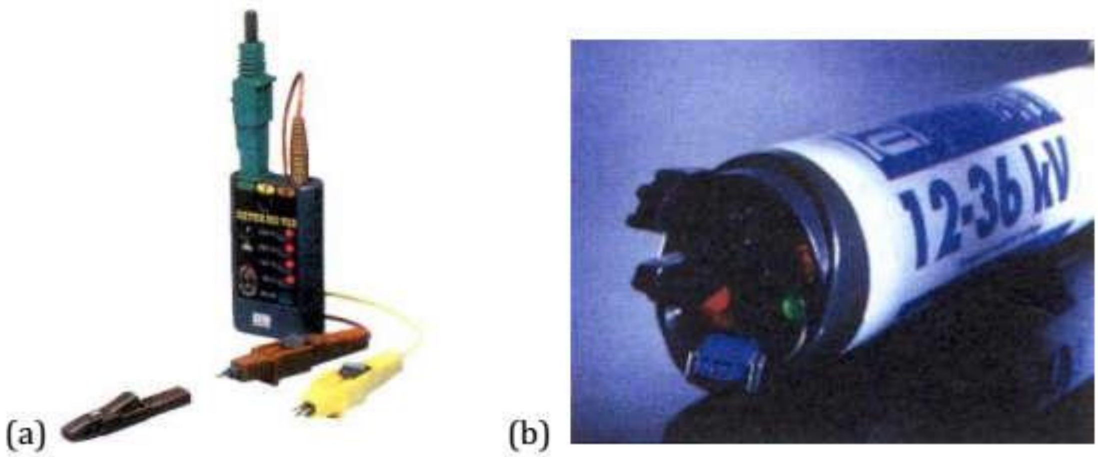


Figure III.14: No voltage checker (a) for LV and (b) for HV A

Verifying the absence of voltage on all active conductors (neutral included) is mandatory before any operation on an installation that has been de-energized. Indeed, a circuit breaker (or a switch) may have been subjected to significant electric arcs during previous openings: the poles may remain welded or have poor insulation resistance due to the metallization of the interrupting chambers.

Earthing (MALT) and short-circuiting (CCT) protect against risks due to induced voltages, charged capacitors and possible re-power supplies. This operation is optional on BTA installations. It is mandatory on a long BTA cable in BTB and HT.

The connection is made at the separation points of the structure concerned and as close as possible to the work zone. The connection is made first on the earth circuit, then on all active conductors (neutral included), as close as possible to the work area.

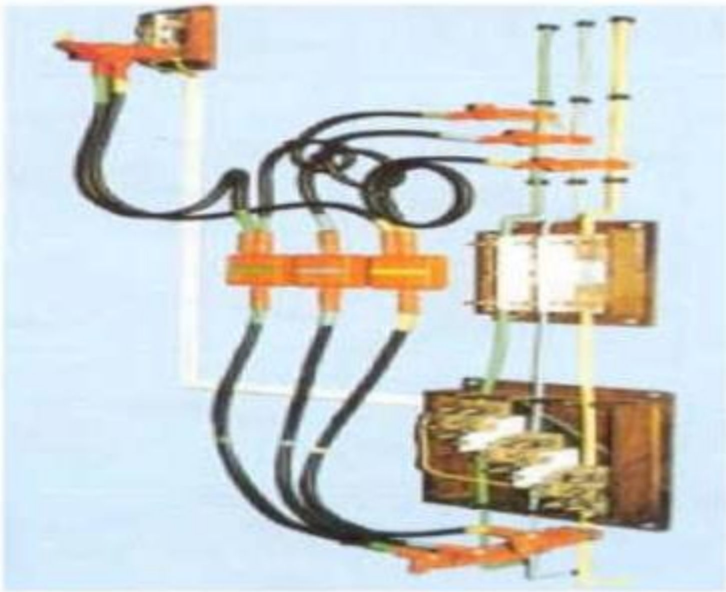


Figure III.15: Earthing and short circuit devices for overhead lines

III.9.3.2 Live work

Work under tension is authorized:

On public distribution networks, production works and their annexes;

On other structures, for operational or use reasons or if the very nature of the operations makes switching off the power dangerous or impossible.

Work under tension can be carried out under 3 conditions:

1. On bare live parts;

2. In the immediate vicinity of bare, accessible live parts;

In the vicinity of accessible bare live parts, for which distances have been set, in relation to the bare live parts, taking into account all possible movements of the bare live parts and all possible movements of the materials and machines used.

The employer, before authorizing the approach to structures to carry out live work, must take the necessary safety measures and notify those concerned. The rules to be respected (working methods, operating procedures, training and authorization, work organization) are specified below.

III.9.3.2.1 Working methods

Chapter 3: Protective measures

Before undertaking electrical work under voltage, it is necessary to organize it, to avoid accidental contact or ignition with live parts. For this, and to ensure their complete safety, the performer must respect all protective measures so that no part of their body can come into contact with:

- bare conductors or other unprotected elements under voltage,
- conductive masses connected to earth (equipment frames, power conduit fluid,...),
- the ground.

To do this, the operator must:

- Isolate themselves by using individual and collective protection,
- Arrange the location of your work,
- Choose your equipment,
- Respect some special measures before starting the operation.

Individual protection

Personal protective equipment is mandatory for work in the vicinity and workunder tension.

- The operator must wear:
- Insulating gloves,
- An insulating helmet,
- Protective glasses or mask against ultraviolet and infrared radiation,
- Dry, non-flammable clothing that completely covers arms and legs, not including
- conductive parts (metal zippers, etc.).
- Insulating shoes with wedge soles

Figure III.16: Electrician's overalls and shoes, helmet and insulating gloves

The operator must avoid:

Wearing metal rings and bracelets which considerably increase the current entry surfaces if they come into contact with a live part.

Layout of the work location

The operator must:

- Have a clear location and support ensuring a stable position,
- When conditions permit, insulate yourself using appropriate insulation(screen, mat, ladder, etc.).
- Material
- The operator must:
- Use insulating or insulated tools
- Use measuring or control devices that do not present a danger in the event of a connection error, poor choice of measuring range, or insulation fault.

Exclude the use or carrying of dangerous conductive objects (meters or metal rulers)

Before starting the operation

The operator must:

Organize work to limit risks,

Clearly designate the dangerous area with signs or warning tape,

Ensure that you are constantly seen or heard by another person who knows the maneuvers to carry out to cut off the power and carry out artificial ventilation if necessary,

Insulate bare conductors or other unprotected elements that are live in the immediate vicinity using sheaths, cables, caps, insulating profiles, etc.

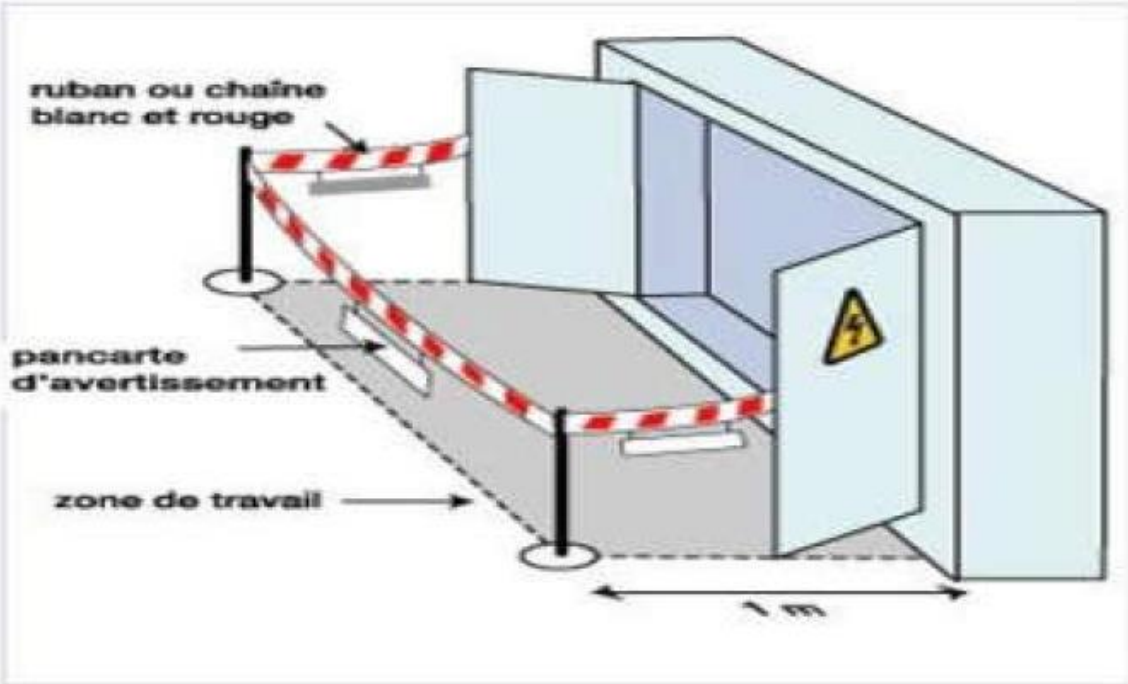


Figure III.17: Marking around an open electrical cabinet

III.9.3.2.1.a Remote work

The operator stays outside the zone defined by the minimum approach distance around bare live parts. He carries out his work using tools mounted at the end of insulating poles and in certain cases insulating ropes, these tools and ropes having insulation appropriate to the voltage level of the parts on or near which he is working. This method is used for all voltages.

Figure III.18 Remote working: example for high voltage

III.9.3.2.1.b Contact work

The operator enters, with the protections and precautions prescribed, the zone defined by the minimum approach distance around the bare live parts. The tasks are carried out using insulating or insulated hand tools and the operator is equipped with insulating individual protection (gloves, arm protectors, etc.). This method is used for voltages up to 30 Kv

Figure III.19 Contact work: example for low voltage and high voltage A

III.9.3.2.1.c Work at potential

The operator puts himself at the potential of the part he is working on. It thus creates around itself a new zone defined by the minimum approach distance from which other potentials must be kept away. The operators wear conductive clothing guaranteeing them perfect equipotentiality once the connection is established.

During the transfer from ground potential to conductor potential and vice versa, the operator is not connected to any fixed potential. It is said to have floating potential. This method is particularly suited to voltages in the HTB domain

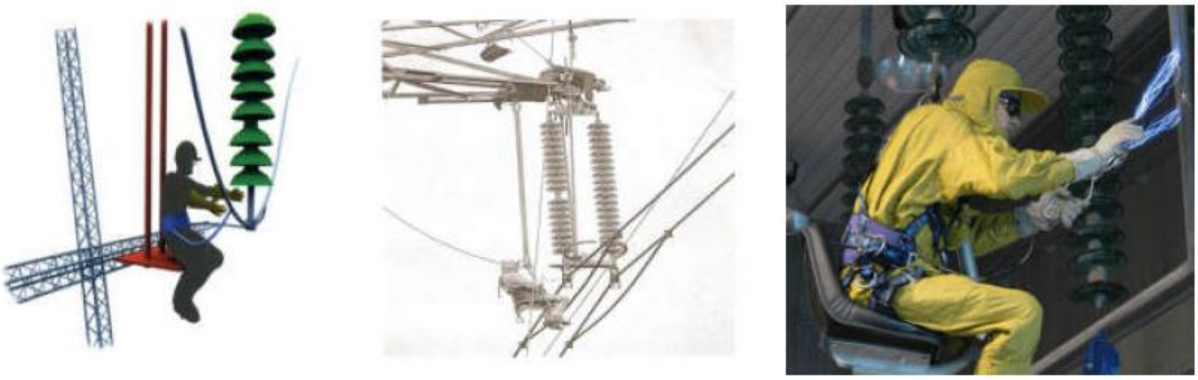


Figure III.20 Working at potential: example for high voltage

It should be noted that the execution of work under tension requires certain prerequisites to be met, such as atmospheric conditions. If these conditions are not met, the procedures for work without voltage must be applied.

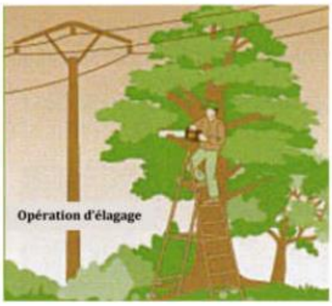
III.9.3.2.1.d Works in the neighborhood

These are works or operations carried out in the vicinity of bare live parts. These operations may or may not be electrical. It is necessary to distinguish between the two operations by considering different work areas and by grading the procedures, the means of protection to be implemented and the competence to be sought for the personnel. The operator must stay away from bare live parts, at defined distances, or use insulating protection placed between people and these parts. These distances can be materialized by more or less effective obstacles such as barriers, screens, banners, placed at precise distances and defined in the rules

Figure III.21: Means of materializing the separation distances of bare parts undervoltage.

Insulating protections covering or enveloping the bare live parts are used, the material of which must resist the over voltages which appear on the installations in operation.

Figure III.22: Enclosure of bare parts under tension with cables, caps and clamps



III.10. Protective equipment

Individual and Collective Protection are used for interventions and work on electrical installations.

III.10.1 Personal Protective Equipment (PPE)

- They are mandatory for work in the vicinity and work under tension.
- insulating gloves,
- protective glasses or mask against ultraviolet and infrared radiation,
- dry, non-flammable clothing completely covering arms and legs, not containing any conductive parts (metal zippers, etc.),
- insulating shoes with wedge soles,
- Eliminate metal rings and bracelets which considerably increase the current entry surfaces if they come into contact with a live part.

Figure.III.24: Personal Protective Equipment (PPE)

III.10.2. Use of insulated or insulating tools

In order to protect the operator and avoid the occurrence of short circuits, it is prescribed to use insulated or insulating tools such as:

- universal or insulated handle pliers,
- screwdriver with insulating handle,
- various keys coated with insulating materials,
- ... etc.

Material with reinforced insulation is used to avoid accidental contact of parts at different potentials; it is marked with 2 crossed triangles. This equipment is suitable for work or interventions in LV neighborhood areas

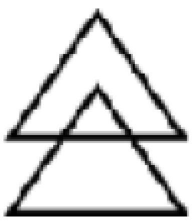


Figure III.25: Electrical tool symbol

Figure III.25: Insulated hand tools

Insulating poles and adaptable tools for live work (NF C 18-402-HD 542 S1). Two types of poles are usually used: the insulating rescue pole, also called a body pole, and the maneuvering pole.

Figure III.26: Insulating poles

Figure III.26: Insulating ladders (a) and (b) and insulating basket (c)

Figure III.27: Harnesses for work at height

III.10.2. Collective protection

III.10.2.1 Collective Safety Equipment (ECS)

a) Permanent collective protection:

Are incorporated in electrical installations in order to avoid the risks of direct contact with bare live parts (covers of switching devices, protective grills and screens, equipotential enclosures, shielding, automatic earthing, etc.)

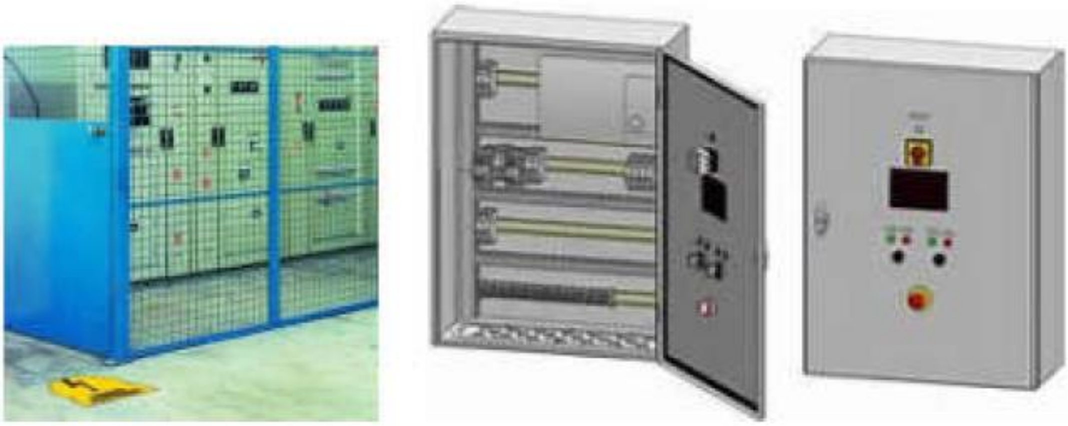


Figure III.29: Permanent protection by mesh (a) and door (b) of electrical cabinet

b) Collective protection of a temporary nature, necessary only during the time of intervention on machines, structures and installations.

Screens, protective grills and insulating protectors, intended to isolate a work area from any accidental contact with live parts or conductors. They can be made of insulating materials (baked wood, expanded plastics, fiberglass, etc.).They make it possible to create an isolated enclosure within which workers can move in safety or, conversely, to limit an area in which any movement or intervention is prohibited to anyone.

Vinyl insulating mats (EN 61112) possibly held by wooden clamps, used to totally or partially isolate low voltage distribution, control or metering panels, as well as for underground cables, from the rest of the installation on which the operator must intervene.

Insulating mats (NF C 18-420 – EN 61111), helps avoid the risk where the equipotentiality of the surrounding ground is not achieved.

Profiles insulators For THE drivers (NF C 18-425),

Insulating caps for overhead network insulators protect the operator(s) from electrical contacts, without prejudice to the individual protection measures to be taken in the case of live work.

Insulating protective caps adapted to the cable section, used to insulate the ends of insulated or protected conductors, awaiting installation on junction devices, during connection under voltage.

- Marking to delimit the work location.

- Work warning sign (responsibility of BR or B2)

Figure III.30: temporary protection by screen (a), layers, caps and clamps (b)

marking (c), (d) and signage (d) and (e)

c) Device locking equipment

When working on a de-energized installation, the switching device must be locked in the open position by means of a personal lock or padlock and affix a very legible sign bearing an inscription such as “Device locked –Do not operate”.

Figure III.31: Lockout by padlock and sign

III.11. Safety distances

Within the framework of publication UTE C185-15,we distinguish between works and interventions:

- under voltage,
- in the immediate vicinity of bare live parts,
- in the vicinity of bare live parts,

without prescription, Work for which distances have been fixed, in relation tobare live parts, taking into account:

- all possible movements of bare parts under tension,
- all possible movements of the materials and machines used.

III.11.1 Premises Reserved for Electricians (LRE)

These are enclosures normally kept closed to which access is only possible by authorized and designated or authorized and supervised persons. They contain Electrical Works (installations and equipment) allowing possible access to bare live parts in the low voltage or high voltage areas.

We consider that a live part becomes directly accessible when its protection indexis less than IP2x for LV and IP3x for MV.

There regulation does not require not there closing has key of the local BT.

The interior of the LRE is divided into environmental and neighborhood zones. The degrees of authorization required for access to LREs vary depending on the voltage range and the distance maintained between the person and bare live parts. A Permanent Safety Instruction (IPS) notifies the instructions to be respected within the LRE.

In the neighborhood area the person must wear Personal Protective Equipment(PPE)

III.11.2 Environmental zone By environmental zones

we mean those relating to people, in relation to electrical works. There are four zones.

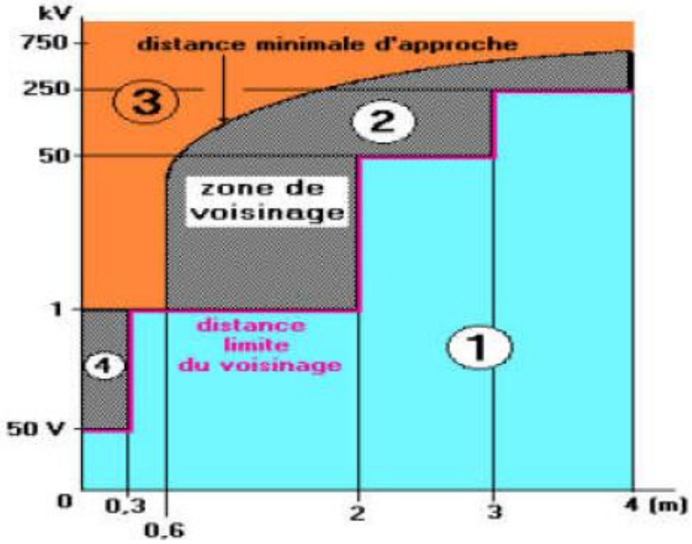


Figure III.32: Environmental zones

zone 1: this is the zone which extends beyond the neighborhood limit

zone 2: this is the neighborhood zone of the HT domain

zone 3: this is the zone between the bare live parts and the minimum approach distance (DMA) of the HV domain. The DMA is the distance from which there is a risk of initiation.

zone 4: this is the neighborhood or live work zone of the LV domain (distance less than30 cm from bare live parts). Any equipment corresponding to the IP2X degree of protection must not be considered as a bare live part.

III.11.3 General requirements

ZONE	TITRE	LIEU - DOMAINE	EPI
ZONE 1 – BT	B0, B1, B2	Intérieur du local à plus de 30 cm des pièces nues sous tension (BT)	Casque (voir IPS)
ZONE 1 – TBT	Pas d'habilitation Si TBTS ou TBTP<25V	Intérieur du local à moins de 30 cm des pièces nues sous tension	
ZONE 4	B0V, B1V, B2V B1T, B1N, B2T	ZONE DE VOISINAGE DE LA BT A moins de 30 cm des pièces nues sous tension	Casque Gants isolants Lunettes anti-UV
ZONE 1 – HT	H0, H1, H2	Intérieur du local en delà des zones de voisinage de HT	Casque (voir IPS)
ZONE 2	H0V, H1V, H2V	ZONE DE VOISINAGE DE LA HT	Casque Gants isolants HT Lunettes anti-UV
ZONE 3	H1T, H1N, H2T	Entre la **DMA** et les pièces nues sous tension (HT)	Equipements spéciaux HT

Table III.4: General requirements

III.11.4: Minimum approach distance (DMA)

The DMA is the distance from which there is a risk of initiation. It is the sum of the tension distance and the guard distance.

The voltage distance t (expressed in meters) is given, in the absence of appropriate protection or out-of-range devices, by t = 0.005 Un, with Un (in kV)nominal value of the voltage.

The guard distance ga aims to free the operator from the constant worry of respecting the tension distance

III.11.5: Neighborhood limit distances

They make it possible to define so-called neighborhood work and intervention zones and concern work carried out by authorized persons or by non-authorized persons supervised by authorized persons. The (upper) limit distances from the vicinity of bare conductive parts under voltage are:

• 0.30 m in LV • 2 m in HT for1kV < Un <5 0kV • 3 m in HT for50 kV< Un < 250 kV • 4 m in HT for Un > 250 Kv VIII.7: Work area

It is the one in which the operator is required to evolve with his tools or the materials he handles. Inside this area, which must be marked, only persons authorized or designated for the work to be carried out there must enter.

This notion of work zone must be taken into consideration whatever the operation to be carried out, whether it is powered off, powered on, in the vicinity, or whether it involves an intervention. As an example, tables (III.5) and (III.6) below give the limit distances D of the working zone as a function of the tension of the bare part.

Zone \classe de tension	BT	MT	HT 5,5kV	HT 15kV	HT 20kV
Sans prescription de sécurité	3m*	3m	3m	3m	3m
Au voisinage de pièces nues sous tension	0, 30m	0,30m	0,65m	0,70m	0,80m
Au voisinage immédiat de pièces nues sous tension	Très près mais sans contact	0,10m	0,45m	0,55m	0,60m
Sur pièces nues sous tension	Contact	contact	contact	contact	Contact
*A l'intérieur des bâtiments cette distance est ramenée à 1m.					

Table III.5: lower limits of the working area compared to the bare part under voltage depending on the voltage class.

Zone de travail et d'intervention	220 ou 380 V (Valable de 50 à 430 V)	20 kV
Sans prescription	D>1m**	D>3m
Voisinage	0,30<D<1m*	0,80<D<3m
Voisinage immédiat	D≤0,30 m	0,60<D<0,80m
Sous tension	Au contact	D≤0,60m
*A l'extérieur 0,3<D<3m **A l'extérieur D>3m		

Table III.6: limits of the work area compared to a bare live part depending on the voltage level

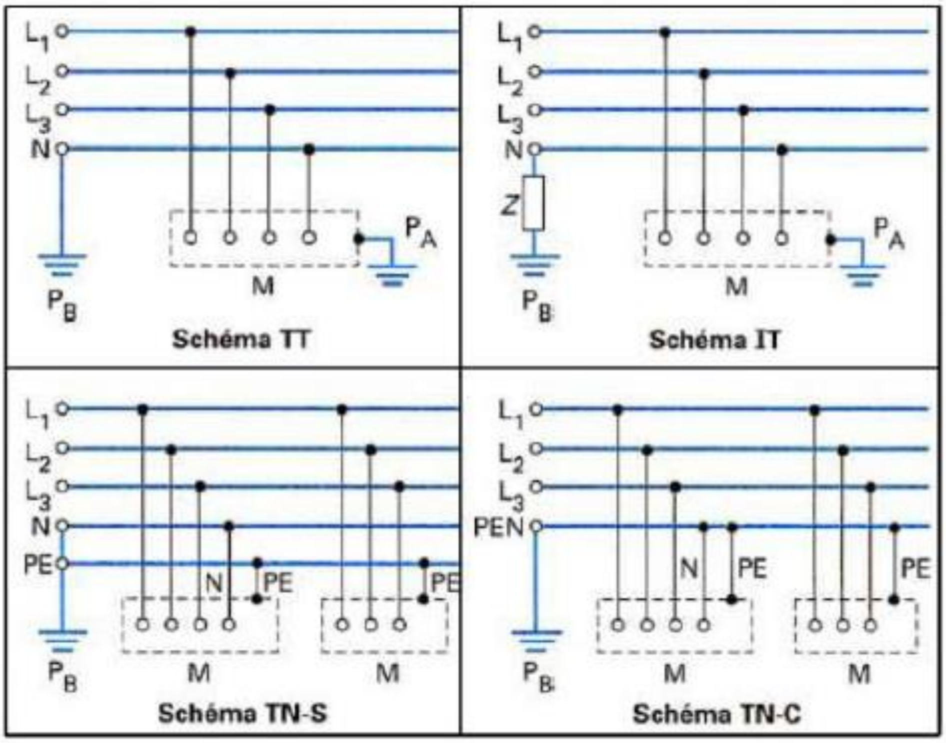
III.12. Earth connection diagram (SLT)OR Neutral regimes

The different low voltage distribution schemes are coded by the following letters:

1ère lettre : Neutre de l'alimentation *(Transformateur)*		**2éme lettre :** Masses de l'installation *(Utilisateur)*	
Raccordé à la terre	**T**	**T**	Raccordées à la terre
Isolé à la terre	**I**	**T**	Raccordées à la terre
Raccordé à la terre	**T**	**N**	Raccordées au neutre

Notes:

- The neutral of the power supply can be isolated to earth through an impedance.
- The masses are connected directly to the neutral of the grounded power supply,
- Either by a common conductor with the neutral(third letter C), TNC regime
- Or by a conductor separate from that of the neutral (third letter S). NRT diet



L1 L2 L3: Conducteurs de phases.

N : Neutre.

MA : Masses.

PEA : Conducteur de protection.

PEN : Conducteur de protection et de neutre confondus.

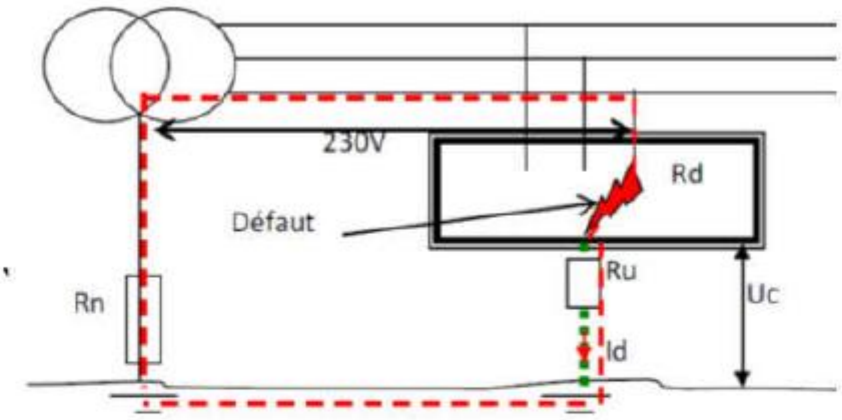
PA : Prise de terre des masses.

PBA : Prise de terre de l'alimentation.

Z: Impédance.

III.12.2. Neutral regime

TT: the first T indicates that the neutral of the installation is connected to earth on the generator side and the second indicates that the masses (metal frame) are connected to earth.



TT SYSTEME

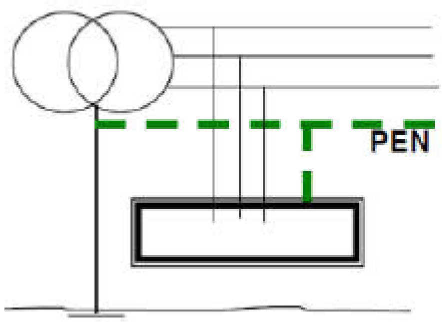
III.12.3. TN regime The neutral of the power supply is connected to earth and the masses are connected to neutral. Any insulation fault becomes a fault between phase and neutral (neutral phase short circuit).

III.12.3.a. TNC SYSTEME

The protective conductor and the neutral are combined into a single PEN conductor:

Electrical Protection + Neutral

Section of active conductors ³ 10 mm²

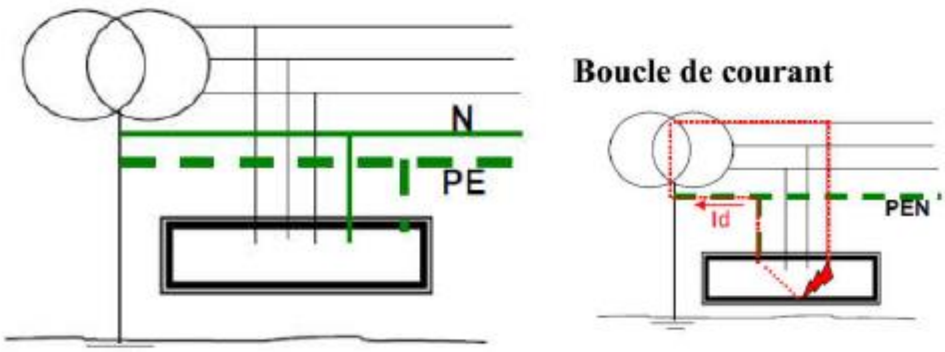


TNC SYSTEM

III.12.3.b. TNS SYSTEM

The neutral and mass earth connections are interconnected. In the event of a fault, a current Id flows in the PE or PEN conductor.

- Short circuit so Id is important.
- Triggering of protections.



TNS System

Characteristics :

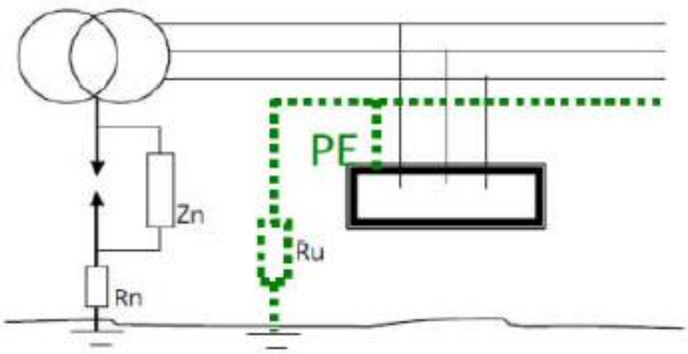
* Trip on first fault.

* Distribution of earth connections throughout the installation.

* Phase/ground insulation fault is transformed into a phase/neutral fault

III.12.4. IT regime:

The neutral is isolated from earth (connected to earth by an impedance). The masses are connected to an earth connection.



IT System

III. 13. Effects of electric and magnetic field

II.10.2.1 Proven effects

During exposure to very high intensity 50 Hz electric and/or magnetic fields, direct effects may appear. These effects have been well studied in human volunteers and in animals. Standards and recommendations protect us from these proven direct effects.

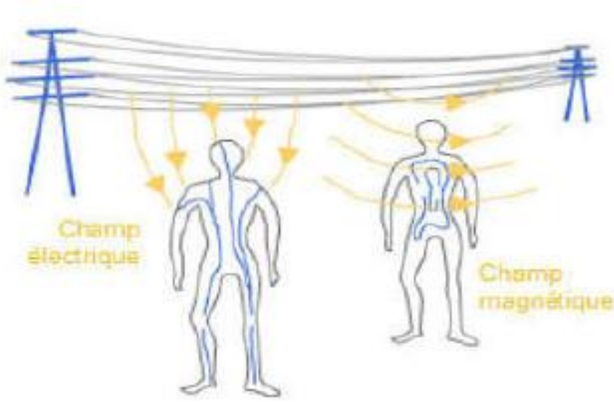


Fig.III.33 Passage of electric and magnetic field

- There are many proven effects on the nervous system linked to exposure to 50Hz electric and magnetic fields:
- Direct stimulation of nervous and muscular tissues
- Induction of phosphenes in the retina.
- You should also know that electric currents exist naturally in the human body:
- An electroencephalogram records the electrical activity of the brain. The recording of electricity produced by neurons in the brain is collected using small electrodes placed on the scalp.

An electrocardiogram records the electrical activity of the heart. The heart is a muscle, which, like all muscles, emits a certain amount of electricity when in action. The electricity emitted can be recorded using an electrode.

III.13.2. Induced voltages

Induced voltages result from pollution produced by the 50Hz network or house hold appliances. These induce a variable tension on the periphery of the body. An alternating induced field causes oscillation or movement of free charges and rotation of polar molecules, proportional to the exposure frequency. One end of the device is connected to an earth connection, the other to the hand. To reduce these induced voltages, we place shields or Farade cages on the sources, then we connect then on a correct equipotential connection.

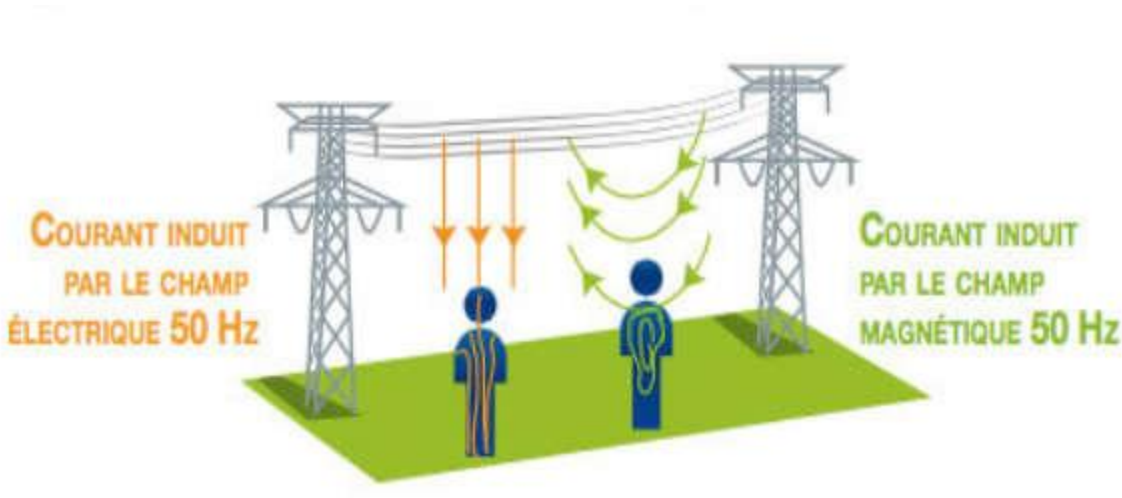


Fig.III.34. Current induced by electric and magnetic field

Chapter 4: Safety measures against indirect effects of electric current

IV. Fires and explosions of electrical origin

An electrical fault can lead to the production of sparks and abnormal heating of an electrical system then carried by a current incompatible with its characteristics. These effects can lead to widespread fire or explosion if flammable materials are nearby. Fires and explosions in the workplace are often spectacular and sometimes fatal. Their prevention is subject to specific regulations.

IV.1. The explosions

The main manifestation of an explosion is the sudden increase in pressure which causes a blast effect and a pressure wave, accompanied by flames and heat. Furthermore, the effects of an explosion always combine with a significant release of heat, and a zone of flames can invade a volume ten times greater than that of the initial explosive atmosphere space".

IV.1.1. The causes of the explosion

There can only be an explosion under certain conditions, after formation of an explosive atmosphere, resulting from a mixture with air of flammable substances in proportions such that an ignition source of sufficient energy produces its explosion. Six conditions to be met simultaneously for an explosion to take place

- Presence of an oxidant (generally oxygen in the air)
- Presence of fuel
- Presence of an ignition source

Special state of the fuel, which must be in gaseous, aerosol orsu spended dust form

Obtaining of a domain explosiveness (domain of concentration of combustible in the air inside which explosions are possible); Sufficient containment; The source of ignition in the case of electrical explosions is limited to the spark and the electric arc.

In the workplace, explosive atmospheres can form in the presence of:

Gases and vapors: fuels for heating, drying installations, etc., stored combustible gases, flammable solvent vapors stored or handled.

combustible dust: likely to form explosive clouds with air during routine operations, such as flour, sugar, milk, coal, sulfur, starch, cereals, wood, plastics ,metals...).

IV.1.2 Prevention against explosions

Avoid the formation of explosive atmospheres

Product-related measurements - Preliminary tests to determine the explosive characteristics of the fuel, particularly for dust.

- Reduction of the oxygen content (oxidant) of the air, using inert gas (nitrogen for example)

- Process-related measures

-Cooling - Control of temperatures and pressures

Identify sources of ignition - Establishment of the fire permit procedure for work involving hot spots (prohibition of flames and open fires, limitation of the temperature of hot surfaces)

No smoking in risk areas.

- Control and/or elimination of spark sources of mechanical, electrical and electrostatic origins

- Limit the effects of explosions -Distance or separation of installations

- Explosion resistant construction

- Relief of explosion pressure (installation of vents)

- Devices making it possible to stop the development of an explosion in an enclosure (stopping the explosion) or a pipe (technical decoupling such as flame arresters, quick-closing valves, triggered extinguishers, etc.) before the overpressure has reaches a dangerous value for the installation.

Adopt organizational measures - Training and awareness of allstaff about the “explosion” risk

- Establishment of intervention procedures

- Information from external companies

- Cleaning

- Marking IV.2. Electrical fires

For an electrical fire to occur, there must be simultaneously:

- a heat source or spark (activation energy necessary to start combustion);

- an oxidizer (the oxygen in the air which supports combustion).

a fuel (burning body composed of carbon and hydrogen).

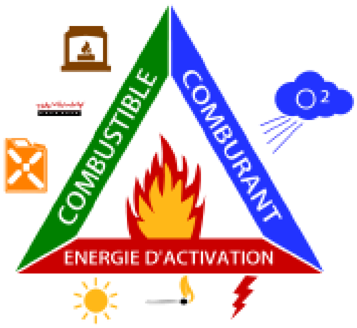


Figure IV.1: Fire triangle

The dangers of fires lie in:

smoke (toxicity, opacity, high temperature),

- Combustion gas (toxicity) -Flames (burning)

IV.2.1. The main causes of electrical fires

1- Over currents

1-1-Overload:

- Unsuitable section of cables (heating, loss of insulation).
- Poor tightening of the terminals, existence of play.
- Poor crimping of terminals or poor fixing.
- Unsuitable fuses (break response).
- Multiple sockets overloaded

1-2-short circuits:

Cutting of cables(Electric arc).

- Contact with bare live parts.

1-3-insulation faults:

- Poor connection of metal masses.

- Poor equipotentiality of metal masses.
- Wear or damage to insulation.

2- Surges

- Direct and indirect effects of lightning are frequently found

3- surrounding area:

electrostatic discharge.

- Static electricity is an indirect cause of fires. In fact, it can cause sparks whichact as activation energy.

IV.3. Prevention

- Use of safety systems
- Infrared Thermo graphic Control: This is a means of identifying electrical and mechanical components that are hotter than they should be. An excellent tool for industrial maintenance, it helps reduce productions top pages due to breakdowns.
- A Fire Safety System (SSI): It is planned from the design of a premises or building. It consists of a fire detection system (SDI) and a fire safety system(SMSI).
- 1- Fire detection system (SDI): You must judiciously choose the types of detectors (NF certified or APSAD approved, etc.) adapted to the premises, the people and the property to be protected and install them in sufficient quantities.
- 2- Fire safety system (SMSI): This system brings together a signaling and control unit, as well as activated safety devices (fire doors, mechanical smoke extraction systems).

  3- Implementation of extinguishing equipment: These means cannot be improvised; first and second intervention equipment as well as fixed extinguishing installations must be chosen judiciously so that they are suitable and sufficient. They must be checked regularly.

Figure IV. 2: Diagram of a water fire extinguisher

A. Striker

B. Percussion and carrying handle

C. Safety Pin Location

D. Faucet body

E. Sparklet (propellent gas cartridge)

F. Gas injection tube

G. Dip tube

H. Fire extinguisher body

has. Nozzle

b. Extension

c. Trigger

d. Soft hose

IV.3.2. Firefighting officers

Agent extincteur	CLASSE A	CLASSE B	CLASSE C	Feu d'origine électrique	Portée en mètres
Eau pulvérisée	Très efficace	Inefficace	Inefficace	DANGER !	2 à 3 m
Eau pulvérisée +additif	Très efficace	Peu efficace	Inefficace	DANGER !	2 à 3 m
Poudre BC	Inefficace	Très efficace	Très efficace	DEGATS	3 à 4 m
Poudre polyvalente ABC	Peu efficace	Très efficace	Très efficace	DEGATS	3 à 4 m
CO2	Inefficace	Efficace	Efficace	Très efficace	Environ 0.5m m
Halons	Inefficace	Efficace	Inefficace	Très efficace	Environ 0.5m

Table IV.1: Fire fighting agents.

IV.3.4 What to do in the event of an electrical fire

- Raise the alarm.
- Turn off the power to the installation, and possibly neighboring installations (cutoff the gas supply if necessary).
- Close doors and windows.
- Attack the fire at the base using a suitable fire extinguisher (carbon dioxide, water spray, powder).
- After extinguishing the fire, ventilate toxic gases.

IV.4. The effects of noise and vibrations

Some electrical equipment, machines and tools generate a lot of noise and/or emit vibrations. Given their intensity and the number of hours of exposure, noise and vibrations are harmful to health and are recognized as a source of occupational illnesses which appear with a certain latency. The period between the start of exposure to risk factors and the declared illness can vary between a few months and several years.

IV.4.1 The effects of noise

Noise can cause health problems, illnesses, including hearing loss or deafness, but also other pathologies (stress, fatigue, etc.), as well a swork accidents. . It is recognized as a source of occupational disease.

IV.4.1.1 Noise level

50 dB(A) = usual conversation level, 85 dB(A) = harmful threshold (for exposure of 8 hours/day), 120 dB(A) = noise causing a painful sensation , A noise of 150 dB causes the

eardrum to rupture. The decibel scale shown in the following table (IV.2) gives an overview of the different sound levels encountered in everyday life and on construction sites.

Vie de tous les jours	Niveau	Vie sur chantier
	150 dB (A)	Dynamite
Perte d'équilibre	140 dB (A)	Perte d'équilibre
Tonnerre	130 dB (A)	Pistolet de scellement
Seuil de douleur	120 dB (A)	Seuil de douleur
Réacteur d'avion	110 dB (A)	Marteau piqueur
	100 dB (A)	Pistolet de peinture
Train sur un pont	90 dB (A)	Banc de scie
Carrefour urbain	80 dB (A)	Foreuse
Usage difficile du téléphone	70 dB (A)	
Voiture	60 dB (A)	
Conversation	50 dB (A)	
Musique douce	40 dB (A)	
Murmure	20 dB (A)	
Bruissement d'une feuille	10 dB (A)	
Seuil d'audibilité	0 dB (A)	

Table IV.2: Noise levels encountered in everyday life and on construction sites. - Intense noises can be the cause of:

hindrance to work (poor communication, poorly understood orders, unperceived danger signals);

accidents (noise has a masking effect on warning signals, disrupts

verbal communication, diverts attention);

physiological disorders such as: -increased heart rate,

- an increase in tension, respiratory rate,

- dilation of the pupils,

- dizziness,

- a certain fatigue,

- headaches,

- aggression, dissatisfaction, irritability, anxiety;

- sleep disorders, etc.

hearing fatigue

permanent deafness caused by damage to the inner ear (destruction of hair cells) in the event of prolonged exposure to intense noise. This hearing loss is irreversible.

The frequency, type and duration of noise affect the degree and extent of hearing loss: - High-pitched noises are more dangerous than low-pitched noises given the position of the hair cells that receive high frequencies (harm to the hearing). 'inner ear);

- Continuous noise (noise which continues over time at a frequency greater than one per second) is better tolerated than discontinuous noise such as impact noise (any noise formed by mechanical shocks of solid bodies or by impulses repeated or not at a frequency less than or equal to one per second);

- Noises of a given intensity become harmful if the duration of exposure exceeds a certain number of hours per day. Table (IV.3) opposite gives the exposure times in relation to the lower action value of 80 dB(A) stipulated in European Directive 2003/10/EC.

Heures d'exposition par jour	dB (A)
8h	80
4h	83
2h	86
1h	89
0h30	92
0h15	95
0h08	98
0h04	100

Table IV.3: Exposure times compared to the lower action value of 80 dB

(A) stipulated in European Directive 2003/10/EC

For a working day (8 hours), the ear is considered to be in danger from 85dB(A). If the noise level is higher, the exposure should be of shorter duration. If the level is extremely high (greater than 130 dB(A)), any exposure, even of very short duration, is dangerous.

IX.2.1.2 Noise prevention measures

?

Avoid the risk by using working methods whose noise exposure does not exceed80 dB (A).

•Evaluate the risk by estimating the noise level.

-

If you have to raise your voice to communicate, it is because it is high: at a distance of 2 meters, if you have to shout, it is because it is at least 85 dB(A).

- Measurement must be carried out. Combat risk; replace what is dangerous with what is less dangerous

- choice of work equipment emitting as little noise as possible;

- maintenance of equipment, replacement of worn parts;

- locate noises in a specific space isolated from the rest;

- avoid the propagation of noise by anti-vibration mountings.

- Provide collective protective equipment

- Covering a noise source (complete or partial enveloping of a noise source intended to reduce the propagation of noise)

Figure IV.3: Covering a noise source

Provide personal protective equipment

-Use individual, appropriate and correctly fitted hearing protectors (NBN-EN 458Noise Protectors standard) such as earplugs (NBN-EN 352-2), whether disposable, reusable, pre-shaped or made to measure .

-Use earmuffs on headbands or helmets (NBN-EN 352-1 and 3). . There are certain models that allow the voice to pass through a so-called vocal membrane.

Figure IV.4: Individual hearing protection

IV.2.2 The effects of Vibrations on the human body

A vibration is the periodic movement of a mass around its point of equilibrium. Vibrations are characterized by:

their frequencies measured in Hertz (Hz): number of vibrations per second;

their amplitudes measured in m/s², that is to say the acceleration; their directions;

- along 3 axes in relation to the body: the vertical axis, the horizontal axis or the left-right axis in relation to the body;

- along 3 axes in relation to the hands: wrist-finger axis, horizontal axis and vertical axis of the hand flat (see figure IV.5);

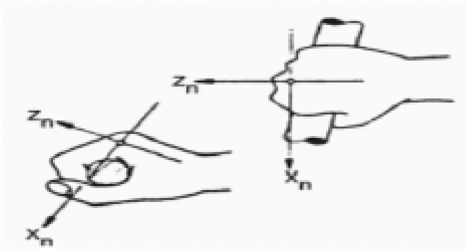


Figure IV.4: The axes in relation to the hands

IV.2.2.2 Preventive measures against vibrations

Preventive measures concerning the hand-arm system, the following solutions should be adopted:

Isolation against vibrations; this consists of placing shock absorbers below the insulating machine on a fixed support point on the building;

Active reduction at the source which aims to reduce the load caused by vibrations on the energy supply. The added source must therefore be in counter-phase with the original source;

The use of personal protective equipment: Anti-vibration handles and gloves;

Organizational measures: consists of reducing exposure time.

Preventive measures concerning the whole body

Adjustable seats: reduction of vibrations thanks to the use of suspension seats, or even a suspension control cabin.

Remote-controlled machines: the vibration load can be reduced by using a robot or remote-controlled tool.

Figure IV.10: Reduction of vibrations by use of remotely controlled vehicles

Chapter 5: Relief measures and care

ACCIDENT PREVENTION

No matter how carefully a system is engineered, no matter how carefully employees perform their tasks, and no matter how well trained employees are in the recognition and avoidance of hazards, accidents still happen. This section provides a general approach that may be employed to reduce the number and severity of accidents. Four basic steps—employee responsibility, safe installations, safe work practices, and employee training—combine to create the type of safe work environment that should be the goal of every facility.

Individual Responsibility

The person most responsible for your own personal safety is you. No set of regulations, rules, or procedures can ever replace common sense in the workplace. This statement should not be construed to mean an employer has no responsibility to provide the safest practical work environment, nor does it mean that the injured person is "at fault" in a legal sense. Determining fault for accidents is, in part, a legal problem and is beyond the scope of this handbook. Time after time, accident investigations reveal that the injured person was the last link in the chain. If the injured person had only been wearing appropriate safety equipment or following proper procedures, or if he or she had only checked one last time, the accident never would have occurred. Table 7.1 lists five behavioral approaches that will help to improve the safety of all employees. To make certain employees have both the responsibility and the authority to carry out the five steps listed in Table 7.1, employers should adopt a policy similar to the one listed in Table 7.2. Simply putting such a statement in a safety handbook is insufficient.

An employer must believe in this principle and must "put teeth into it." Such a credo provides the absolute maximum in individual employee responsibility and authority and will maximize the safety performance of the organization. Installation Safety

Design. Proper design of electrical systems is composed of three parts—selection, installation, and calibration.

Employee Safety Behavior

• Determine the nature and extent of hazards before starting a job.

• Each employee should be satisfied that conditions are safe before beginning work on any job or any part of a job.

• All employees should be thoroughly familiar with and should consistently use the work procedures and the safety equipment required for the performance of the job at hand.

• While working, each employee should consider the effects of each step and do nothing that might endanger themselves or others.

• Each employee should be thoroughly familiar with emergency procedures.

Selection.

Electric equipment should be selected and applied conservatively.That is, maximum ratings must be well in excess of the quantities to which they will be exposed in the power system. To help with this, manufacturing organizations such as the National Electrical Manufacturer′s Association (NEMA) have established ratings for equipment that ensure member companies only manufacture the highest-quality equipment. Equipment is tested per manufacturer′s procedures by independent laboratories such as the Underwriter′s Laboratory (UL). Equipment that is rated and labeled by such organizations should be used in electrical systems to help ensure safety. OSHA, NEC,* and NESC requirements should be considered as minimum criteria for safe selection. With increasing cost consciousness, many companies are opting for the installation of recycled rather than brand-new equipment.

While the selection and use of such equipment can be a financial advantage, at least two criteria should be considered in the purchase:

1. Even though used, the equipment should have been originally manufactured by a reputable, professional firm.

2. The recycled equipment should be thoroughly reconditioned by a professional recycling company such as those represented by the Professional Electrical Apparatus Recyclers League.

3. Engineering studies such as short-circuit analysis and coordination studies must be performed to ascertain that the recycled equipment has adequate ratings for the system in which it is being placed. Since the system short circuit values may change with time, this requirement is true even if the recycled equipment is a direct replacement for the previous equipment.

• *Installation.* Equipment should be installed in a safe and *sensible* manner. Adequate work spaces for safety clearance should be allowed, safety barriers should be provided when necessary, and electrical installations should never be mixed with areas that are used for general public access.

• *Calibration.* Equipment always should be properly calibrated. For example, protective devices should be calibrated so that they will operate for the minimum abnormal system condition. Equipment that is improperly calibrated can result in accidents as though the equipment had been improperly selected to begin with. Calibration is also a two-step process:

1. Proper engineering should be performed by professional engineers to ensure that the

selected calibration settings are suitable for the application. The starting point for such a system is in the performance of an appropriate suite of power system studies, described later in the section.

2. Proper testing and physical setting of the devices should be carried out to ensure that the equipment is capable of performing when called upon. Such settings should be executed by professional technicians who are certified to perform this work. Organizations such as the International Electrical Testing Association (NETA) have been formed to ensure quality control on the education and performance of electrical technicians.

Electrical Protective Devices. Protective devices such as circuit breakers, fuses, and switches must be capable of interrupting the currents to which they will be subjected. The National Electrical Code has numerous passages that require proper sizing of protective devices.

Maintenance. Improperly maintained equipment is hazardous. For example, circuit breakers can explode violently if not properly maintained. Equipment should be periodically inspected and tested. If deficiencies are observed, the equipment must be repaired, adjusted, or replaced as required. Properly trained and certified technicians and mechanics should be used for such work. As mentioned earlier, national organizations such as NETA can be used to provide qualified personnel.

Operating Schemes. Many personal injury accidents could be prevented if systems were all designed for safe operating procedures. The following are some of the key design concepts that should be used for any new or refurbished electrical system:

1. Arc-resistant switchgear should be employed. In addition to reducing the possibility of electrical arcs and resulting blasts, arc-resistant switchgear is designed to contain the blast and blast products. Such switchgear also has pressure relief systems that will redirect the release of arc and blast products and energy in directions that are safe for workers.

2. Remote operating controls should be used for all circuit breakers, switches, and other such control devices. This relatively simple and inexpensive design technique allows workers to operate equipment while stationed remotely from the possible results of failure. Whether supervisory control systems or simple remotely placed, hard-wired control switches are used, the distance will allow the workers to operate the equipment in relative safety.

3. Control panels should be designed with protective barriers to prevent shock hazard and contain arcs and arc products. For example, many industrial control panels are fed via 480

V circuit breakers. This breaker, in turn, feeds a step-down transformer. The control voltage output of the transformer feeds the various control circuit throughout the panel.

If the 480 V portions of the circuit are designed with appropriate protective covers, workers in the panel need to protect themselves only from the electrical hazards presented by the 120 V circuits.

General First Aid Procedure

- Act quickly.
- Survey the situation.
- Develop a plan.
- Assess the victim′s condition.
- Summon help if needed.
- Move the victim only if danger is imminent.
- Administer required first aid:

  Shock

  Electrical burns

First Aid Checklist

Is the circuit still energized?

- Is the victim contacting the circuit?
- Are noxious gases or materials present that may cause injury?
- Is fire present or possible?

What to Do If the Victim Is Responsive

- Ask the victim what is wrong.

• Assess the victim's condition and treat the injuries as best as possible.

• Treat the worst injuries first.

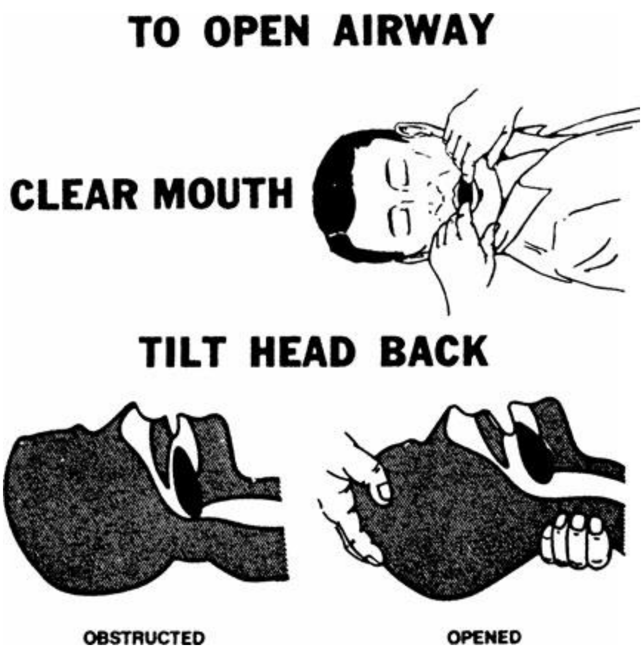
• When the victim is out of immediate danger, or if you are unable to help because the injuries are beyond your abilities, summon help.

• Attend to the victim(s) and keep them safe until help arrives.

• When help arrives, give the first aid workers your assessment of the situation and stand by to help

The ABCs of First Aid

- **A**irway
- **B**reathing
- **C**irculation
- **D**octor



Clearing the airway of an injured worker.

Checking the circulation.

Typical Symptoms of Electric Shock

• Victim may lose consciousness. This may occur at the moment of contact; however, it can also occur later.

• Victim has a weak or irregular pulse.

• Victim has trouble breathing or has stopped breathing.

• Small burns may appear at the entry and exit points of the electric current.

Precautions for Performing First Aid on an Electric Shock Victim

• Do not touch any energized wires with any part of your body or with any conductive tools or equipment.

• Do not touch a victim who is still in contact with an energized wire with any part of your body or with conductive tools or equipment.

• Do not try to move any energized wires unless you are qualified to do so. Qualified in this instance means that you are trained in the performance of such a procedure and are able to avoid electrical hazards.

First Aid Procedures for Conscious Electric Shock Victims Who Exhibit No Symptoms

• Keep the victim still and quiet. Remember that heart and respiratory problems can be delayed in electric shock victims.

• Monitor the victim′s condition for at least 1 hour.

• If the victim continues to show no symptoms, take them to a doctor for a thorough examination.

First Aid Procedures for Unconscious Electric Shock Victims with Symptoms

• Check the ABCs. If the victim is not breathing or has heart irregularities, perform resuscitation as described later in this cours

• If wounds are evident, cover them with sterile dressings.

• If external burns are evident, they should be cooled using clear, pure water.

• Try to cool burns with sterile compresses.

• Immediately seek medical aid.

Rescue Breathing (Mouth-to-Mouth Resuscitation).

If the preliminary assessment indicates that the victim is not breathing, mouth-to-mouth resuscitation should be performed as follows:

1. Open the airway, clear the mouth, and tilt the head back, as shown in Fig. 7.1.

2. Gently pinch the victim′s nose to seal it closed, as shown in Fig. 7.4.

3. Take a deep breath and seal your lips around the victim′s mouth creating an air-tight seal.

4. Gently blow into the victim′s mouth for $1_{1}/_{2}$ to 2 seconds. While blowing, watch to be sure the victim′s chest is rising.

5. Stop blowing and allow the victim′s lungs to exhale.

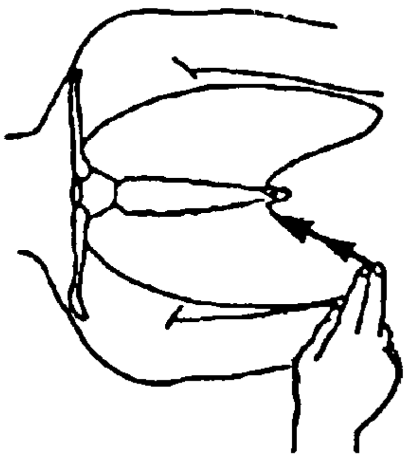
6. Repeat steps 4 and 5.

7. Stop the procedure and watch the victim for 5 to 10 seconds to determine if the victim is breathing on his/her own.

8. If the victim is not breathing normally, repeat steps 4 and 5 until the victim starts breathing normally or until qualified help arrives to relieve you.

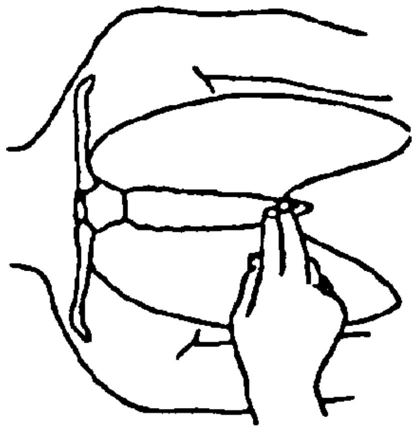
The rescuer gently pinches the nose closed with the thumb and index finger of the hand on the forehead breathes into the victim′s mouth.

a



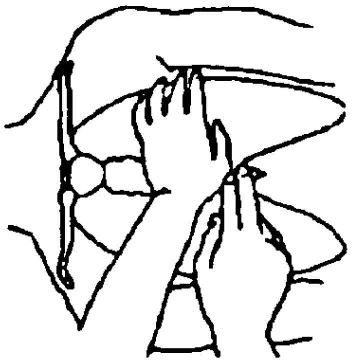
Kneel facing the victim's chest. Find the correct hand position by sliding your fingers up the rib cage to the breastbone.

b



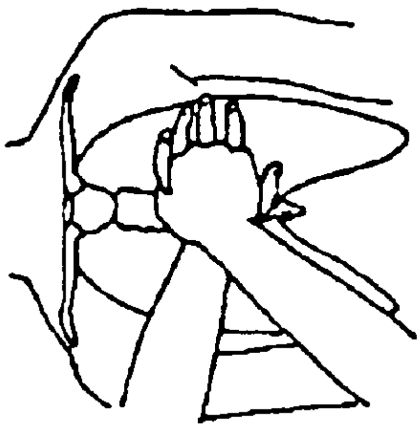
Place your middle finger in the notch and the index finger next to it on the lower end of the breastbone.

c



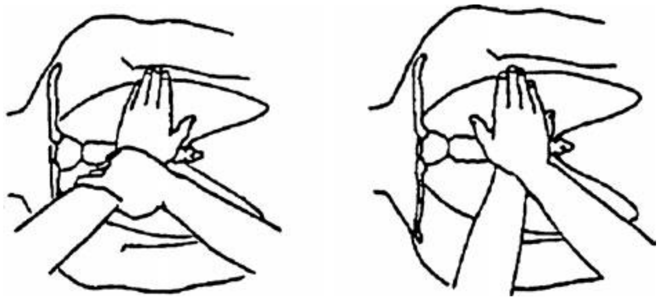
Place your other hand beside the two fingers.

d



Place hand used to locate notch on top of the other hand. Lace the fingers together. Keep fingers off of the chest. Position shoulders over hands, with elbows locked and arms straight.

Steps a, b, c, and d illustrate the procedure to properly position your hands prior to perorming CPR.



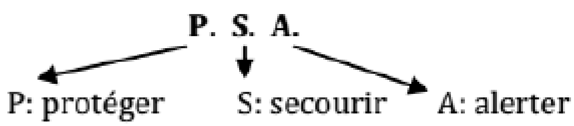
Alternate positions for hands while applying CPR.

Often, simple but well-timed actions are enough to save a human life. In truth, the preservation of this life depends on a simple action under pinned by two tasks: Protect-Alert. But above all, ensure that this impulse of dedication, altruism and courage does not lead to serious injuries or the death of rescuers. For obvious safety reasons, you must refrain from undertaking certain dangerous spontaneous actions with the intention of saving a life, such as:

- throw yourself into the water
- cross the highway
- go down into a pit
- rush towards a person who has suffered an electrical accident. The alert, when it implodes, allows rapid treatment of the victim by the specialized emergency services which take over.

X.2 What to do following an electrification?

The action to be taken in the event of an electrical accident is based on the general rule of first aid which is:



X.2.1 Protect

This means ensuring your protection, that of the victim, their property, as well as that of witnesses. In the case of an electrical accident, the goal is to remove the people present and the accident victim from any live conductors or parts. If the victim is in contact with the electrical source, any careless intervention risks causing an accident. rescuer. To remove the victim from the effects of the current, it is necessary to turnoff the power and the rescuer must isolate himself. To do this, proceed in order: Cut off or have the power supply cut off

- by operating an emergency stop,- or by operating the power circuit breaker, -switching off the meter,

- or by unplugging a socket, - spread the wire with an insulating object (insulating pole, piece of dry wood) or using insulating gloves, etc.

- Make sure that there discount below tension born will be able to be performed,
- free the victim if necessary.

Figure V.1: To protect is to isolate, cut off and release

-Emergency extrication consists of removing the victim from the scene of the accident as quickly as possible and bringing them to safety, if they are exposed to the risk of an accident or a vital danger, without worsening their condition.

- Generally,
- We do not move
- We don't move
- Do not touch Emergency release can only be carried out on:
- An unconscious victim subjected to danger,
- A victim unable to escape from herself.

V.2.2 Alert

It means preventing or having specialized emergency services notified by formulating a clear, precise and concise message. The action to be taken is:

Protection civil,

Find (Service Help Medical Urgent),

Police,

Gendarmerie

A doctor

- Formulate the alert message which must specify:
- Phone number
- Accident location
- Number of victims
- State of victims
- Actions taken
- Never cut the communication first, wait for the correspondent's order
- Stay with the victim until help arrives.

V.3 Rescue

This means assisting the victim while waiting for help to arrive. As soon as the accident victim has been removed from contact and emergency services have been alerted, there scuer must carry out assessment and monitoring which first consists of collecting information:

- What happened?
- Voltage, points and contact times?
- Was the victim stuck at the source?
- Was the victim thrown after contact with the power source?
- Did the victim feel the current passing through his body? Are there burn marks at contact points on the skin?
- Was the contact voltage greater than 1 kV?

- Is the victim a pregnant woman? After which you must:
- Appreciate the three vital functions, c. has. d. : check :

- the state of consciousness
- ventilation
- traffic

Check for a possible lesion:

Hemorrhage

Wound

Brulur

Fracture... Monitor vitalfunctions

X.3.1 Appreciate the state of consciousness

The rescuer must:

Ask simple questions: your name? Are you okay?... (Figure V.2)

Give simple orders: open your eyes, shake my hand...

Lightly pinch the victim (deaf and mute)

Figure V.2: Assessment of the state of consciousness

V.3.2 Assess the ventilatory function

The rescuer must:

Ensure airway clearance (LVA),

Loosen anything that is tight (tie, collar, belt, etc.), Open the victim's mouth, clean it (remove bridge, candy) and wipe away the phlegm using a clean cloth,

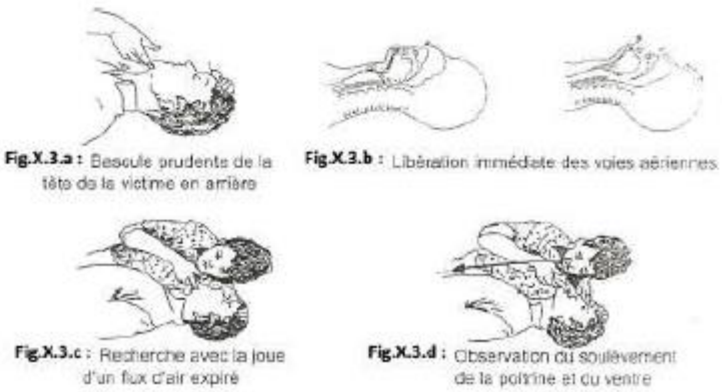
Place the four fingers of one hand on the victim's forehead,

Place two fingers of the other hand under the tip of the chin, resting on the bone and not in the soft part of the chin,

Carefully tilt your head back (Figure V.3.a),

Lean your ear and cheek over the victim's mouth and nose to feel the flow of exhaled air (figure V.3.c),

Observe the lifting of the chest and stomach (figure V.3.d)



X.3 : Appréciation de la fonction respiratoire