Discharging, Storage, and Disposal of Capacitors in Electronic Equipment

Why do we need a Capacitor Safety Program for Capacitors in Electronic Equipment?

When we have a notable event and someone gets injured or there is a potential for an injury, there is a realization that we should implement a new policy for preventive measures. In NFPA70E (2015), there is no particular guidance for capacitors.



REAL SCENARIO: Let's take the Notable Event from February 3, 2022, that identified a need for corrective action when a RadCon employee received a minor shock surveying a damaged electronics power supply. The employee was performing a radiological survey on a failed 15VDC power supply from an electronics equipment cabinet DIN rail that was removed from Hall C. It was completely and appropriately isolated from a power source or output device and removed by a Hall C employee. The power supply was removed from it housing due to the device not working properly/damaged. The Hall C employee put the power supply on the bench with it out of its housing to allow the RadCon employee to perform a radiological survey before it was to be disposed of. When the RadCon employee's left hand. After an investigation, it was determined the shock occurred when the RadCon employee contacted the conductors on the power supply that remained energized by the capacitors on the supply. It was found that the capacitors were not discharged and the discharging circuitry on the card had failed. The circuit card did not "look" to be physically damaged.

CAPACITOR SAFETY: Capacitors are common components in electronic devices. They store a charge that can be released at once to components that need it. When building, repairing, or salvaging electronics, there is the possibility of encountering them. Before working on

electronics, it is essential to have a Qualified Electrical Worker (QEW) familiar with the equipment first discharge any capacitors, .

Capacitors are capable of holding onto charges for long periods of time. Especially if their circuit does not contain a "bleeder" resistor that dissipates the electric charge when the device is powered off. If an employee comes into contact with the terminals of a charged capacitor, the charge can pass through their body. Sometimes this can even happen over a small distance, like when your fingers are close to the terminals and the charge arcs over. There is no easy rule for the amount of energy that can cause (lethal) harm, because there are also other factors that matter. For example, skin conductance, skin thickness, hydration levels, and the surface area you touch all play a part in how well current can travel through your body. Although many of these have a discharging circuit built into them, We should verify they are operable by mnually discharging stored energy.



Capacitor Safety Risk Assessment:

This risk assessment should be performed when the following hazard thresholds are exceeded:

- a. Less than 100V and over 100 Joules
- b. Greater than or equal to 100V and greater than 1 Joule
- c. Greater than or equal to 400V and 0.25 Joules
- 1. Capacitor safety and stored energy for the worker exposure. An exposure should be considered to exist when a conductor or circuit part that could potentially remain energized with hazardous energy is exposed.
- 2. Thermal Hazard- The appropriate PPE shall be selected and used if the stored energy of the exposed part is greater than 100J.
- 3. Shock Hazard- The appropriate shock PPE (in accordance with NFPA70E) shall be selected and used if the voltage is greater than 100V.
- 4. Arc Flash and Arc Blast hazard at the appropriate working distance. The appropriate protection for the Arc Flash and Arc Blast hazard shall be selected as follows:
 - a) Arc Flash PPE in accordance with NFPA70E shall be selected and used using JLab policies and procedures and if the incident energy is 1.2k/cm² (5J/cm²) at the working distance.

- b) Hearing protection shall be required where the stored energy exceeds 100J.
- c) Lung Protection Boundary shall be determined if the stored energy is above 122kJ. Employees shall not enter the Lung Protection Boundary.
- d) Alerting techniques in accordance with NFPA70E shall be used to warn employees of the hazards.
- 5. Required test and grounding method. Soft grounding shall be used for stored energy above 1000J. If capacitors are equipped with bleed resistors, or if used a soft grounding system, the required discharge wait time shall be determined were applicable.
- 6. Develop a written procedure that captures all of the required steps to place the equipment in an electrically safe work condition. Included information about the amount of stored energy available, how long to wait after de-energization before opening the enclosure, how to test for absence of voltage, and what to do if there is still stored energy present.



Associated Hazards:

- 2. Shock Hazard: Covers are open or the circuit card is outside of the chassis. Make sure covers are closed and the conductors are not exposed. The circuit cards usually have a discharge circuit to bleed the energy from a capacitor. Discharge capacitors, as necessary, in accordance with the manufacturer's directions.
- 3. Short Circuit Hazard: If the card has potential faults or failures. Take care to watch alarms or failure screens to alert of an impending circuit card failure. Shock PPE (safety glasses and electrical gloves rated for the highest potential of voltage (either input or output).
- 4. Thermal Hazard: When making physical contact with the circuit board that is over 100 Joules. Shock PPE (safety glasses and electrical gloves rated for the highest potential of voltage (either input or output) with leather protectors.
- 5. Reflex Hazard: When the capacitor is over 0.25 Joules and >400V. Shock PPE (safety glasses and electrical gloves rated for the highest potential of voltage (either input or output).
- 6. Fire Hazard: Rupture of a capacitor can create a fire hazard from the ignition of the dielectric fluid. Dielectric fluids can release toxic gases when decomposed by fire or the heat of an electric arc.
- 7. Arc Flash: At approximately 120kJ in open air or 44 kJ in a box, there exists sufficient stored energy for there to be >1.2 cal/cm² at a working distance of 18 in. Appropriate Arc Flash PPE is required above those energies.
- 8. Arc Blast: Hearing protection should be used above stored energies of 100 J. Above 122kJ a lung collapse hazard can exist.

Safety Equipment:

- 1. Gloves with covers rated for the voltage of the capacitor (input and output voltages MUST be considered). Leather covers, especially to prevent thermal hazards.
- 2. Safety Glasses
- 3. Hearing Protection
- 4. Properly rated and maintained Grounding Tool
- 5. Barriers for Capacitors rated as Class 2 and above when discharging or conductors are exposed.
- 6. Arc Flash PPE if required based on stored energy.

<u>Required Training</u>: MUST be a QEW with courses ESC001-ESC008

If you have any questions, please contact Electrical Safety at <u>electricalsafety@jlab.org</u>.

I certify that I have read all Discharging, Storage, and Disposal of Capacitors in

<u>Electronic Equipment</u> to its entirety.

I certify that I understand my role and responsibility under the Electrical Safety program.

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