# Method era – electricity with risk assessment – risk assessment proposal for interventions in electrical installations

# Era do método - eletricidade com avaliação de risco - proposta de avaliação de risco para intervenções em instalações elétricas

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**RESUMO**
O setor de segurança em instalações e serviços em eletricidade é certamente o mais presente em todas as atividades econômicas, na atualidade, no Brasil. A demanda de ações cada vez mais especializadas e que atendam às necessidades deste leva anualmente à renovação de aplicação de novas tecnologias e metodologias que representem melhoria contínua em tais ações. Métodos de apreciação de risco elaborados com foco em seu campo de aplicação e embasado em premissas e estudos que apontem para sua eficiência igualmente são uma necessidade fundamental. O método ERA é proposto com o objetivo

de auxiliar os gestores na identificação de pontos críticos e tomada de decisões e adequações de modo mais célere e assertivo e dinâmico.

**Palavras-Chave:** Análise de Risco, Apreciação de Risco, Elétrica, Eletricidade, NR-10, Instalações.

**ABSTRACT**
The security sector of installations and services in electricity is certainly the most prevalent in all economic activities today in Brazil. The demand for increasingly specialized actions that meet these needs leads annually to the renewal of the application of new technologies and methodologies that represent continuous improvement in such actions. Risk assessment methods designed with a focus on their field of application and based on assumptions and studies that point to their efficiency are also a fundamental need. The ERA method is proposed with the objective of assisting managers to identify critical points and make decisions and adjustments in a faster, more assertive and dynamic way.

**Keywords:** Risk Analysis, Risk Assessment, Electrical, Facilities, NR-10.

## 1 INTRODUCTION

It is an essential step to observe sources of danger for any risk assessment, since once identified the interactions of professionals exposed to a risk due to carrying out their work activity will be questioned in order to estimate the risk of occupational accidents.

In general, risk assessment methods can seem very subjective, unless they make use of risk matrices that organize different data collected in the field. These should then be analysed to obtain a result that scales the relevance or severity of situations or events analysed. When done in an orderly manner it will assist in the decision making process for preventive actions.

The correct application of the ERA method makes it a powerful tool that will demonstrate points of attention for criticality in the analysed system in addition to supporting the more assertive commitment of resources for adjustments.

Therefore, it is of utmost importance that the risk manager is well aware of the nature of the activity being assessed so that he can use the most appropriate method, considering both the application and the reliability of the metrics. This is a challenging task, especially when considering the need to insert field data into predetermined factors, which were not elaborated for that specific activity. The choice of the least suitable methodology or a wrong customization of its matrices can result in addictive results and, consequently, ineffective or inefficient decision making generating loss of time, resources and mainly, compromising the safety index.

Many industrial and commercial premises do not have protocols for occupational health and safety measures. In reality, those installations and services rely on electricity, since electricity is the main source of light, driving force and heat for the modern world.

In Brazil, there is an extensive complex of norms and technical specifications related to the theme, the most evident of which is Regulatory Norm No. 10, included in Ordinance 3214 of June 8, 1978 of the Ministry of Labor, currently the Secretary of Labor. Its main objective is to establish minimum requirements and conditions for safety, control and preventive systems implementable in electrical installations and services, in order to guarantee the safety and health of workers exposed directly or indirectly to the risks and dangers of electricity.

The risks associated with the exposure of professionals to this source of danger require the attention of legislators, inspection bodies and associations specialized in drafting current and precise legislation and technical standards, as well as managers. They should all rigorously contribute in choosing appropriate tools to analyse and evaluate risks enabling actions to be taken in the right sequence and at the right time.

At times, when applying non-specialized risk assessment tools, the occupational safety manager will face inequalities that may represent doubts or discrepancies in the risk matrices. For example, the verification of the severity of an accident where in electrical systems and installations the death factor is the most commonly expected consequence of the unwanted event.

Faced with this scenario, the ERA (Electricity with Risk Assessment) analysis and evaluation method was developed taking into account the HRN (Hazard Rating Number) method in order to better meet the needs for risk assessment in electrical systems, considering its particularities, thus having specific parameters inserted for work with electricity. Its parameterization was conceived considering, specifically, work with electricity, adapting factors and metrics to this reality and applying correction factors (IFC) that make the risk scales, one by one, and the result coefficient (CR) that will more precisely scale the risk identified.

This article will present all the necessary steps for the execution of this method, as well as demonstrating its differential regarding the application of concepts taking into account the needs of the sector.

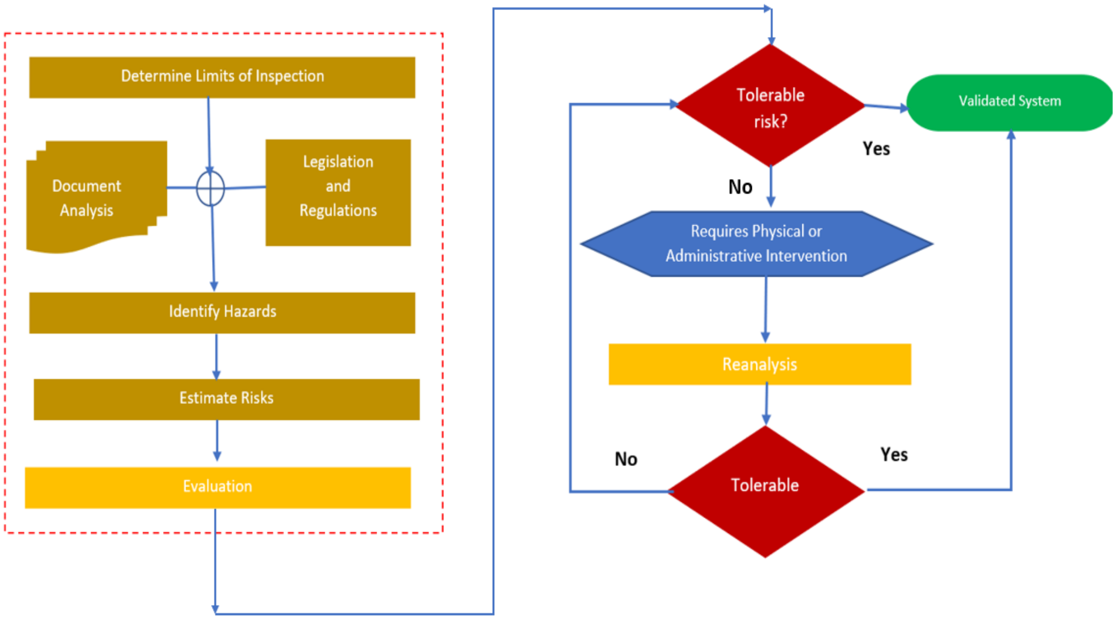
## 2 EXPERIMENTAL PROCEDURE

The principles and guidelines of Occupational Risk Management (ORM) are an integral part of the basic concepts and application of this method. It aims to be a precise and synergistic tool, in line with ISO 45001: 2018, in addition to the main related regulations, such as ABNT NBR ISO 31000:2018; ABNT ISO/IEC 31010:2012; ABNT ISO/TR 31004:2015; ABNT ISO GUIA 73:2009, among others.

The risk assessment is organized so that the electrical system is widely defined, considering its structure, configuration, power and use, and whether employees will have access to it, directly or indirectly. Inspection limits are determined to describe the objectives of the study and which points will be observed in the survey, considering the field data that will be tabulated in the indices determined in the method according to the normative and legal references in force, as well as the documents maintained by the company.

The evaluation begins when the hazards are identified and the risks are recognized and estimated according to the method. After surveying and obtaining the results, the company considers, according to the report, whether the risk will be tolerable or not, and may or may not proceed to the adaptation phase, which will be followed by reanalysis. The method assists in the projection of risk estimates both in the scenario found and in that of full compliance with the technical and legal paradigms.

Figure 1. Flow diagram for risk assessment used to perform the method and present results



## 3 EXPERIMENTAL PROCEDURE

Risk assessment by the ERA method is presented in 2 phases, phase 1 contains four steps and phase 2 five steps. These are all essential for knowledge and analysis of the system in order not only to identify risks and non-conformities, but also to estimate their severity in the scenario found and after recommended adjustments. Each step is subdivided into smaller steps that will help the evaluating professional to quantify the data found in the field.

### 3.1 PHASE 1, STEP 1: DETERMINATION OF THE DEGREE OF CONSEQUENCE

Step 1, the knowledge phase of the system, will identify its dangers and recognize the risks involved in the activities carried out and due to the non-conformities found, determine what consequences are expected in undesired or sinister events as a result of an accident or not. The method considers five possibilities of consequences in case of accidents, based on previous studies of accidents at work and accidents involving electricity that will be observed by the evaluating professional.

Table 1. Flow chart for risk assessment used to perform the method and present results.

| Item | Consequence | Observation |
|---|---|---|
| 1 | Death **(iD)** | Death and / or amputation of limbs due to accidents related to electricity. |
| 2 | Burns **(iB)** | Burns due to the passage of electric current through the human body (electric shock) and / or the explosion of an electric arc. |
| 3 | Fractures due to falls **(iF)** | Fractures due to falls resulting from the accident. They are usually related to activities performed outside on the floor level. Eg - maintenance of a lighting system. |
| 4 | Cuts / Bruises **(iC)** | Minor injuries related to electrical activity caused by sharp parts in electrical panels, live edges of cable trays, etc. |
| 5 | Fires **(iI)** | Sources of fire due to poor sizing or maintenance of the electrical system. |

### 3.2 PHASE 1, STEP 2: CLASSIFICATION OF CONSEQUENCE

Observing the non-conformities evidenced in the analysed scenario, due to the technical and legal paradigms, the consequences of accidents will be investigated based on the established indices, the possibility of each one being estimated, in order to quantify and classify them. The method creates five levels of possibilities that are quantified from 1 to 5. Each possibility must have its level determined, according to table 2.

Table 2. Classification levels of consequence

| Level | Observation | Indicator |
|---|---|---|
| Insignificant | Very low chance of occurrence (≤1%) | 1 |
| Low | Low chance of occurrence (>1% to 10%) | 2 |
| Medium | Moderate chance of occurrence (>10% to 50%) | 3 |
| High | High chance of occurrence (>50% to 80%) | 4 |
| Very High | Very high chance of occurrence, close to certain (>80% to 90%) | 5 |

Table 3. Possibility and level of classification of consequences

| **Possibility** | **Consequence classification - Indicators** | | | | |
|---|---|---|---|---|---|
| | Insignificant | Low | Medium | High | Very High |
| Death | 1 | 2 | 3 | 4 | 5 |
| Burns | | | | | |
| Fractures due to falls | | | | | |
| Fractures / bruises | | | | | |
| Fires | | | | | |

## 3.3 PHASE 1, STEP 3: CALCULATE THE RESULTING VALUE (VR)

Having considered step 2, the values found will be calculated to give the resulting value (VR). This is the product of the multiplication of the indices attributed to the consequences due to the probability estimated or investigated by histories presented according to Eq. (1).

$$VR = iD \times iB \times iF \times iC \times iI \qquad (1)$$

The resulting value is in the range 1 to 3125.

## 3.4 PHASE 1, STEP 4: DEFINITION OF THE RESULTING INDEX (IR)

Once the VR is found, the resulting index (IR) determined by table 4 will be defined.

Table 4. Resulting value (VR) and resulting index (IR).

| Resulting Value(VR) | Resulting Index (IR) |
|---|---|
| 1 a 31 | 2 |
| 32 a 242 | 5 |
| 243 a 1023 | 10 |
| 1024 a 3125 | 15 |

## 3.5 PHASE 2, STEP 1: DEFINITION OF THE RESULTING INDEX (IR)

Having determined and classified the possibilities of each consequence, the application of the method proceeds to Phase 2, which will quantify factors such as probability of accidents, frequency of exposure to associated risks and the correction factor, which acts as a mitigating or aggravating index of the assessed data.

To determine the possibility of an event, as defined by ABNT NBR ISO 31000, is to ascertain the “chance of something happening”, regularly in an empirical way, as it is not measured or determined even if objectively or subjectively, qualitatively or quantitatively. However, it is strongly recommended that reliable databases are used for this, such as the company's history or indexes of specialized associations or supervisory bodies.

The probability of occurrence (PO) as used in this method is valid as a reference for the parameters defined by the HRN methodology, see table 5.

Table 5. Probability of occurrence (PO).

| **Probability of occurrence - (PO).** | | |
|---|---|---|
| **Level** | **Observation** | **Index** |
| Not expected | Taking into account the current conditions of the facilities, the procedures and the technical training of the professionals who will interact, the accident is not expected. | 1 |
| Possible | In the current conditions of the facilities, in the event of misuse, failure to comply with good maintenance practices and / or non-compliance with operating procedures, an accident is possible. | 2 |
| Expected | In the current conditions of the facilities, if there is any mistake from the point of view of intervention (considering at least trained professionals) or specification of devices, the accident is expected. | 4 |
| Certain | Considering the current conditions of the facilities, the lack of operational and safety procedures, the interaction by untrained and / or qualified professionals, the environmental conditions of the place and the frequency of interaction, the accident or accident can occur at any time. | 8 |

## 3.6 PHASE 2, STEP 2: DETERMINING THE FREQUENCY OF EXPOSURE

The frequency of exposure aims to quantify the periodicity of intervention in the electrical installations under consideration so that the conjuncture of the analysed documentation and collected field data can estimate, within the regular work cycle, the maintenance history (corrective and preventive) and other procedures achievable. The exposure frequency (FE) of this method uses the parameters defined by the HRN methodology, as shown in table 6.

Table 6. Exposure frequency (FE).

| **Exposure frequency - FE** | | |
|---|---|---|
| **Repetition** | **Observação** | **Index** |
| Annual | Activity occurs few times a year | 2 |
| Monthly | Activity occurs one or more times a month | 4 |
| Weekly | Activity occurs 2 or more times a week | 6 |
| Daily | Activity is repeated daily | 8 |

## 3.7 PHASE 2, STEP 3: DETERMINING THE NUMBER OF PEOPLE INVOLVED

The index declares the number of people directly involved in the intervention processes or exposed to risks, identifying how many professionals are normally connected with the intervention in the analysed facilities. Although there may be seasonality depending on the type of intervention, the choice of the number should consider an average frequency of exposure.

Table 7. Number of people involved (NP).

| **Number of People - NP** | |
|---|---|
| **Nº People** | **Index** |
| 1 | 2 |
| 2 | 4 |
| 3 | 6 |
| 4 | 8 |
| Above 4 | 10 |

## 3.8 PHASE 2, STEP 4: CALCULATION OF THE CORRECTION FACTOR INDEX (IFC)

The correction factor index (IFC) has the scope to import additional factors evidenced in the field for the method quantifications that may represent mitigating or aggravating facts and that should contribute to the evaluation result.

There can be evidence such as administrative and operational procedures of the activities performed, or characteristics of the system or its use that can be collected in the field and which can be seen, in the eyes of the evaluator, as modifying factors in the scenario considered. The method cites three examples of factors:

- Intervention factor;
- Qualification factor;
- Documentary factor.

The intervention factor (fI) takes into account whether interventions in electrical systems are carried out with the system de-energized, energized or with the installations energized only for preventive inspection activities (measurements and thermographs) performed by qualified professionals.

Table 8. Intervention factor (fI)

| | Description | fI |
|---|---|---|
| **Intervention Factor** | Intervention only with de-energized installations | 0,1 |
| | Intervention with the installation energized only for preventive inspections (thermography and measurements) performed by a qualified professional | 1 |
| | Interventions with energized installations | 2 |

The qualification factor (fQ) considers that interventions in the electrical system are carried out by trained professionals, qualified or not, who will be able or not to identify risk situations to which they are exposed in the different circumstances they may encounter.

It is important to note that when choosing this factor, the appraiser must observe the requirements established by item 10.8 of NR10, as well as by table 18 of ABNT NBR 5410 (Low voltage electrical installations).

Table 9. Qualification factor (fQ)

| | Description | fQ |
|---|---|---|
| **Qualification Factor** | Only by trained, qualified and or qualified professionals | 0,1 |
| | Sometimes by untrained, qualified or qualified professionals in the electrical field (eg machine operators, mechanics) | 1 |
| | Any unannounced personnel (general public) | 2 |

The documentary factor (fD), observable at the beginning of the risk assessment, indicates that there are elements that demonstrate that the company has standardized and formalized operating procedures. They demonstrate the existence of continuing education mechanisms or other measures made available to workers to know and fulfil their obligations, processes within well-defined security protocols. It is important to note that the documents analysed must demonstrate agreement with good technical practices in the electricity sector and occupational safety, as well as the legislation in force.

Table 10. Documentation factor ( fD )

| | Description | fD |
|---|---|---|
| Documentation Factor | It has operational procedures prepared by a qualified professional, in particular: de-energization procedure, Lockout/Tagout | 0,1 |
| | It does not have a procedure, or if it does, it was not possible to evidence its use in practice | 5 |

All correction factors (IFC) will be the product of their multiplication after careful consideration and with clear evidence, according to equation (2).

$$IFC = fI \times fQ \times fD \qquad (2)$$

As with the application of the index, a scenario can be conceived where there is an electrical panel with an exposed bus, non-compliance with a high risk of accident and an easily measurable consequence. However, this scenario changes when there is intervention performed only by qualified professionals, guided by documented procedures and with the electrical panel de-energized. The IFC will assist the assessor in demonstrating the decreased likelihood of accidents, improving subtle differences between different circumstances.

## 3.9 PHASE 2, STEP 5: CALCULATION OF THE RESULT COEFFICIENT ( CR )

The evaluator will obtain the result coefficient (CR) using the quantification factors, as shown in the tables, once all the information necessary for the evaluation has been collected in the field and when all stages of both steps of the method have been completed. The index represents the trend of the electrical system. When the procedures and personnel with access to the field of study are included it indicates the possibility of work accidents or other accidents occurring, under the conditions found in the field survey.

$$CR = IR \times PO \times FE \times NP \times IFC \qquad (3)$$

The resulting value is within the range of 0.008 to 192000.

The CR resulting from the risk assessment is classified according to table 11:

Table 11. Classification of the risk assessment ( CR )

| Risk assessment rating | |
|---|---|
| **Classification** | **CR Index** |
| Insignificant | ≤5 |
| Low | 6 to 50 |
| High | 51 to 150 |
| Extreme | 151 to >800 |

In which:

• **Insignificant:** the calculated risk shows that the likelihood of an accident occurring is very remote. It does not require actions, as long as the current conditions of the electrical system are maintained.

• **Low:** the calculated risk represents some chance of an accident or accident occurring, but requires immediately, only administrative actions such as signalling, training, procedures and, in the medium term, forecast of corrective actions.

• **High:** the risk of accident or accident is accentuated, so that corrective and administrative actions need to be foreseen in the short term.

• **Extreme:** the risk of an accident or accident is expected at any time, so that immediate corrective and administrative actions become necessary; if necessary, the site can be banned.

The method can be used in small, medium and large companies with significant improvement in the understanding of those responsible for the decision making when determining the adequacy of processes for electrical systems, assisting occupational safety managers in this endeavour.

As there is a prediction in the method in its application to indicate the non-conformities found and calculate the current scenario, at the same time projecting the one in which there are necessary improvements according to the technical and legal paradigm, the re-evaluation process becomes faster, allowing the validation of the system to be made more quickly.

Evaluation by the ERA method takes into account the current conditions of the scenario of electrical installations and observes the criteria that the company uses to intervene in this scenario. In this way, it is able to arrive at a precise and real risk assessment. In order to determine the consequences used in the method, a field research was carried out, mapping consequences due to the non-conformities presented in the inspected facilities.

With the application of the method it is possible to identify the real scenario related to the accident or risk of accident with electricity, and in this way, companies are able to put in place an appropriate action plan, being possible to prioritize simple risk reduction actions. The method is also a powerful risk assessment tool for insurance companies and auditors.

The model presented by the method is considered quantitative, depending on the values applied to all indicators.

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