Risk Assessment Tools for Electrical Work

Introduction

Provided are two options to classify electrical hazards. The first is a standard approach utilized in general risk management processes, and the second is based on the following two documents: Department of Energy Electrical Safety Handbook (2013), Appendix D, and "A Complete Electrical Hazard Classification System and its Application," from *2009 IEEE IAS Electrical Safety Workshop*. This is merely one possible way to designate hazard levels consistently and is not mandatory.

Both methods are discussed in the DRS online training “Electrical Safety: Risk Assessment”. This document is a supplement to, not a substitute for, that training. Also, keep in mind this is a planning tool – low, high, and medium risk are relative terms. They do not give specific actions required but allow you to prioritize your planning and mitigation efforts.

Matrix Method

The matrix method assesses risk based on severity and likelihood of harm.

Likelihood of occurrence of harm	**Severity of harm** Current < 5 mA or Voltage < 50 V	**Severity of harm** Current ≥ 5 mA or Voltage ≥ 50 V
Low / Improbable	**Low Risk**	**Medium Risk**
High / Probable	**Medium Risk**	**High Risk**

Risk Matrix Table

As the table indicates, if current is kept below 5 milliamps and voltage below 50 volts with a low likelihood of occurring, overall risk is low. For the same current and voltage but a high likelihood of occurrence, we assess a medium level of risk. If either current or voltage are above those levels with low probability of occurrence is giving medium risk, and for high probability, we consider the overall risk level high.

DOE Method

A more comprehensive method to determine the level of risk for procedures involving electrical hazards is used by the Department of Energy. Based on their guidelines, the Electrical Hazard Classification System was developed for research laboratories at Illinois. Keep in mind that this is a tool for standardizing classification of various electrical hazards. This has no direct correlation to any formal guidance promulgated in the OSHA or NFPA regulations.

The system uses numbers (**N.n**) to denote categories and hazard levels. The hazard class (**N**) is denoted with a number 1 through 5. The hazard level (severity of the hazard) is denoted with a number (**n**) and color:

Class: N	Hazard Level: n
1: 60 Hz AC power	**0: No hazard**
2: DC	**1: Minimal hazard**
3: Capacitors	**2: Moderate hazard**
4: Batteries	**3: High hazard**
5: Radio Frequencies (RF)	**4: Extreme hazard**

DOE Classification System

The following images provide a way to determine the hazard level for the various classes listed above.

Class 1: 60 Hz power

Primary hazards: shock, arc flash

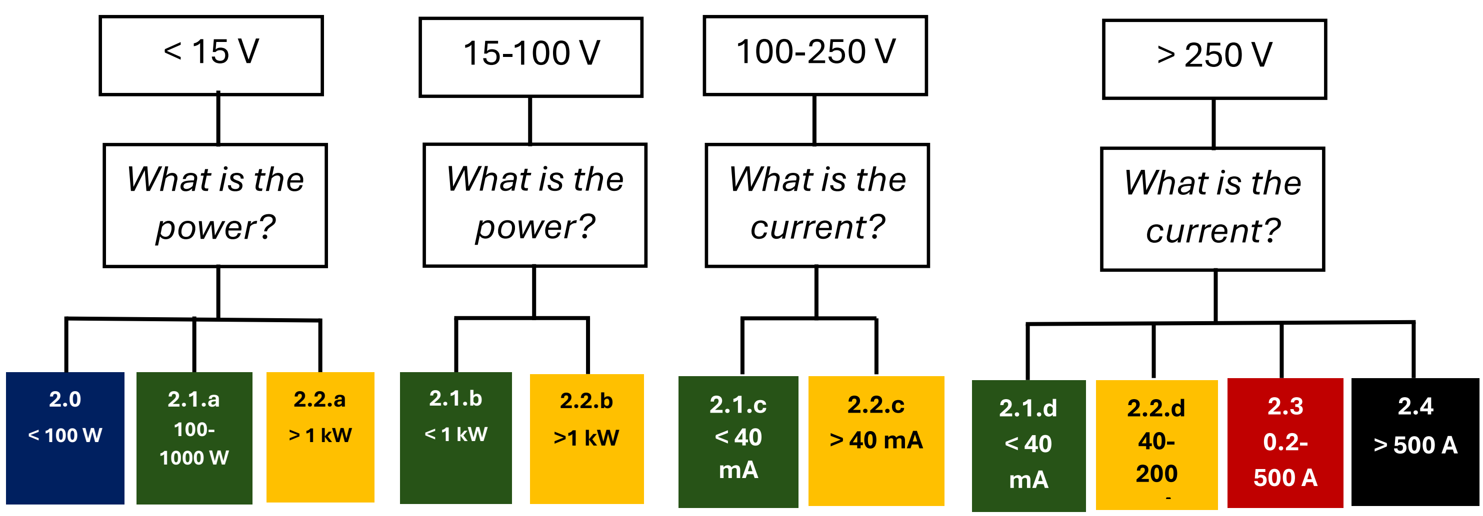
1.0	1.1	1.2	1.3	1.4	1.5
< 12 V	12 - 50 V	50-230 V	230-600 V	> 600 V Facility	> 600 V Utility

Voltages here are root-mean-square values, not peak voltages.

Generally, voltages less than 50 V are not considered hazardous under normal conditions. However, there are some circumstances for which some minimal danger could exist down to 12 V. Dry, intact, skin provides good protection under around 50 V. However, if the skin is wet or broken and an individual has certain preexisting cardiac issues, there is some risk. Since it takes a few unusual conditions, many of which are easily preventable, 12-50 V is considered a **minimal hazard**. 50 to 230 V is considered a moderate hazard. The 230 V boundary between moderate and high hazard comes from the increased arc flash hazard with higher voltage. There are different requirements above 240 V, and the 230 V gives a small buffer under that limit. Many other requirements change at 600V where the risk becomes extreme.

Class 2: DC power

Primary hazards: shock, high current, arc flash



The voltage cutoffs are based on the following:

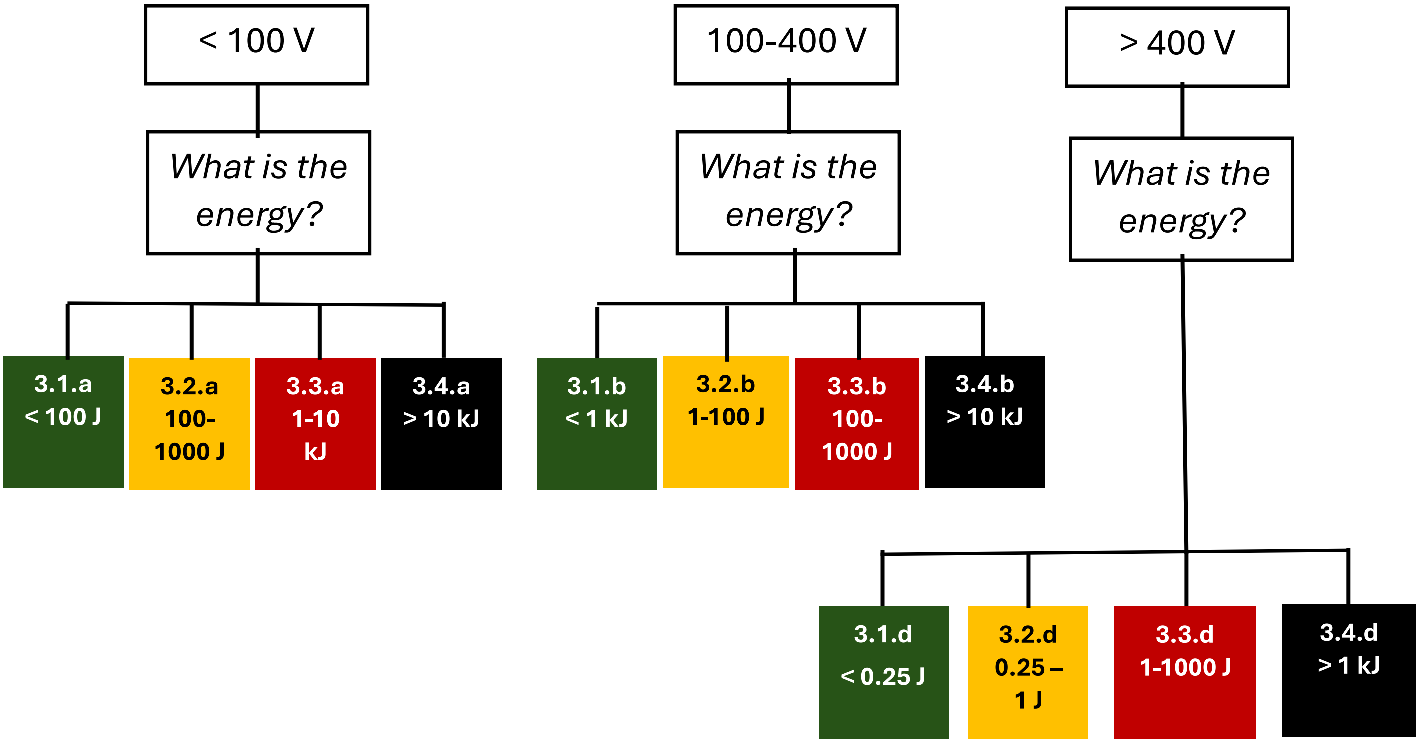
< 15V: Under most circumstances, hazard at these low voltages is zero or minimal due to shock. However, for short circuit powers greater than 1000 W, there is the potential for a thermal burn due to high current through tools, jewelry, etc. For power less than 100 watts, the situation is classified 2.0 (no hazard). For 100 watts through 1 kilowatt, it is classified 2.1.a (minimal hazard), and for greater than 1 kilowatt, we designate it as 2.2.a (moderate hazard).

15-100 V: Hazard due to electric shock is still minimal except, as above, for high power, in which case a thermal burn hazard must be considered. Examples are welders and electromagnet systems. In this range we designate systems less than 1 kilowatt as 2.1.b (minimal hazard), and greater than 1 kilowatt, 2.2.b (moderate hazard).

100-250 V: The main hazard in this region is no longer thermal burn, but electric shock. For DC, current less than 40 mA is considered of minimal risk.

Greater than 250 V: In addition to electric shock hazard, now you must also consider arc flash hazards. Below 40 mA current, this hazard is minimal. Between 40 – 200 mA arc hazard risk is still low, but now we are above the let-go threshold, so if exposed to a voltage, the worker may be unable to let go. From 0.2-500 A, arc flash becomes a serious concern, and the shock hazard becomes more serious in terms of effects on the heart. Above 500 A, there are no additional hazards, but the risks and effects discussed in the previous range are more severe.

Class 3: Capacitors: shock, high current, arc flash, inductive forces



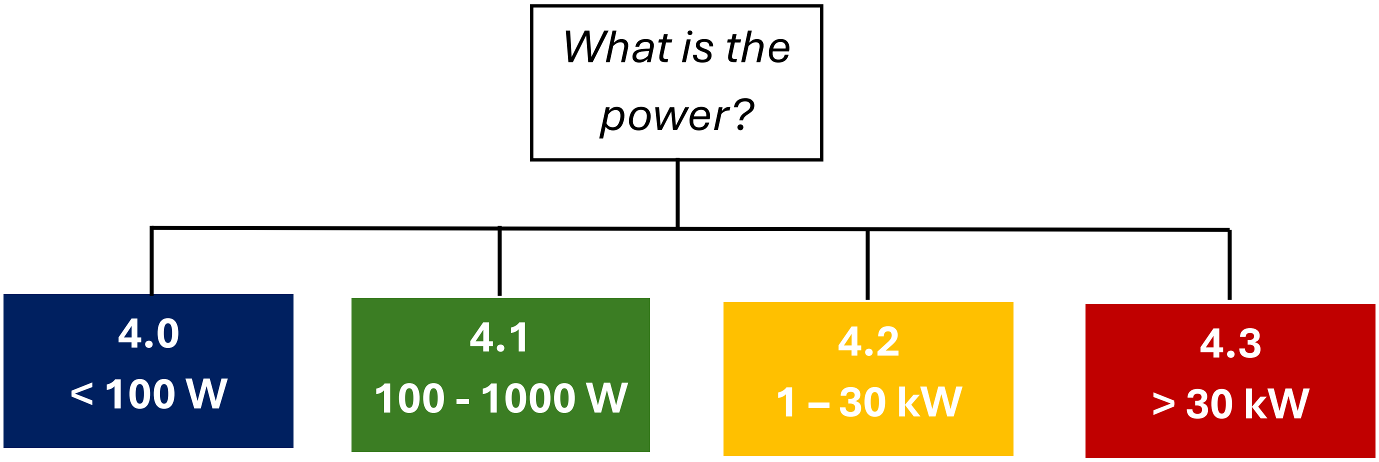
Below 100 V_{dc}, as stated above, hazard due to shock, specifically, from DC is minimal except for some special circumstances. A capacitor will discharge until all, or most of, the energy stored has been discharged. Even if the shock hazard itself is small, there are other potential sources of danger. The primary danger below 100 V is thermal burns due to the heating of metal. This is assessed as minimal if the total energy stored in the capacitor is less than 100 joules, moderate between 100 – 1,000 joules, high from 1 – 10 kilojoules, and extreme above 10 kilojoules.

Between 100 – 400 volts, shock is the main hazard. In this range, the hazard with less than 1 kilojoule of stored energy is minimal, 1-100 joules is moderate, 100 – 1000 joules is high, and greater than 10 kilojoules is extreme.

400 V is close to the skin breakdown voltage. Below this, dry skin's resistance is good protection of interior tissue, but above this, the voltage can damage the skin, allowing the voltage to be applied across the much lower internal resistance. Even at these high voltages, with very low total energy (0.25 J), the reflex action is likely to provide protection from shock and thermal burns, so this is still considered minimal hazard. 0.25 – 1 joules yields a moderate hazard, 1-1000 joules a high hazard, and greater than 1000 J an extreme hazard.

Class 4: Batteries (lead acid)

Primary hazards: high current, arc flash, chemical, explosive hazard



This category is specifically for use with batteries below 100 V. For higher voltages, use category 2 above (DC hazards). The primary hazard of a battery is due to a high current through tools or jewelry. As examples, portable batteries (AAA, AA, C, D) typically have available short circuit power in the 10's of W and are categorized as no hazard. A car battery, due to its available fault power on the order of 10 kW would present a moderate hazard. More specifically, available power less than 100 watts, we consider no hazard to exist. For 100 watts up to 1 kilowatt, we assess the hazard as minimal. If power is between 1 and 30 kilowatts, the hazard is moderate, and above 30 kilowatts, the hazard level is considered high.

References

- Department of Energy Electrical Safety Handbook (2013)
- L. B. Gordon and L. Cartelli, "A Complete Electrical Hazard Classification System and its Application," *2009 IEEE IAS Electrical Safety Workshop*, St. Louis, MO, **2009**, 1-12. DOI: 10.1109/ESW.2009.4813972