

Understanding Emergency Power Off (EPO)

White Paper #22

APC[®]
Legendary Reliability[®]

Executive Summary

Emergency Power Off (EPO) is the capability to power down a piece of electronic equipment or an entire installation from a single point by activating a push button. EPO is employed in many applications such as industrial, telecommunications, information technology (IT), etc. This white paper describes the use of EPO for protecting data centers and small IT equipment rooms containing UPS systems. Various applicable standards that require EPO are discussed. Recommended practices are suggested for the use of EPO with UPS systems.

Introduction

EPO is a safety feature intended to power down equipment or an entire installation in an emergency so as to protect personnel and equipment. Some of the causes requiring EPO activation include fire, flood, equipment overheating due to HVAC failure, etc. In case of an emergency, it may not be possible to access the main disconnect device on the equipment leaving EPO as the only means to power down the equipment. Also, in a complex information technology equipment room multiple breakers would have to be tripped to power down the entire installation. Consequently, various safety agencies have mandated requirements to have one central means of disconnecting power.

EPO is typically used either by fire fighting personnel or by equipment operators. When used by firefighters, it is used to assure that equipment is de-energized during fire fighting so that firefighters are not subjected to shock hazards. The secondary purpose is to facilitate fire fighting by eliminating electricity as a source of energy feeding combustion. When used by equipment operators, it is used to turn off equipment from a safe distance. This might be desirable if equipment is emitting smoke, fire, or fumes. Also, an operator may use EPO to stop power if another person is being electrocuted.

The EPO system in any data center is a subsystem that facility managers and operations personnel hope that they never have to use. There is a large cost associated with abruptly shutting down a data center. So accidental EPO tripping incurs an enormous expense. It is therefore essential that the EPO systems are designed such that accidental shut downs are minimized.

Standards and Legal Requirements

Standards may be applied either to products or installations. Products are approved or listed to various international standards that dictate its safety and functionality. National regulations and local codes or authorities govern installations. EPO design is affected by both product and installation safety guidelines. Applicable product standards relating to EPO on a UPS are as follows:

Underwriters Laboratory - UL 1778: A disconnection device shall be provided for the output ac and dc power circuits of a fixed UPS, and a remote battery supply/cabinet assembly.

EN50091: This European UPS standard requires EPO on any hard-wired UPS. However the EPO may be integral to the UPS and not required to be activated at the exit doors.

Local authorities may require that installed equipment meet the above standards before it can be operated. In addition, local authorities may require that the installation meet some or all of the following requirements:

IEC 364-4-46: This international standard titled: "Electrical installations of buildings part 4: protection for safety" requires that a "means shall be provided for emergency switching of any part

of an installation where it may be necessary to control the supply to remove unexpected danger". Although not explicitly referenced, computer rooms are considered such an installation. Furthermore, "the arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger."

National fire protection agency - NFPA 70: This document, also called the US National Electrical Code, specifies in clause 645-10 & 645-11 that UPSs above 750 VA installed within information technology rooms must be provided with a means to disconnect power to all UPS supply and output circuits. The disconnecting means shall also disconnect the battery from its load. The code further requires that the control for these disconnecting means shall be grouped and identified and shall be readily accessible at principal exit doors.

National fire protection agency - NFPA 75: This document, titled "Standard for the Protection of Electronic Computer / Data Processing Equipment", incorporates the related clauses of NFPA 70 and therefore contains identical requirements.

Data Center and EPO Requirements

One of the most confusing areas for IS professionals is a determination of what constitutes a "data center" and whether an EPO is required. In particular, how big or complex does an installation need to be before it comes under the legal definition of a "data center"? Can a wiring closet be considered a "data center"?

NFPA 70 defines an information technology room (a data center) as a room containing power supplies, computers and data processing equipment, telecommunication equipment, associated interconnecting wiring and grounding of equipment and systems. The information technology room per NEC 2002 has to meet the following conditions:

1. The room is separated from other occupancies by fire-resistant rated walls, floors and ceilings with protected openings.
2. A means shall be provided to disconnect power to all electronic equipment in the room (EPO). There shall also be a means to disconnect the power to all dedicated heating / ventilating / air-conditioning (HVAC) systems serving the room and cause all fire smoke dampers to close. The control for these disconnecting means shall be grouped and identified and shall be readily available at principal exit doors.
3. A separate HVAC system that is dedicated to the room is provided. Any HVAC system that serves other occupancies shall be permitted to also serve the information technology room if fire / smoke dampers are provided at the point of penetration of the room boundary. Such dampers shall operate on activation of smoke detectors and also by operation of the disconnecting means for HVAC systems.
4. Properly listed information technology equipment is installed in the room.

5. Only those personnel needed for the maintenance and functional operation of the installed equipment occupy the room.

Based on the above definition, small installations of a few servers or a wiring closet are not considered "computer rooms" or information technology equipment room. However, it is highly desirable to have an EPO device for small installations to protect personnel and equipment from serious injury or damage in case of fire or other emergencies.

Item (2) above requires disconnection of power to all electronic equipment. Whether all power to the room has to be disconnected or not is subject to interpretation by local authorities. Some inspectors require that all power to the information technology room be disconnected by the main input breakers feeding the room.

Using UPS with EPO

NFPA 75 states, "A means shall be provided to disconnect power to all electronic equipment. The disconnecting means shall also disconnect the battery from the load". For a UPS with an integral battery, the NFPA 75 requirement is satisfied by having an EPO that shuts off the UPS output. For a UPS with a remote battery, the battery power must be disconnected by the EPO because UPS is considered electronic equipment and its source must be disconnected.

If the UPS is in the datacenter, then achieving EPO by tripping breakers inside the data center may not be possible. Disconnecting input power to the UPS will not disconnect AC output power, as the UPS will interpret this event as a power failure and simply continue to supply power from its associated battery. Just tripping the UPS output breakers also does not meet EPO requirements, as the UPS remains powered even though the loads may be shut down. EPO that trips the UPS input breakers, and DC battery breakers would be required. The EPO design should therefore be capable of tripping the breakers feeding main and bypass input power to the data center and DC battery breakers (if battery is not integral to the UPS). It is also required to trip UPS output breakers when the EPO is activated.

EPO is a standard feature in most UPS over 5 kVA and is often available as an option on smaller units. In some cases, EPO can be retrofit as a plug-in accessory to standard UPS. However, the implementation of EPO varies among different UPS. System design work may be needed to integrate the UPS EPO with an existing data center EPO. Although this is not complicated, it is important to note that integration is usually not a simple plug-in installation. Consult the application or installation notes for the specific UPS.

On larger UPS systems, the UPS breakers are contained in a bypass panel, bypass panel / PDU or switchgear. The EPO function on larger systems must therefore be able to trip multiple breakers to disconnect all power to and from the UPS.

How Does EPO Work?

Pressing the EPO button permanently shuts down all power in the installation. Power cannot be restored at the EPO switch, but must be reset either at the circuit breaker panels or at the load equipment.

In the most basic form, the EPO button is wired back to special "remote trip" or "shunt trip" circuit breakers in the UPS system. The special circuit breakers are equipped with "trip coils" which are driven by the EPO circuit. The shunt trip unit consists of a solenoid tripping device mounted in the breaker. The tripping device must be energized by some control power source of AC or DC voltage. When a pilot device, such as a push button, remotely energizes the solenoid coil, the plunger moves to activate the trip bar to trip the breaker. At the same time a cut off switch operates, disconnecting power to the solenoid and preventing coil burn out. Breakers with shunt trip capability have terminals for connecting the shunt trip control voltage. The shunt trip coils of multiple breakers can be connected in parallel so that a single EPO push button can trip many breakers.

Shunt trip breakers trip when the EPO circuit is closed (or opened). Multiple EPO switches can be connected in parallel (or series) to multiple paralleled breakers so that any EPO switch trips all breakers.

Remote trip breakers trip when a control voltage is applied to them. A source of voltage, typically 24 or 48V AC/DC is required. However, some breakers use 120 V or 240 V AC/DC coils. These can be operated directly from the line. The AC shunt trip control voltage can have a frequency of 50 Hz or 60 Hz. The standards do not specify any particular voltage for shunt trip control to facilitate flexibility in design. Although the shunt trip control voltage can vary in different circuit breakers, the basic operation of the shunt trip unit remains the same.

In contrast to a shunt trip, Undervoltage Release mechanism (UVR) is an alternate means available to trip a circuit breaker. As the name implies, the UVR mechanism trips the breaker whenever the control voltage falls below a predetermined level. Like shunt trip units, UVRs are available with a wide variety of control voltage ratings. The UVR consists of a solenoid with a plunger and tripping lever. The UVR mechanism is reset by the tripping lever when normal control voltage has been restored and the circuit breaker handle is moved to the "OFF" position. UVR equipped circuit breakers are used when a normally closed circuit is desired for EPO design.

Assuring EPO Functionality

From a safety standpoint it is absolutely essential that the EPO works when needed. Two different design approaches can be used: one with normally open (NO) contacts and the other with normally closed (NC) contacts. Each of these designs has its own tradeoffs between reliability and safety.

The EPO design with NO contacts use one normally open contact for each breaker to be tripped. The EPO push button would close the contact to trip the breaker. Multiple NO contacts are closed by the EPO push

button to trip multiple breakers in the information technology room. A broken wire would not be detected by this EPO design. However, a broken wire would not cause a nuisance trip since the contacts are normally open.

The EPO design with NC contacts use one normally closed contact for each breaker to be tripped. The EPO push button in this design will open the contact to trip the breaker. Multiple NC contacts are opened by EPO push button to trip multiple breakers in the information technology room. If a wire gets broken, it would trigger an EPO event in this type of design. However, if the pair of wires connected to the NC contact is shorted then the connected breaker would not trip in case of an emergency.

Most users demonstrate EPO functionality by periodic tests. In fact, local regulatory authorities may require such tests. It would be highly desirable to have a selection switch on the UPS and ancillary equipment that enables the EPO to be checked periodically by setting the switch to a “test” position. In the “test” position the EPO can be activated and the EPO functionality tested without actually shutting the system down and disconnecting the load. After the EPO the test, the switch can be set to its “normal” position

The complexity of the EPO design and associated reliability depends on the size of the installation. A simple EPO push button can be employed for a few pieces of UPS equipment using a set of contacts wired serially to each push button at the exits. This approach works okay for 2-3 circuits, but gets laborious and less reliable for a larger installation. For a data center of multiple UPS components it becomes necessary to design a controller that can trip multiple breakers at the same time. If the controller power supply fails then the EPO will not function when needed. A UPS can be used to back up the EPO control power supply to increase reliability. However, this increases the complexity of the EPO system and the number of failure modes. In addition, periodic maintenance of the EPO controller would also be required to check the status of UPS battery and other components. An alternative approach would be to design an EPO with passive components that can still reliably trip all associated equipment.

Recommended Practices

Data centers or small information technology equipment rooms may have multiple UPS and associated equipment. Since one UPS system may or may not be galvanically isolated from the others, there should be independent contacts for breaker shunt trip or UVR. Whether or not to use a powered EPO device with relays is an important design consideration. If the EPO device has input power then a UPS or battery back up would be necessary to make sure that the EPO is ready and functional at all times.

An alternate approach is to use normally open contacts and use an EPO push button that closes multiple independent contacts to initiate EPO function. Such an EPO device would not need any input power. When using multiple EPO devices, it is highly desirable to have pre-made and tested cable harnesses for interconnection that enhances ease of installation and reliability.

EPO devices designed around human factors provide two important benefits:

- 1) Lower probability of failure due to installation mistakes thus improving the reliability of EPO system operation
- 2) Lower probability of false trips due to human error thus increasing the availability of IT operations

The EPO device preferably should be aesthetically pleasing, easy to install and have a large push button. The wiring connecting to the EPO device should have sufficient room to neatly route and dress inside the EPO enclosure. This reduces the likelihood of miswiring by allowing the installer to keep track of all wiring and see all terminations from one angle. It is also important for the EPO device to be able to trip the main breaker feeding the information technology room. These contacts must be able to accommodate various shunt trip voltages up to 240 V AC.

Figure 1a shows the standard industrial EPO push button device with depths ranging from 6 to 9 inches (15.24 to 22.86 cm). The contacts of the push button are normally stacked in the back making the depth larger as the number of contacts increases.

An example of an EPO device with a 2 inch depth (5.08 cm) is shown in Figure 1b.

Figure 1a: – Standard EPO

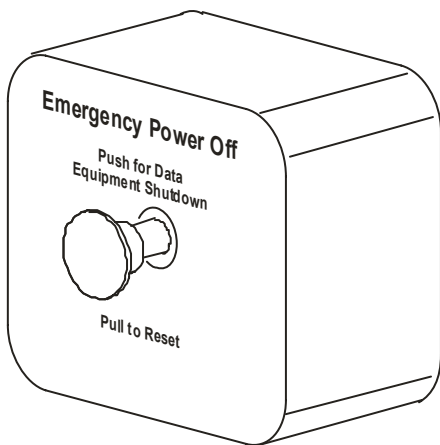
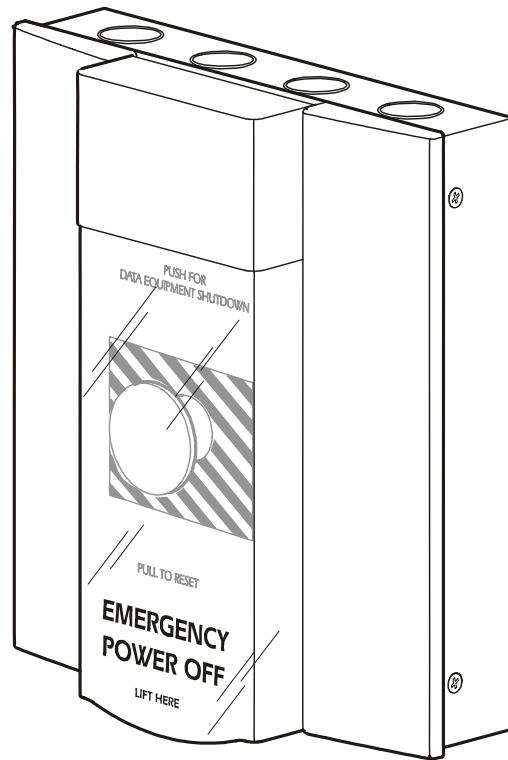


Figure 1b: – APC EPO



EPO devices should allow for mounting with conduit along the wall or behind the wall as shown in figure 2a and 2b respectively.

Figure 2a: –Conduit along the wall

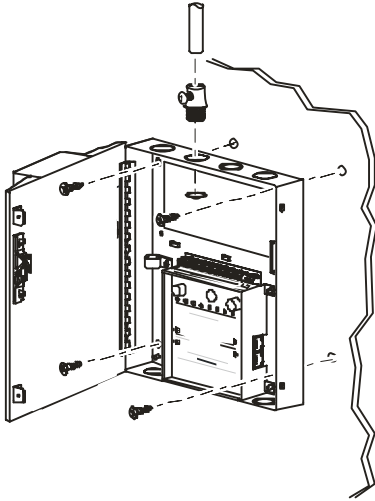
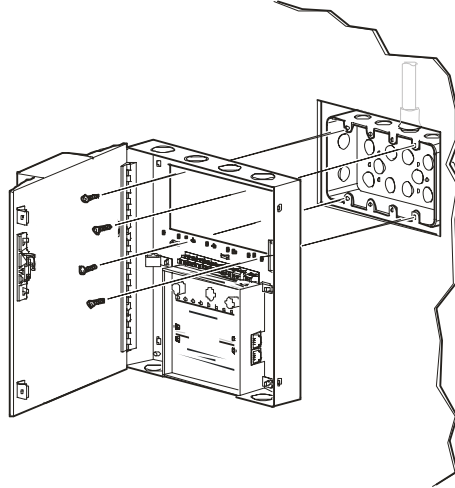


Figure 2b: –Conduit behind the wall



The wiring inside the standard industrial EPO device terminates to the contacts clustered around the push button making it cumbersome to wire thereby decreasing the reliability as shown in figure 3a. EPO devices should allow support for multiple UPS and for tripping one additional circuit breaker (shunt trip up to 240 V AC), which can be the main breaker feeding power to the information technology room. In addition, the wiring inside the device should be intuitive and spacious to allow for organized wire dressing. These features in turn decrease the chance of installation errors thus increasing the reliability of EPO operation. An example of such a device is shown in Figure 3b.

Figure 3a: –Stacked terminal

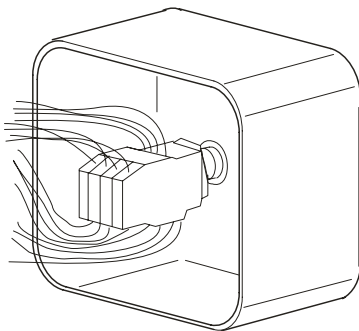
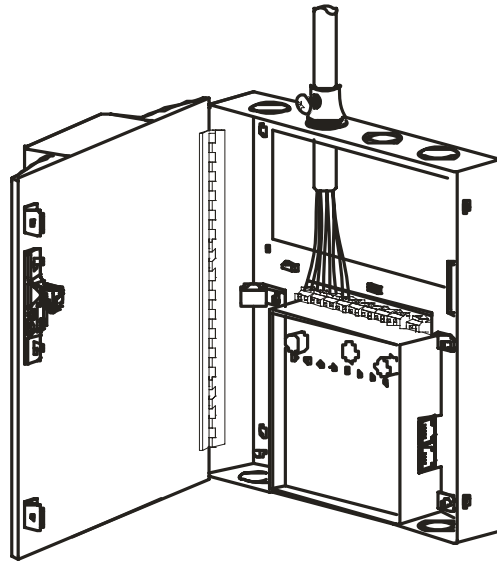
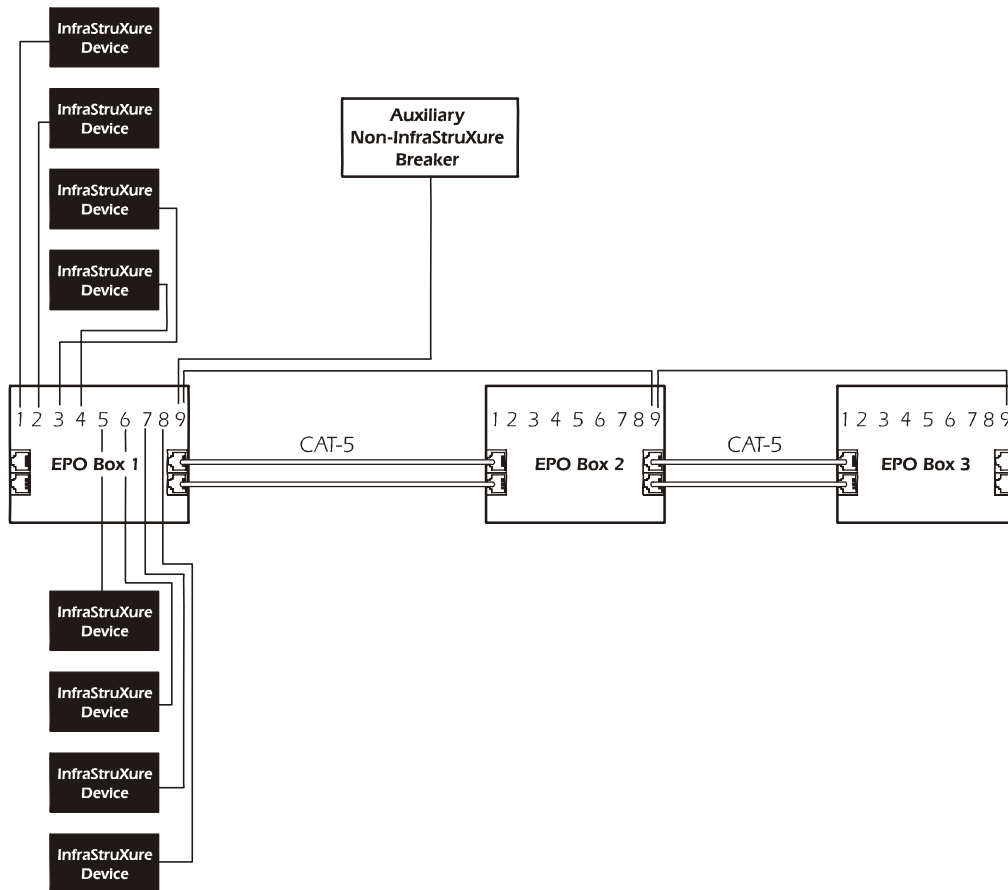


Figure 3b: – Linear terminal block



If multiple EPO devices are needed, then the EPO device, like the one shown in Figure 1a, will require discrete parallel wires run between individual EPO devices. If an information technology room needs three such EPO devices then the parallel wiring will make this system very messy and unreliable. Alternatively, Figure 4 shows the parallel connection of EPO devices using pre-assembled CAT-5 cables. The internal connections are done on a printed circuit board. The CAT-5 cables can be obtained with specific lengths required at each location making the installation quick and reliable. Like all EPO connections, the CAT-5 cables should be securely run in conduit to prevent inadvertent disconnection from the EPO device.

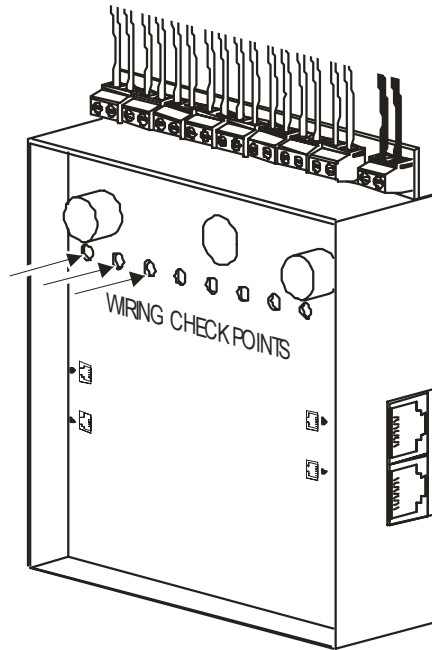
Figure 4: – Parallel EPO connection using CAT-5



Since data center shut downs can be caused by accidental EPO activation, it is imperative that such shut downs are minimized. A protective transparent plastic cover would prevent a person leaning on the EPO device from activating an EPO. A lock and key arrangement could be used to open the protective covering but this has two distinct disadvantages. First, the key might get misplaced and may not be available when needed to activate the EPO. Secondly, the process of opening of EPO lock would take up valuable time in an emergency. So, a simple protective cover over the EPO push button would be the preferred design approach (Figure 1b).

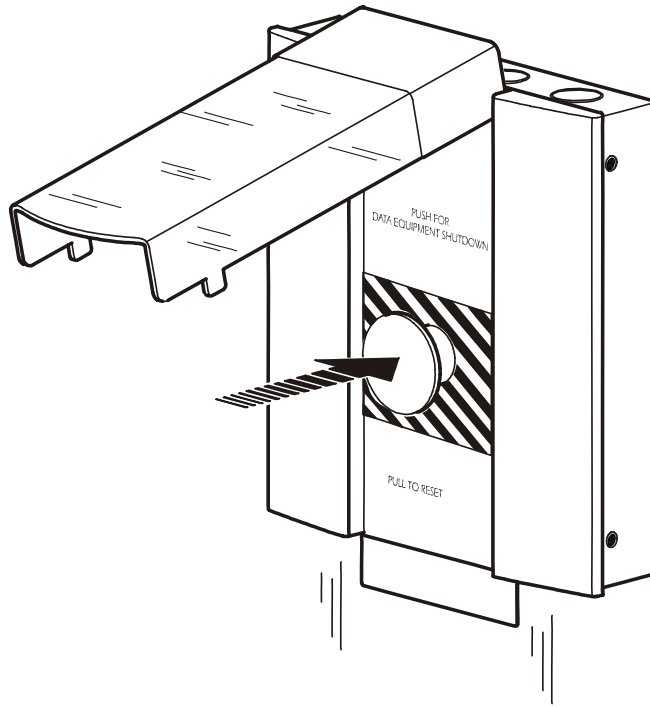
An EPO control device that is fully tested with the equipment that it protects is highly recommended. More often than not EPO controllers are designed to be site specific and not fully tested with all the equipment it is supposed to protect because of site testing limitations. It is therefore highly desirable to have an EPO test function built into the EPO device which is generally not available in commercial EPO devices like the one shown in Figure 1a. An example of an EPO test function is shown in Figure 5 where each individual circuit on the EPO device can be tested by pressing the appropriate micro switches.

Figure 5: – EPO test function



Another desirable feature in an EPO device is an indication as to which device was activated for accident investigation. On a sophisticated “active” microcontroller-based EPO device, this is accomplished by communication to the Building Management System. On a “passive” EPO device that does not have any input power and microcontroller, two features are available for indication when the device is activated. First, the EPO push button is a latching type which provides one indication of activation of the device. Secondly, the EPO device has a red flag that drops down as soon as the protective cover over the push button is lifted up for EPO activation as shown in the Figure 6.

Figure 6: – EPO Activation



Conclusions

EPO is an important safety feature for UPS equipment within a data center that may be legally required. This paper discusses various applicable standards worldwide that require the use of an EPO device. In addition, careful attention must be paid to design features of the EPO device such as size, type of contacts, wiring neatness, complexity, cost, etc. The EPO device must also be fully tested with the UPS systems that it protects. Following recommended practices for an EPO device will increase reliability and reduce human error.