



INTERNAL PROTECTION OF UPS SYSTEMS AGAINST UNINTENTIONAL CONTACT WITH LIVE PARTS

Clarifying internal IP20 requirements

Introduction

Safety of people who may come in contact with the uninterruptible power supply systems is of primary importance. The level of voltages inside an industrial UPS system may be dangerous and it is important to ensure a sufficient level of safety so that the life of general public (any ordinary person), operator or a maintenance engineer is not jeopardized.

This paper explains the standards that are to be followed by industrial UPS manufacturers and has as its purpose to explain how, at Vertiv Industrial Systems, any Chloride® industrial equipment is compliant with all the safety requirements of international standards and protects anyone, from an ordinary person, to operators or maintenance engineers. While technical specifications often cite the requirement for the IP2x inside the UPS enclosures to achieve this level of safety, we will see that from the regulatory and practical points of view this is a misleading requirement, and there are more efficient ways of preventing unintentional contact.

1 IEC 60529

Degrees of protection provided by enclosures (IP code)

International standard IEC 60529:1989 (+AMD1:1999 + AMD2:2013) describes a system for classifying the degrees of protection provided by the enclosures of electrical equipment. The purpose of IEC 60529 is to define the IP code i.e. Ingress Protection ratings that are used to define a level of sealing effectiveness of enclosures against intrusion from foreign matter (tools, dust, water, etc.)

The IEC 60529 standard title clearly defines the applicability of this standard: “Degrees of protection provided by enclosures (IP Code)”. The object of this standard is to define the degrees of protection provided by the **enclosures** of electrical equipment as regards to:

- The protection of persons against access to hazardous parts inside the enclosure:
- this means that people must be protected by the enclosure, i.e. from the outside of the enclosure, against any hazardous part located inside the enclosure.
- The protection of the equipment inside the enclosure against ingress of solid foreign objects
- The protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

The IEC 60529 defines several key points:

EXTRACT FROM IEC60529:1989

[...]

3 Definitions

3.1 Enclosure

A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact (IEV 826-03-12)

[...]

3.2 Direct contacts

Contact of persons or livestock with live parts (IEC 826-03-05).

Note This IEV definition is given for information. In this standard, “direct contact” is replaced by “Access to hazardous parts”.

3.3 Degree of Protection

The extend of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water

[...]

END OF EXTRACT

As we can see in the above extract, the **IEC 60529 standard is applicable to the enclosures**. In other words, the “Internal IP20” or “Internal IP20 as per IEC 60529”, concept frequently written in most technical specifications, is not referenced in this standard.

SUMMARY

- The international standard IEC 60529 is applicable to the external enclosure of the UPS system.
- The level of protection inside the enclosure of a UPS system is regulated by other international standards, such as the product standards. IEC 60529 cannot be the applicable standard inside the enclosure of the UPS system.

2 IEC 62040-1: 2008

General and safety requirements for UPS

The 2008 version of the international standard IEC 62040-1 relates to the safety requirements for Uninterruptible Power Systems (UPS). The scope of this standard is to specify the requirements to ensure safety for the ordinary person who comes into contact with the UPS and, where specifically stated, for the skilled person. Among other points, the object of this standard is to reduce risks of electric shock, energy and mechanical hazards during use and operation and, where specifically stated, during service and maintenance.

To ensure the appropriate level of safety, the standard defines the accessibility levels to the industrial UPS units and the level of protection against electrical hazards to be provided.

2.1 Accessibility to the UPS units

The IEC 62040-1:2008 defines the accessibility levels to UPS systems to ensure safety of people.

EXTRACT FROM IEC62040-1:2008:

"[...]"

3.11 Accessibility

The definitions of 1.2.7/RD apply.

"[...]"

END OF EXTRACT

As we can see from the above, the IEC 62040-1:2008 refers to the RD, which is the IEC 60950-1:2005. This standard defines the accessibility levels, as shown here after:

EXTRACT FROM IEC60950-1:2005

"[...]"

1.2 Definitions

1.2.7.1 Operator Access Area

Part of the equipment to which, under normal operating conditions, one of the following applies:

- Access can be gained without the use of a TOOL;
 - The means of access is deliberately provided to the OPERATOR;
 - The OPERATOR is instructed to enter regardless of whether or not a TOOL is needed to gain access
- The terms "access" and "accessible", unless qualified, relate to an OPERATOR ACCESS AREA as defined above.

1.2.7.2 Service Access Area

Part of the equipment, other than an OPERATOR ACCESS AREA, where it is necessary for SERVICE PERSONS to have access even with the equipment switched on.

1.2.7.3 Restricted Access Location

Location for equipment where both of the following apply:

- Access can only be gained by SERVICE PERSONS or by USERS who have been instructed about the reasons for the restrictions applied to the location and about any precautions that shall be taken; and
- Access is through the use of a TOOL or lock and key, or other means of security, and is controlled by the authority responsible for the location.

NOTE The requirements for equipment intended for installation in RESTRICTED ACCESS LOCATIONS are the same as for OPERATOR ACCESS AREAS, except as given in 1.7.14, 2.1.3, 4.5.4, 4.6.2 and 5.1.7.

1.2.7.4 Tool

Screwdriver or any other object that may be used to operate a screw, latch or similar fixing means.

[...]

1.2.13.5 Service Person

Person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons

1.2.13.6 User

Any person, other than a SERVICE PERSON
The term USER in this standard is the same as the term OPERATOR and the two terms can be interchanged.

1.2.13.7 Operator

see USER (1.2.13.6)

"[...]"

END OF EXTRACT

SUMMARY

- Chloride industrial systems are designed to be installed in a Restricted Access Location as defined by the IEC 60950:2005 standard.
- Should a Chloride industrial system be installed in an Operator Access Area as defined by the IEC 60950 standard, access to the internal parts of the UPS cannot be achieved without the **use of a tool, i.e. a lock and a key**. This means that in terms of safety, the Operator can come close to the UPS unit without any risk, as the operator will be protected by the enclosure

that is locked and that provides an Ingress Protection level (IP) of minimum IP20 (or different, as required by the specific project specification).

- Should a Chloride industrial system be installed in a Restricted Access Location as defined by the IEC 60950 standard, **access to the internal parts of the UPS can only be achieved by mean of a tool, i.e. a lock and a key.** This statement complies with the requirements of both IEC 62040-1:2008 and 60950-1:2005.
- Chloride industrial systems complies with all the safety requirements of the IEC62040-1 (2008 version) and of the IEC60950-1 (2005).
- It is important to note that it remains the **responsibility of the authority responsible for the industrial site to control the access to the internal parts of the UPS.**

2.2 Protection from Electrical Hazards

The IEC 62040-1:2008 defines the levels to protect the people from electric shocks.

EXTRACT FROM IEC62040-1:2008:

"[...]"

5 Fundamental design requirements

5.1 Protection against electric shocks and energy hazards

5.1.1 Protection for UPS intended to be used in operator access areas

The requirements and restrictions of 2.1.1/RD apply.

"[...]"

END OF EXTRACT

Here again, the IEC 62040-1:2008 refers to the RD (IEC 60950-1:2005). Let's have a look at this point.

EXTRACT FROM IEC60950-1:2005

"[...]"

2 Protection from hazards

2.1 Protection from electric shock and energy hazards

2.1.1 Protection in operator access areas

This subclause specifies requirements for protection against electric shock from energized parts based on the principle that the OPERATOR is permitted to have access to:

- bare parts of SELV⁽¹⁾ CIRCUITS; and
- bare parts of LIMITED CURRENT CIRCUITS; and
- TNV⁽²⁾ CIRCUITS under the conditions specified in 2.1.1.1.

Access to other energized parts, and to their insulation, is restricted as specified in 2.1.1.1.

"[...]"

2.1.1.1 Access to energized parts

The equipment shall be so constructed that in OPERATOR ACCESS AREAS there is adequate protection against contact with:

- bare parts of ELV⁽³⁾ CIRCUITS; and
- bare parts at HAZARDOUS VOLTAGES;

"[...]"

Protection shall be achieved by insulation or by guarding or by the use of interlocks.

"[...]"

2.1.1.5 Energy Hazards

There shall be no risk of injury due to an energy hazard in an OPERATOR ACCESS AREA.

"[...]"

END OF EXTRACT

SUMMARY

- As noted previously, a Chloride industrial system is designed to be installed in a Restricted Access Location as defined by the IEC 60950:2005 standard. It means that the Operator shall not have access to the bare parts at hazardous voltages without adequate protection against contact with these parts. The protection of the Operator against direct contact with hazardous voltages is provided by the enclosure that can only be open by the means of a key.
- **Internal access by the operator can only be granted by the local on-site authority who is responsible for providing appropriate information about electrical hazards.**

(1) SELV CIRCUIT: Secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value.

(2) TNV CIRCUIT: circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions, the voltages do not exceed specified limit values.

(3) ELV CIRCUIT: Secondary circuit with voltages between any two conductors of the circuit, and between any one such conductor and earth (see 1.4.9), not exceeding 42,4 V peak, or 60 V d.c., under normal operating conditions, which is separated from HAZARDOUS VOLTAGE by BASIC INSULATION, and which neither meets all of the requirements for an SELV CIRCUIT nor meets all of the requirements for a LIMITED CURRENT CIRCUIT

2.3 Fundamental UPS design requirements

Let's now focus on UPS fundamental design requirements and particularly on the protection for UPS intended to be used in service access areas and in restricted access areas.

EXTRACT FROM IEC62040-1:2008:

[...]

5.1.2 Protection for UPS intended to be used in service access areas

Bare parts at hazardous voltage shall be located or guarded so that unintentional contact with such parts is unlikely during service operations involving other parts of the equipment

[...]

Any guards required for compliance with 5.1.2 shall be easily removable and replaceable if removal is necessary for servicing.

[...]

5.1.3 Protection for UPS intended to be used in restricted access areas

For equipment to be installed in a restricted access location, the requirements for operator access areas apply, except as permitted in the following three paragraphs.

Contact with bare parts of a secondary circuit at hazardous voltage with the test finger, Figure 2A/RD (see 2.1.1.1/RD) is permitted. However, such parts shall be so located or guarded that unintentional contact is unlikely.

Bare parts that present a hazardous energy level shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.

No requirement is specified regarding contact with bare parts of TNV-1, TNV-2 and TNV-3 circuits.

[...]"

END OF EXTRACT

From the above extract, we can note 2 major points with regards to the **Service Access Areas** and the **Restricted Access Areas**:

- In both types of areas, bare parts at hazardous voltage must be guarded to **avoid unintentional contact**
- In restricted access areas, **contact with bare parts with the test finger is permitted**, but these parts are **guarded to protect people against unintentional contact**.

SUMMARY

- Chloride industrial UPS systems are compliant with IEC 62040-1:2008 and with IEC 60950-1:2005 with regards to the level of safety provided, once the UPS doors are open.
- Chloride industrial UPS systems are provided with internal protection barriers made of plexiglass to prevent people from unintentional contact with hazardous live parts
- Chloride industrial UPS systems are provided with internal protection barriers made of plexiglass to prevent service people from unintentionally bridging conductive materials when removing the barriers.

3 IEC 62040-1: 2017 Uninterruptible power systems safety requirements

The latest revision of the IEC 62040-1 related to safety requirements of UPS systems has been updated to provide additional and revised information.

Let's review these updates in detail.

3.1 Definitions

According to the latest revision of the international standard IEC62040-1:2017, some definitions have been updated, as shown hereafter.

EXTRACT FROM IEC62040-1:2017:

"[...]"

3.102 skilled person

Person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which the equipment can create.

Note 1 to entry: Such person has access to restricted access areas.

3.103 instructed person

Person adequately advised or supervised by skilled persons to enable him or her to perceive risks and to avoid hazards which the equipment can create

Note 1 to entry: Such person has access to restricted access areas.

3.104 ordinary person

Person who is neither a skilled person nor an instructed person

Note 1 to entry: Such person does not have access to a restricted access area and is not trained to identify hazards. Such person may otherwise have access to the equipment or may be in the vicinity of the equipment. An ordinary person will not intentionally create hazards nor have access to hazardous parts under normal and single fault conditions.

3.105 service access area

Area accessible by skilled persons by the use of a tool, where it is necessary for skilled person to have access regardless of the equipment being energized
[...]"

END OF EXTRACT

We can see from the above that the terms "operator/user" and "service person" that were mentioned in the previous versions of the standard have been replaced by other wordings to help understand the ability of people to **perceive the risks and hazards**.

In addition to these definitions, the latest revision of the IEC 62040-1 also refers to the IEC 62477-1:2012 related to "Safety requirements for power electronic converter systems and equipment", where a revised definition of a "restricted access area" is given, as shown hereafter.

EXTRACT FROM IEC62477-1:2012:

"[...]"

3.48 restricted access area

Area accessible only to electrically skilled persons and electrically instructed persons with the proper authorization

Note 1 to entry: An electrically skilled person is a person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create

Note 2 to entry: An electrically instructed person is a person adequately advised or supervised by electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create

"[...]"

END OF EXTRACT

SUMMARY

- The latest revision of the UPS standards focuses on the ability of people to perceive risks.
- As stated earlier in this document, a Chloride industrial system is designed to be installed in a **Restricted Access Location**. This means that only skilled and electrically instructed persons, with proper authorization, shall have access to these UPS systems.

3.2 Protection against electric shocks

The basic requirements for the design of such UPS, are given by the IEC62040-1:2017 and the IEC 62477-1:2012 standards.

EXTRACT FROM IEC62040-1:2017:

"[...]"

Subclause 4.4 in IEC 62477-1:2012 applies

"[...]"

END OF EXTRACT

Thus, we have to refer to the important parts of the IEC 62477-1:2012.

EXTRACT FROM IEC62477-1:2012:

"[...]"

4.4.3 Provision for basic protection

4.4.3.1 General

Basic protection is employed to prevent persons from touching hazardous live parts. It shall be provided by one or more of the measures given in:

- Protection by means of basic insulation of live parts in 4.4.3.2;
 - Protection by means of enclosures or barriers in 4.4.3.3;
- [...]

4.4.3.3 Protection by means of enclosures or barriers

Live parts with voltage higher than DVC As⁽¹⁾ shall be:

- arranged in enclosures or located behind enclosures or barriers, which meet at least the requirements of the Protective Type IPXXB according to Clause 7 of IEC 60529:1989;

- located at the top surfaces of enclosures or barriers which are accessible when the equipment is energized shall meet at least the requirements of the protective type IP3X with regard to vertical access only.

[...]

If the PECS is installed in a restricted access area, IPXXB instead of IP3X applies.

[...]

It shall only be possible to open enclosures or remove barriers:

- with the use of a tool or key; or
- after de-energization of these live parts.

”

END OF EXTRACT

In addition to the above, the IEC 62040-1:2017 gives the following recommendations:

EXTRACT OF IEC62040-1:2017

[...]

4.4 Protection against electric shock

[...]

UPS within the scope of this document are by default specified for indoor dry environmental service conditions and for access by an ordinary person.

[...]

For equipment to be installed in a restricted access area, the following exceptions are permitted.

- Contact with bare parts of a circuit at hazardous voltage with the test finger is permitted (see Figure M.101). However, such parts shall be so located or guarded that unintentional contact is unlikely.
- Bare parts that present a hazardous energy level shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.

[...]

END OF EXTRACT

As seen previously, the level of protection provided by the enclosure on a Chloride industrial system satisfies the requirement to protect ordinary persons.

In addition, as a Chloride Industrial UPS system is designed for use in restricted access area, it must integrate several protective devices to protect any category of people (ordinary, instructed, skilled, service persons) from unintentional contact with hazardous live parts. This is achieved inside Chloride UPS systems with internal protection barriers made of plexiglass.

Finally, removable internal barriers inside Chloride systems are not metallic in order to avoid unintentional bridging by conductive materials and therefore satisfying the IEC standards.

SUMMARY

- A Chloride industrial UPS system is compliant with the requirement of the IEC62477-1:2012 with regards to the protection of “ordinary persons”: A Chloride system is systematically provided with an enclosure that can only be open with the use of a key.
- Should a Chloride system not be installed in a restricted access location, it will not place an ordinary person at risk because all the live components are fitted inside a metallic enclosure of minimum ingress protection level IP20, as per IEC 60529.

(1) DVC As: maximum safe voltage values to be touchable, coming from DVC Ax.

DVC: decisive voltage class. Classification of voltage range used to determine the protective measures against electric shock and the requirements of insulation between circuits.

Conclusion

When UPS systems need to be operated in specific environmental conditions, they need to be adequately designed to avoid the penetration / intrusion of foreign objects. The purpose of the IEC 60529:1989 is to classify the degrees of protection provided by enclosures of electrical equipment. In other words, the IEC 60529:1989 gives guidelines to:

- protect the persons against access to hazardous parts that are placed inside the enclosure,
- protect the equipment inside the enclosure against ingress of solid foreign objects
- protect the equipment inside the enclosure against harmful effects due to the ingress of water.

Additionally, one shall bear in mind that, once the door of the electrical equipment is open, the IEC 60529:1989 can no longer be applicable. Once the door of an electrical equipment is open, the specific product standard becomes the reference point in order to ensure the safety of people. This means that it becomes irrelevant to require an IP20 level with an open door.

With regards to the safety for UPS systems, the applicable standard is IEC 62040-1. As we have seen through this document, the major point regarding UPS systems, is to protect people against electric shocks, hazardous voltages and unintentional contacts. In order to achieve these requirements, Chloride Industrial UPS systems are designed and manufactured to be installed in restricted access locations, with full respect of the IEC 62040-1 standard:

- Each Chloride UPS unit is provided with the appropriate external IP degree according to the project requirement and according to the IEC 60529:1989.
- The enclosure of any Chloride industrial UPS unit protects any kind of population (ordinary person, operator, user, instructed person, skilled person, service person, etc.) against electrical shock by means of the equipotential earth bonding metallic enclosure provided, in compliance with the IEC 62040-1 (2008 and 2017).

Each Chloride UPS enclosure is provided with a lock and key, in compliance with the IEC 62040-1 (2008 and 2017), to avoid ordinary persons to have access to live parts. Then, it becomes the responsibility of the local on-site authority to grant access to the internal parts of the UPS according to the level of knowledge of people on-site.

- Each Chloride industrial UPS is provided with internal protection barrier, made of transparent acrylic plates to avoid unintentional contact with hazardous live parts, according to IEC 62040-1 (2008 and 2017), IEC 60950-1 (2005) and IEC 62477-1 (2012)
- Each Chloride industrial UPS is provided with non-metallic removable internal protection barriers to avoid unintentional bridging by conductive material when removing the screen.

As a conclusion, an internal IP20 is an over-reaching requirement: internal IP20 means that the test finger (Test probe B of IEC 61032) can never touch any live part, once the door of the equipment is open. This feature means complex additional work for the industrial UPS manufacturer and one must have in mind the additional cost related to this additional work.

Even if the technical specifications often mention the need for an internal ingress protection level of IP20 (with door open), the real need behind this requirement is to protect people against unintentional or accidental contact. This does not need to be provided in the form of an internal IP20 level, as long as it satisfies the customer's safety requirements as well as the international standards to which the technical specification refers.

4 References

IEC/EN 60529:1989: Degrees of protection provided by enclosures (IP Code)

IEC/EN 60950-1:2005: Information technology equipment – Safety

IEC 62477-1:2012: Safety requirements for power electronic converter systems and equipment

IEC 62040-1:2008: General and safety requirements for UPS

IEC 62040-1:2017: Uninterruptible power systems (UPS) – Safety requirements

5 Appendix

Appendix 1: Example of internal protection against unintentional contacts

Appendix 1

Examples of internal protection against unintentional contacts





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