3.3 Hazard Class 1.x, 50-60 Hz Nominal Power

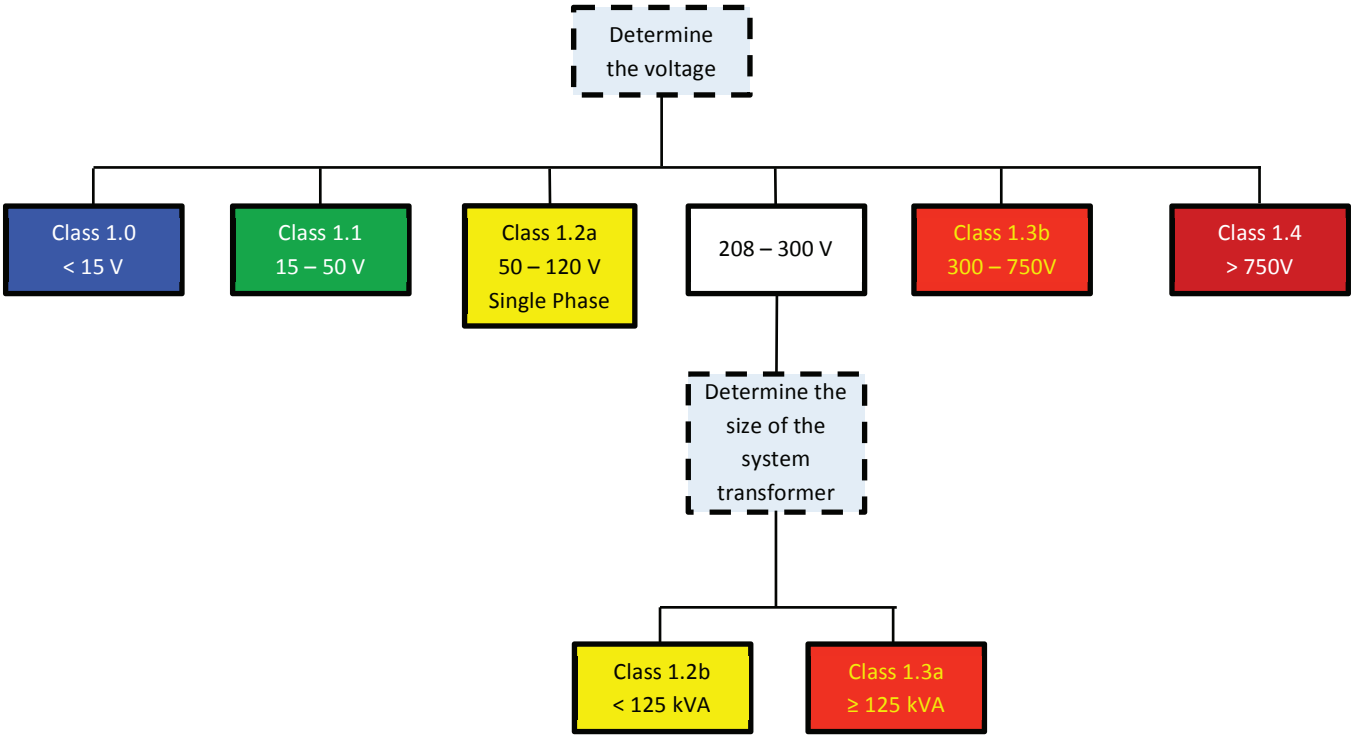

Fig. 3.3. Hazard Classes 1.x, for 50-60 Hz Nominal Power

Notes on use:

1. The voltage is the root mean square (rms) voltage.
2. For current limited 50-60 Hz circuits (≤5 mA), use hazard Class 6.x, Sub-RF.

Table 3.3. Control Table for Work in Hazard Classes 1.x, 50-60 Hz AC Nominal Power

Class	Mode	Two-Person	QEW Level	Work Control	PPE
1.0 <15 V	All	Alone	Non-QEW	None	None
1.1 15–50 V	All	Alone	Non-QEW	None	None
1.2a 50–120 V Single Phase	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[2]
	2	Standby Person[1]		YES	
	3	Safety Watch		YES, EEWP	
1.2b 208–300 V 3-Phase <125 kVA	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[2]
	2	Standby Person[1]		YES	
	3	Safety Watch		YES, EEWP	
1.3a 208–300 V ≥125 kVA	0	Alone	QEW 2	LOTO	None
	1	Standby Person		YES	Shock[2], Arc Flash[3]
	2	Safety Watch		YES	
	3	Safety Watch		YES, EEWP	
1.3b 300–750 V	0	Alone	QEW 2	LOTO	None
	1	Standby Person		LOTO	Shock[2], Arc Flash[3]
	2	Safety Watch		YES	
	3	Safety Watch		YES, EEWP	
1.4 >750 V	0	Alone	QEW 3	LOTO	None
	1	Standby Person		LOTO, ESWP	Shock[2], Arc Flash[3]
	2	Safety Watch		ESWP	
	3	Safety Watch		YES, EEWP	

[1] Mode 2 in Class 1.2 may be performed alone, if proper voltage rated gloves and leather protectors are worn.
[2] Determine PPE by performing a shock hazard analysis using methods covered in Section 7.1.
[3] Determine PPE by performing an arc flash hazard analysis using methods covered in Section 8.1.

3.4 Hazard Class 2.x, DC

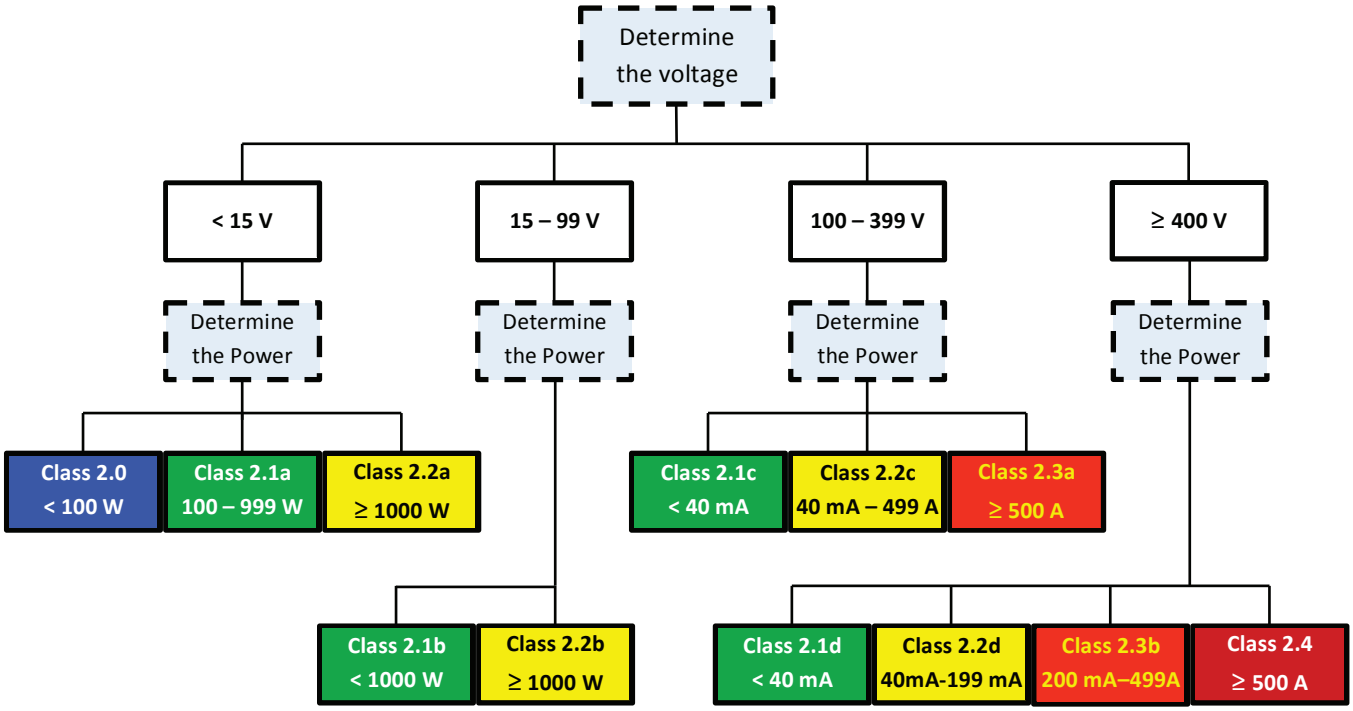

Fig. 3.4 Hazard Classes 2.x, DC

Notes on use:

1. The voltage is the DC voltage.
2. Power is available short-circuit power.
3. Current is available short-circuit current.
4. Most equipment supplying DC also needs to be evaluated for capacitance hazards in Class 3.x.

Table 3.4. Control Table for Work in Hazard Classes 2.x, DC

Class	Mode	Two-Person	QEW Level	Work Control	PPE
2.0 ≤15 V, ≤100 W	All	Alone	Non-QEW	None	None
2.1a,b,c,d ≤100 V, ≤1 kW or >100 V, ≤40 mA	All	Alone	Non-QEW	None	None
2.2a ≤15 V >1 kW	All	Alone	Non-QEW	None	None
2.2b 15–100 V >1 kW	All	Alone	Non-QEW	LOTO	None
		Alone		LOTO	Insulated tools, gloves
		Alone		NO	Insulated tools, gloves
		Alone		NO	Insulated tools, gloves
2.2c 100–400 V 40 mA–500 A	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[1]
	2	Standby Person		YES	
	3[3]	Safety Watch		YES, EEWP	
2.2d >400 V 40–200 mA	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[1]
	2	Standby Person		YES	
	3[3]	Safety Watch		YES, EEWP	
2.3a 100–400 V >500 A	0	Alone	QEW 1	LOTO	None
	1	Standby Person		LOTO	Shock[1], Arc Flash[2]
	2[3]	Safety Watch		YES	
	3[4]	Safety Watch		YES, EEWP	
2.3b >400 V 200 mA–500 A	0	Alone	QEW 2	LOTO	None
	1	Standby Person		LOTO	Shock[1], Arc Flash[2]
	2[3]	Safety Watch		YES	
	3[4]	Safety Watch		YES, EEWP	
2.4 >400 V >500 A	0	Alone	QEW 2	LOTO	None
	1	Standby Person		LOTO	Shock[1], Arc Flash[2]
	2[4]	Safety Watch		YES	
	3[4]	Safety Watch		YES, EEWP	

[1] Determine PPE by performing a shock hazard analysis using methods covered in Section 7.1.
[2] Determine PPE by performing an arc flash hazard analysis using methods covered in Section 8.1.

e. [3] DO NOT move probes while energized.

f. [4] This mode of work should be avoided.

3.5 Hazard Class 3.x, Capacitors

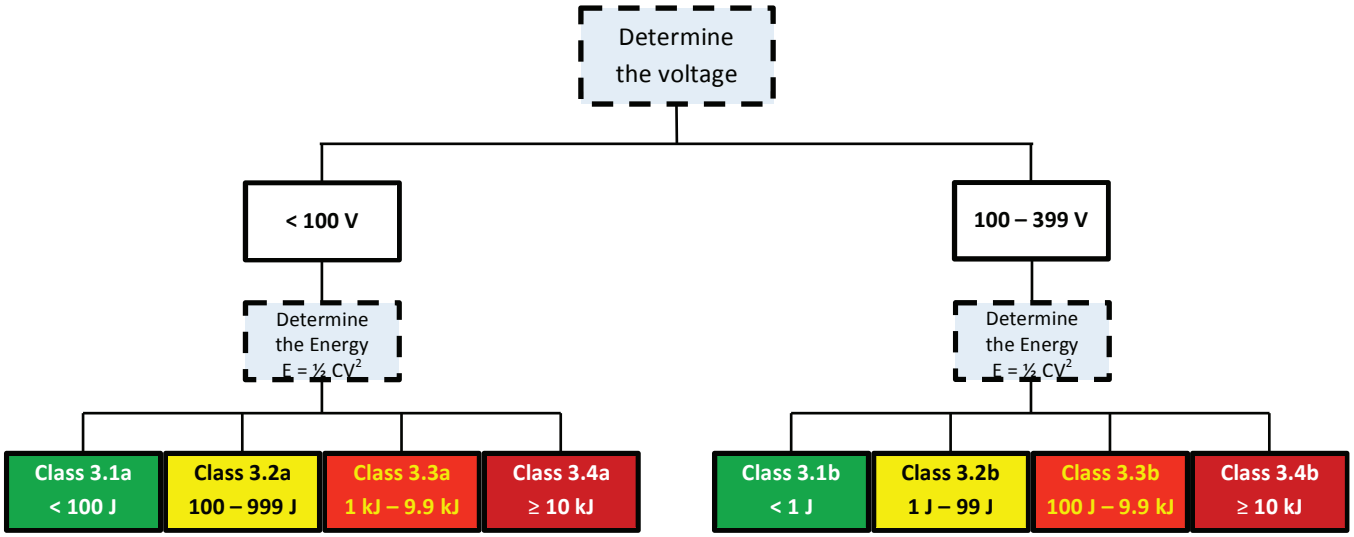

Fig. 3.5a – Hazard Classes 3.x, Capacitors, <400 V

Notes on use:

1. Voltage is peak of the AC, peak impulse or DC maximum charge voltage on the capacitor.
2. Energy is maximum energy stored in the capacitor as determined by $E = ½ CV^2$.
3. The hazards for less than 100 V, Classes 3.2a, 3.3a, 3.4a, are high current through a short circuit, such as tools and jewelry.
4. The hazards for 100 – 399 V, Classes 3.2b, 3.3b, 3.4b, are high current through a short circuit, and a shock hazard.
5. Class 3.4b has an added hazard of mechanical damage due to high currents and strong pulsed magnetic forces during a short circuit.

Table 3.5a. Control Table for Work in Hazard Classes 3.x, Capacitors (< 400 V)

Class	Mode	Two-Person	QEW Level	Work Control	PPE	Stored Energy Removal
3.1a < 100 V < 100 J	All	Alone	Non-QEW	None	None	
3.1b 100 – 399 V < 1 J	All	Alone	Non-QEW	None	None	
3.2a < 100 V 100 J – 999 J	0	Alone	QEW 1 + Capacitor Safety	LOTO	None	
	1	Alone		LOTO	Eye, No Jewelry	Soft Ground Hook
	2	Standby Person		YES	Eye, No Jewelry	
	3	Safety Watch		YES	Eye, No Jewelry	
3.2b 100 – 399 V 1 –99 J	0	Alone	QEW 1 + Capacitor Safety	LOTO	None	
	1	Alone		LOTO	Insulated tools, gloves	Soft Ground Hook > 5 J
	2	Standby Person		YES	Insulated tools, gloves	
	3	Standby Person		YES, EEWP	Insulated tools, gloves	
3.3a < 100 V 1 kJ –9.9 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, No Jewelry	Soft Ground Hook > 5 J
	2	Safety Watch		YES	Eye, No Jewelry	
	3	Safety Watch		YES, EEWP	Eye, No Jewelry	
3.3b 100 – 399 V 100 J –9.9 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, Insulated tools, gloves	Soft Ground Hook
	2	Safety Watch		YES	Eye, Insulated tools, gloves	
	3[4]	Safety Watch		YES, EEWP	Eye, Insulated tools, gloves	
3.4a <100 V ≥ 10 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, No Jewelry	Remote grounding
	2[3]	Safety Watch		YES	Eye, No Jewelry	Remote testing
	3[4]	Safety Watch		YES, EEWP	Eye, No Jewelry	
3.4b 100 – 399 V ≥ 10 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, Ear, shock[1], arc flash[2]	Remote grounding
	2[3]	Safety Watch		YES	Eye, Ear, shock[1], arc flash[2]	Remote testing
	3[4]	Safety Watch		YES, EEWP	Eye, Ear, shock[1], arc flash[2]	

[1] Determine PPE by performing a shock hazard analysis using methods covered in Section 7.1.
[2] Determine PPE by performing an arc flash hazard analysis using methods covered in Section 8.1.
[3] This mode of work should be avoided or done remotely.
[4] This mode of work should be avoided.

Notes on use:

1. PPE–eye is proper eye protection, either goggles or a face shield, for higher energies.
2. PPE–no jewelry for low voltage capacitors, means no jewelry on the hands (e.g., rings, watches) and no dangling jewelry or other objects (e.g., badge).
3. Column 'Stored Energy Removal' is the method used to discharge lower-energy capacitors, or apply a safety ground on higher-energy capacitors.
4. "Remote grounding" means using engineering methods to discharge and verify the capacitors without worker exposure (e.g., a capacitor remote "dump" or discharge system).
5. "Remote testing" means using sensors and instruments that are placed during a Mode 0 condition, then observed from a safe location during Mode 2 work.

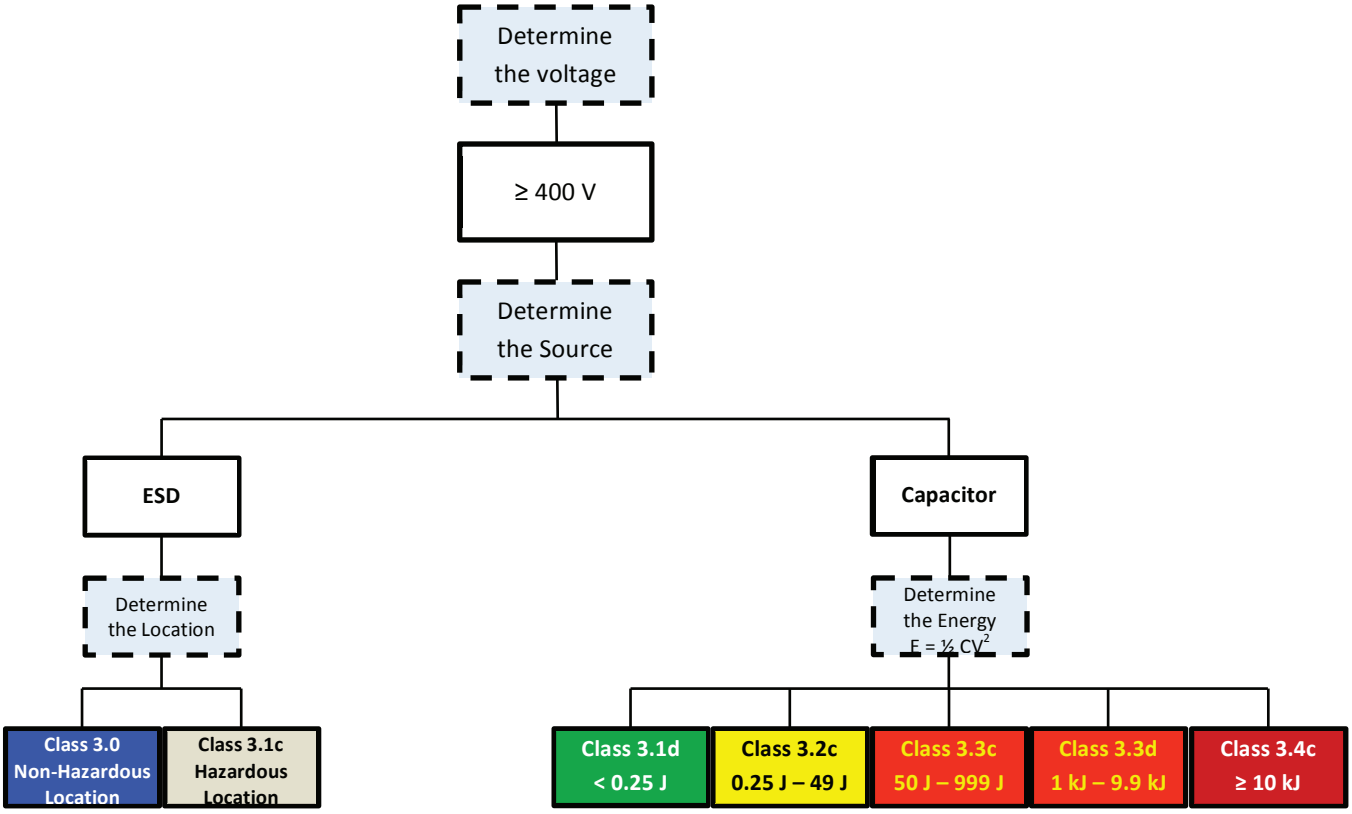

Fig. 3.5b. Hazard Classes 3.x, Capacitors, >400 V

Notes on use:

1. Voltage is peak of the AC, peak impulse or DC maximum charge voltage on the capacitor.
2. Energy is maximum energy stored in the capacitor as determined by $E = ½ CV^2$.
3. The hazards for greater than 400 V, Classes 3.2c, 3.3c, 3.3d, 3.4c are high current through a short circuit, and a shock hazard with a strong reflex action for Class 3.2c, and serious tissue injury and/or death for 3.3c and above.
4. Class 3.3d and 3.4c have the added hazards of mechanical damage due to high currents and strong pulse magnetic forces during a short circuit.
5. For Class 3.1c, the hazard is not electrical; refer to an explosive or hazardous location SME to manage the hazard.

Table 3.5b. Control Table for Work in Hazard Classes 3.x, Capacitors (≥ 400 V)

Class	Mode	Two-Person	QEW Level	Work Control	PPE	Stored Energy Removal
3.0–ESD	All	Alone	Non-QEW	None	None	
3.1d ≥ 400 V < 0.25 J	All	Alone	Non-QEW	None	None	
3.1c[1] – ESD Haz Loc	All	For Class 3.1c refer to explosive safety SME.				
3.2c ≥ 400 V 0.25 J – 49 J	0	Alone	QEW 1 + Capacitor Safety	LOTO	None	
	1	Alone		LOTO	Shock[1]	Soft Ground Hook > 5 J
	2[3]	Standby Person		YES	Shock[1]	
	3	Safety Watch		YES, EEWP	Shock[1]	
3.3c ≥ 400 V 50 J – 999 J	0	Alone	QEW 1 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, Ear, Shock[1]	Soft Ground Hook
	2[4]	Safety Watch		YES	Eye, Ear, Shock[1]	
	3	DO NOT do this mode of work.				
3.3d ≥ 400 V 1 kJ –9.9 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, Ear, Shock[1]	Soft Ground Hook > 5 J
	2[4]	Safety Watch		YES	Eye, Ear, Shock[1]	
	3	DO NOT do this mode of work.				
3.4c ≥ 400 V ≥ 10 kJ	0	Alone	QEW 2 + Capacitor Safety	LOTO	None	
	1	Standby Person		LOTO	Eye, Ear, Shock[1], Arc Flash[2]	Remote grounding
	2[6]	Safety Watch		YES	Eye, Ear, Shock[1], Arc Flash[2]	Remote testing
	3	DO NOT do this mode of work.				

[1] Determine PPE by performing a shock hazard analysis using methods covered in Section 7.1.
[2] Determine PPE by performing an arc flash hazard analysis using methods covered in Section 8.1.
[3] This mode of work should be done remotely.
[4] Do this mode of work remotely.

Notes on use:

1. PPE–eye is proper eye protection, either goggles or a face shield, for higher energies.
2. PPE–no jewelry for low voltage capacitors, means no jewelry on the hands (e.g., rings, watches) and no dangling jewelry or other objects (e.g., badge).
3. Column 'Energy Removal' is the method used to discharge lower-energy capacitors, or apply a safety ground on higher-energy capacitors. See definitions of hard and soft ground hooks.
4. "Remote grounding" means using engineering methods to discharge and verify the capacitors without worker exposure (e.g., a capacitor remote "dump" or discharge system).
5. "Remote testing" means using sensors and instruments that are placed during a Mode 0 condition, then observed from a safe location during Mode 2 work.

3.6 Hazard Class 4.x, Batteries <100 VDC

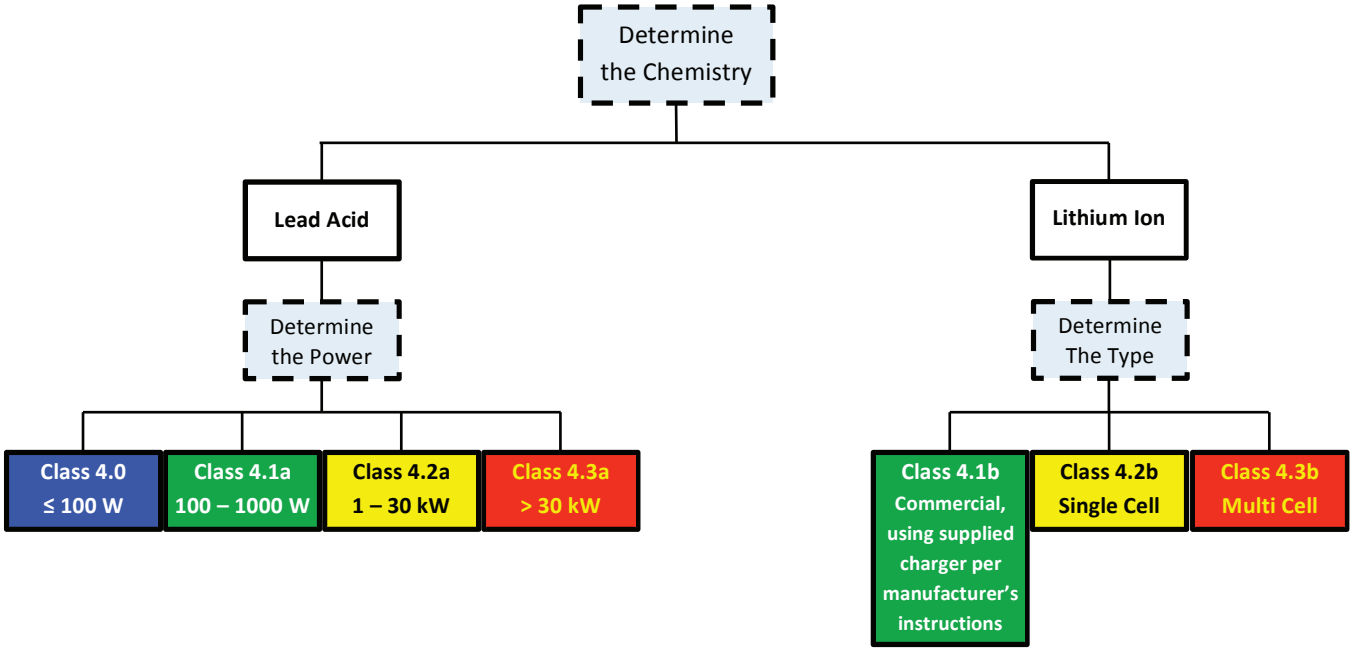

Fig. 3.6. Hazard Classes 4.x, Batteries and Battery Banks <100 VDC

Notes on use:

1. For battery systems ≥ 100 VDC, use hazard Classes 2.x to categorize the shock hazard.
2. Power is the short circuit available power from the battery.
3. There can be no Mode 0 or 1 for batteries, as they are always energized.
4. Additional PPE is necessary for vented lead-acid batteries, depending on the work activity (e.g., chemical PPE).
5. Although all work on Class 4.2 (e.g., automotive batteries) is Energized Work, some of this work (e.g. jump starting cars) is commonly done by the public. Caution should be used, however, and appropriate training and controls in place.
6. Some class 4.2 batteries (e.g., desktop UPS batteries) may have adequate engineering controls, such as recessed terminals, to reduce the need for administrative controls.
7. For batteries and battery systems other than Lead Acid and Lithium Ion, use hazard Classes 2.x to categorize the shock hazard.

Table 3.6a. Control Table for Work in Hazard Classes 4.xa, Batteries (Lead Acid) <100 VDC

Class	Mode	Two-Person	QEW Level	Work Control	PPE
4.0 <100 W	All	Alone	Non-QEW	None	None
4.1a 100–1000 W	All	Alone	Non-QEW	None	No Jewelry
4.2a 1–30 kW	2	Alone	Non-QEW	YES	Eye, No Jewelry
	3	Alone	Non-QEW	YES	Eye, No Jewelry
4.3a >30 kW	2	Alone	Non-QEW	YES	Eye, No Jewelry
	3	Alone	Non-QEW	YES	Eye, No Jewelry, Special Battery Tools

Notes on use:
1 For greater than 100 VDC, use hazard Classes 2.x to categorize the shock hazard.
2 For battery banks greater than 100 VDC, break up bank for energized work, when possible.

Table 3.6b. Control Table for Work in Hazard Classes 4.xb, Batteries (Lithium Ion) <100 VDC

Class	Mode	Two-Person	QEW Level	Work Control	Additional Controls
4.1b Commercial	While Charging	Alone	Non-QEW	Charge per manufacturer's instructions using the supplied charger.	None
4.2b[1] Single Cell	While Charging	Alone	Non-QEW	YES	None
4.3b[1] Multi Cell	While Charging	Alone	Non-QEW	YES	Containment, monitor temp using thermocouples

[1] Ensure, through AHJ equipment approval that the batteries and battery packs have integral protection and that the charging circuit is matched to the battery or battery pack.

Notes on use:
1. For greater than 100 VDC, use hazard Classes 2.x to categorize the shock hazard.
2. For battery banks greater than 100 VDC, break up bank for energized work, when possible.

3.7 Hazard Class 5.x, RF Circuits (5 kHz to 100 MHz)

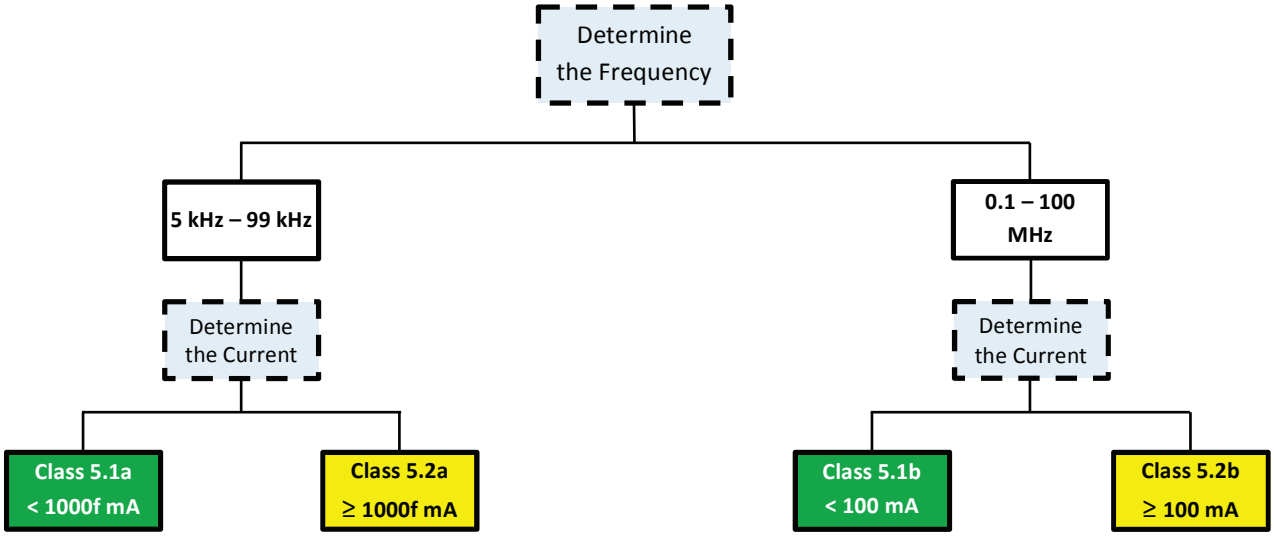

Fig. 3.7. Hazard Classes 5.x, RF Circuits 5 kHz to 100 MHz (f is in MHz)

1. "f" in the Chart is frequency in MHz. "1000f mA" means 1000 times the frequency in MHz. For example, if the frequency is 18 kHz, the shock current threshold is 0.018x1000 = 18 mA.

2. Classes 5.x only address the RF **shock** hazard. They do NOT address the exposure to electromagnetic fields. PUB-3000 Chapter 44, *Non-Ionizing Radiation* covers the exposure to electromagnetic fields.

3. The RF hazard classification chart in Fig. 3.7 determines if the RF source can put out sufficient current to be a shock/burn hazard. However, it does not take into account the body impedance, which is necessary to determine if the source can drive these currents into the body. The tools for body impedance modeling are too detailed to put into this document.

4. Types of waveforms and other factors that are not included in this table will need to be evaluated by competent persons for all hazards.

Table 3.7. Control Table for Work in Classes 5.x, RF Circuits (5 kHz to 100 MHz)					
Class	**Mode**	**Two-Person**	**QEW Level**	**Work Control**	**PPE**
5.1a 0.003–0.1 MHz <1000f mA	All	Alone	Non-QEW	None	None
5.1b 0.1–100 MHz <100 mA	All	Alone	Non-QEW	None	None
5.2a 0.003–0.1 MHz ≥1000f mA	All	Alone	QEW 1	Must perform RF hazard analysis based on PUB-3000 Chapter 44, *Non-Ionizing Radiation*.	
5.2b 0.1–100 MHz ≥100 mA	All	Alone	QEW 1		

3.8 Hazard Class 6.x, Sub-RF Circuits (1 Hz to 5 kHz)

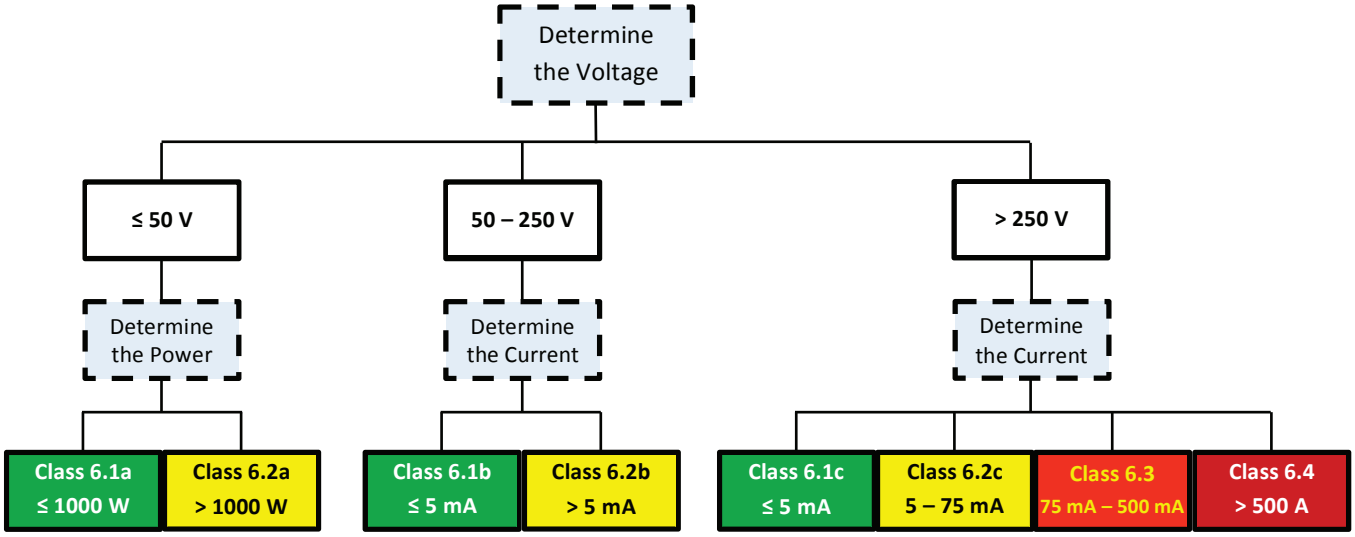

Fig. 3.8. Hazard Classes 6.x, Sub-RF Circuits (1 Hz to 5 kHz)

Notes on use:

1. This hazard class is not to be used for 50-60 Hz power, except for power limited 50-60 Hz circuits that cannot have currents over 5 mA.
2. Power is available short-circuit power.
3. Current is available short-circuit current.

Table 3.8. Control Table for Work in Classes 6.x, Sub-RF Circuits (1 Hz to 5 kHz)

Class	Mode	Two-Person	QEW Level	Work Control	PPE
6.1a,b,c ≤50 V, ≤1 kW or >50 V, ≤5 mA	All	Alone	Non-QEW	None	None
6.2a ≤50 V >1 kW	0	Alone	Non-QEW	LOTO	None
	1	Alone		LOTO	Shock[1]
	2	Standby Person		YES	Shock[1]
	3[4]	Safety Watch		YES, EEWP	Shock[1]
6.2b 50–250 V >5 mA	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[1]
	2	Standby Person		YES	Shock[1]
	3[4]	Safety Watch		YES, EEWP	Shock[1]
6.2c >250 V 5–75 mA	0	Alone	QEW 1	LOTO	None
	1	Alone		LOTO	Shock[1]
	2	Standby Person		YES	Shock[1]
	3[4]	Safety Watch		YES, EEWP	Shock[1]
6.3 >250 V 75 mA–500 A	0	Alone	QEW 2	LOTO	None
	1	Standby Person		LOTO	Shock[1]
	2[3]	Safety Watch		YES	Shock[1]
	3[4]	Safety Watch		YES, EEWP	Shock[1]
6.4 >250 V >500 A	0	Alone	QEW 2	LOTO	None
	1	Standby Person		LOTO	Shock[1], Arc Flash[2]
	2[4]	Safety Watch		YES	Shock[1], Arc Flash[2]
	3[4]	Safety Watch		YES, EEWP	Shock[1], Arc Flash[2]

[1] Perform a shock hazard analysis using methods covered in Section 7.1.
[2] Perform an arc flash hazard analysis using methods covered in Section 8.1.
[3] DO NOT move probes while energized.
[4] This mode of work should be avoided.