

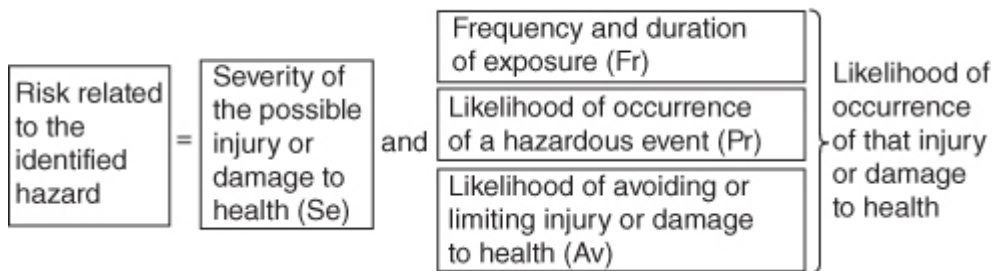
## ELECTRICAL SAFETY RISK ASSESSMENT

The intent of this procedure is to perform a risk assessment, which includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk. A risk assessment should be performed before work is started.

### Risk Assessment Steps

1. Identify the electrical hazards associated with the task and the electrical system, or electrical process involved (example: shock hazard risk; arc flash hazard risk).
2. Identify the electrical work to be performed within the electrical system or process.
3. Define the possible failure modes that result in exposure to electrical hazards and the potential resultant harm.
4. Assess the severity of the potential injury from the electrical hazards.
5. Determine the likelihood of the occurrence for each hazard.
6. Define the level of risk for the associated hazard.
7. If the level of risk is not acceptable, identify the additional measures or corrective actions to be taken. Example: wear appropriate PPE and if the risk too great, do not perform the task.

The risk related to an identified hazard may be thought of as being composed of the severity of the injury and the likelihood of occurrence of that injury.



**Figure 1 Elements of Risk**

### Risk Assessment Calculation

Following are two examples of methods that can be used to conduct electrical risk assessments.

In the first, **The Risk Register Method**, the risk is derived using the risk parameters as shown in Figure 1. In the second, the risk is derived from using a **Risk Assessment Matrix** as shown in Figure 2.

#### Risk Register Method:

1. Severity of the Possible Injury or Damage to Health (Se) – Severity of injuries or damage to health can be estimated by taking into account reversible injuries, irreversible injuries, and death. Typically, the types of hazards to be considered include, but are not limited to, electrical shock and electrocution, burns, and impact. Choose the appropriate Severity value from Table 1 below. Add value to the Risk Register (Table 5)

Severity of Injury of Damage to Health	Se Value
Irreversible – trauma, death.	8
Permanent – skeletal damage, blindness, hearing loss, third degree burns.	6
Reversible – minor impact, hearing damage, second degree burns.	3
Reversible – minor laceration, bruises, first degree burns.	1

**Table 1**

2. Frequency and Duration of Exposure (Fr) - The following aspects should be considered to determine the level of exposure:

- a. Need for access to the hazard zone based on all modes of use; for example, normal operation and maintenance
- b. Nature of access, for example, examination, repair, and troubleshooting.

Choose the appropriate Frequency value from Table 2 below. Add value to the Risk Register (Table 5)

Frequency of Exposure	Fr Value (for Duration > 10 min)
≤ 1 per hour	5
> 1 per hour to ≤ 1 per day	5
> 1 per day to ≤ 1 every 2 weeks	4
> 1 every 2 weeks to ≤ 1 per year	3
> 1 per year	2

**Table 2**

3. Likelihood of Occurrence of a Hazardous Event (Pr) – The occurrence of a hazardous event influences the likelihood of the occurrence of injury or damage to health. The possibility of the hazardous occurring should describe the likelihood of the event materializing during the use or foreseeable misuse, or both, of the electrical system or process. Subjectivity may have a substantial impact on the result of the risk assessment. The use of subjective information should be minimized as far as reasonably practicable.

The likelihood of occurrence of the hazardous event should be estimated independently of other related parameters (Fr and Av) and will typically be based on the results of the completed study of the arc flash potential. The worst-case scenario should be used for this parameter to ensure that short-circuit interruption device(s) have, where practicable, been properly selected and installed and will provide adequate protection.

Elements of the electrical system that are intended to ensure an intrinsically safe design shall be taken into consideration in the determination of the likelihood of the hazardous event(s). These can include, but are not limited to, the mechanical structure, electrical devices, and electronic controls integral to the system, the process, or both at the time of the analysis. Types of components that could contribute to an inherently safe design include, but are not limited to, current-limiting devices and ground-fault circuit interrupters.

This parameter can be estimated by taking into account the following factors:

- a. The predictability of the performance of component parts of the electrical system relevant to the hazard in different modes of use (e.g., normal operation, maintenance, fault finding).  
At this point in the risk assessment process, the protective effect of any personal protective equipment (PPE) and other protective measures should not be taken into account. This is necessary in order to estimate the amount of risk that will be present if the PPE and other protective measures are not in place at the time of the exposure. In general terms, it must be considered whether the electrical system being assessed has the propensity to act in an unexpected manner. The electrical system performance will vary from very predictable to not predictable. Unexpected events cannot be discounted until it can be clearly demonstrated that the electrical system will perform as expected.
- b. The specified or foreseeable characteristics of human behavior with regard to interaction with the component parts for the machine relevant to the hazard, which can be characterized by one or both of the following:
  - i. Stress (e.g., due to time constraints, work task, perceived damage limitation).
  - ii. Lack of awareness of information relevant to the hazard.

Human behavior will be influenced by factors such as skills, training, experience, and complexity of the machine or the process.

These attributes are not usually directly under the influence of the electrical system designer, but a task analysis will reveal activities in which total awareness of all issues, including unexpected outcomes, cannot be reasonably assumed. “Very high” likelihood of occurrence of a hazardous event should be selected to reflect normal workplace constraints and worst-case considerations. Positive reasons (e.g., well-defined application and a high level of user competence are required for any lower values to be used.

Any required or assumed skills, knowledge, and so forth, should be stated in the information for use.

Select the appropriate value for Likelihood of Occurrence of Hazardous Event (Pr) from Table 3 below. Add value to the Risk Register (Table 5).

Likelihood of a Hazardous Event	Pr Value
Very high	5
Likely	4
Possible	3
Rare	2
Negligible	1

**Table 3**

Listed below are examples of general questions to consider in determining the likelihood of an event (risk):

- Has the equipment been installed in accordance with *NFPA 70<sup>®</sup>*, *National Electrical Code<sup>®</sup> (NEC<sup>®</sup>)*?
- Has the equipment been maintained and tested in accordance with the manufacturer's instructions?
- How old is the equipment?
- Is there any visual indication of overheating?
- Is any component, device, or equipment loose or damaged?

*The following are enclosure questions:*

- Do all enclosure doors operate and latch properly?
- Does the enclosure have all of its bolts and screws installed?
- Does the equipment or enclosure have ventilation openings?
- Is the enclosure arc rated?
- Are there openings in the enclosure that rodents or other vermin could enter?
- Is there an indication of moisture in the equipment?
- Has the enclosure been examined for dust, dirt, soot, or grease?
- Is there any indication of overheating of the bus work, etc., in the enclosure, such as discoloration?

*The following are circuit breaker (CB) condition questions:*

- Has the CB periodically been operated in accordance with the manufacturer's instructions?
- Has the CB been applied within its marked rating?
- Has the right type of CB been used?
- Have the proper conductor types and sizes been used to connect to the CB?
- Has the CB been checked for burn marks?
- Have the CB surfaces been examined for dust, dirt, soot, grease, or moisture? If any was found, have the CB surfaces been appropriately cleaned?
- Has the CB been examined for cracks?
- Have all electrical connections to the CB been checked to be certain that they are clean and secure?
- Is there any indication of discoloration of the CB's molded case, discoloration or flaking of external metal parts, or melting or blistering of adjacent wire insulation?
- Is there any evidence of overheating or melting of the arc chute vent or area surrounding the vents?
- Is there evidence of overheating or case blistering?
- If the CB has interchangeable trip units, have the trip units been visually checked for overheating or looseness?
- Have mechanical operation tests been performed on the CB and proper contact operation verified?
- Have insulation resistance and/or individual pole resistance (millivolt drop) tests been performed on the CB?
- Have inverse-time and/or instantaneous overcurrent trip tests been conducted on the CB?
- What is the ampere rating of the CB involved?

4. Likelihood of Avoiding or Limiting Injury or Damage to Health (Av) – This parameter can be estimated by taking into account aspects of the electrical system design and its intended application that can help to avoid or limit the injury or damage to health from a hazard, including the following examples:
  - a. Sudden or gradual appearance of the hazardous event; for example, an explosion caused by high fault values under short-circuit conditions.
  - b. Spatial possibility to withdraw from the hazard.
  - c. Nature of the component or system; for example, the use of touch-safe components, which reduce the likelihood of contact with energized parts. Working in close proximity to high voltage can increase the likelihood of personnel being exposed to hazards due to approach to live parts.
  - d. Likelihood of recognition of hazard; for example, as an electrical hazard, a copper bar does not change its appearance, whether it is under voltage or not. To recognize the presence of the hazard, an instrument is needed to establish whether or not electrical equipment is energized; thus both inadvertent and intentional contact need to be considered.

Select the appropriate value for Likelihood of Avoiding or Limiting Injury or Damage to Health (Av) from the Table 4. Add the value to the Risk Register (Table 5).

Likelihood of Avoiding or Limiting Injury or Damage to Health	Av Value
Impossible	5
Rare	3
Probable	1

**Table 4**

**Risk Register – Enter Values from Tables 1, 2, 3 & 4.**

Scenario No.	Hazard	Severity	Probability of Occurrence of Harm $Po = (Fr+Pr+Av)$				Risk Score (R)
		Se	Fr	Pr	Av	Total	Se x Po

**Table 5**

**A Risk Score (R) higher than 10 requires consideration of additional safety controls.**

## Risk Matrix Method

A risk assessment matrix is a simple table that groups risk based on severity and likelihood. It can be used to assess the need for remedial action, such as the use of PPE for a given task, and to prioritize safety issues.

The following title categories are used to define the risk:

### 1. Likelihood of Occurrence:

- a. Definite – Almost certain of happening.
- b. Likely – Can happen at any time.
- c. Occasional – Occurs sporadically, from time to time.
- d. Seldom – Remote possibility; could happen sometime; most likely will not happen.
- e. Unlikely – Rare and exceptional for all practical purposes; can assume it will not happen.

### 2. Severity of Injury:

- a. Catastrophic – Death or permanent total disability (PTD).
- b. Critical – Permanent partial disability (PPD) or temporary total disability (TTD) 3-months or longer.
- c. Medium – Medical treatment and lost work injury (LWI).
- d. Minor – Minor medical treatment possible.

Slight – First aid or minor treatment.	Severity of the injury (consequences)				
	Slight	Minor	Medium	Critical	Catastrophic
Cal/cm <sup>2</sup>	< 1.2	≥ 1.2 to ≤ 8		> 8 to ≤ 40	> 40
Unlikely	L	L	L	M	M
Seldom	L	L	M	M	H
Occasional	L	M	M	H	E
Likely	M	M	H	E	E
Definite	M	H	E	E	E

Figure 2 Risk Assessment Matrix

### 3. Interpretation of Risk Assessment Matrix:

- a. **Extreme (E) - Intolerable risk:** Do not proceed. Immediately introduce further controls. Detailed action plan required. Color code red.
- b. **High (H) - Unsupportable risk:** Review and introduce additional controls. Requires senior management attention. Color code orange.
- c. **Moderate (M) - Tolerable risk:** Incorporates some level of risk that is unlikely to occur. Specific management responsibility. Consider additional controls. Take remedial action at appropriate time. Color code yellow.
- d. **Low (L) - Supportable risk:** Monitor and maintain controls in place. Manage by routine. Procedures. Little or no impact. Color code green.

## Protective Measures

The appropriate protective measures include the following:

- (1) Elimination
- (2) Substitution
- (3) Engineering controls
- (4) Awareness
- (5) Administrative controls (Procedures)
- (6) Training
- (7) Personal Protective Equipment (PPE)
- (8) Mitigation

Examples:

**Elimination:** Eliminate the hazard. Turn the equipment off and verify a safe work condition.

**Substitution:** Think through the entire procedure and substitute methods and procedures that constitute lower risk.

**Engineering Controls:** Engineering controls can have a substantial impact on risk. They should, where practicable, be considered and analyzed. Typically, engineering controls take the form of barriers and other safeguarding devices such as GFCI protection, zone selective interlocking, differential relaying, energy reducing maintenance switches, high resistive grounding, and current limiting devices.

**Awareness:** Awareness means can be used to complement the effects of engineering controls with regard to risk reduction. They should be chosen based on the design configuration for each specific application and their potential effectiveness during foreseen interaction. Each design and configuration can require unique awareness devices in order to have the desired impact on risk. Typically, awareness means take the form of signs, visual alarms, audible alarms, and so forth.

**Administrative Controls (Procedures):** Procedures and instructions that are required for individuals to safely interact with the electrical system should be identified. The procedures and instruction should include descriptions of the hazards, the possible hazardous events, hazardous situations, and the protective measures that need to be implemented. Procedures and instructions should also be used to communicate foreseeable misuse of the system that could contribute to an increased level of risk. Typically, formal procedures are provided in written form; however, in some cases, verbal instruction can be provided. Care should be taken in the latter case to ensure that the verbal instructions will have the desired impact on risk.

**Training:** Training, with regard to the proper interaction and for foreseeable inappropriate interaction with the electrical system, must be completed. The intent of the training is to ensure that all affected personnel are able to understand when and how hazardous situations can arise and how to best reduce the risk associated with those situations. Typically, training for individuals interacting with electrical systems will include technical information regarding hazards, hazardous situations, or both as well as information related to potential failure modes that could affect risk. This type of training generally will be provided by a trainer who has an in-depth understanding of electrical system design, as well as experience in the field of adult education. Less technical training content could be appropriate in situations in which only awareness of electrical hazards is needed to ensure that unqualified personnel do not interact with the electrical system.

**Personal Protective Equipment (PPE):** The electrical system must be analyzed in order to determine the appropriate PPE. Once the appropriate PPE has been determined, personnel must maintain and use it as required in order to ensure that residual risk remains at the desired level. PPE is the last line of defense.

**Mitigation** – Emergency procedures. Identify who is going to provide assistance and summon help if needed.