**Frequently Asked Question on Isolated Power Supply (IPS)**

**Q: What is an IPS?**
A: IPS is called as Isolated Power Supply or System and is used in a Hospital to ensure safe power supply to OT – Operation Theaters and ICU – Intensive Care Units.

**Q: What does it do?**
A: IPS protects the patients from electrical shock and ensures availability of power even when there is a fault as it avoids the tripping of breakers or Earth Leakage Circuit breakers (ELCB’s) and ensures continuity of power to life saving equipment’s.

**Q: What are the impacts of Leakage current in human body?**
A: Even small currents flowing through the human body can cause electric shock and put the patient’s life and health at risk

- Perception: ~1 mA
- Suffocation: 35 mA
- Ventricular fibrillation: 100 mA
- Rapid burning & tissue damage: +200 mA

The hazardous levels of current for many patients in a Hospital are much smaller than for normal healthy human beings. The hazard level for patients seems to vary between 10 microamperes (μA) and 180 μA. This is only a fraction of the level hazardous to normal healthy human beings. The most susceptible patient is the one exposed to externalized conductors, diagnostic catheters, or other electric contact to or near the heart. Surgical techniques bypass the patient’s body resistance and expose the patient to electrical current from surrounding equipment. The highest risk is to patients undergoing surgery within the thoracic cavity. Increased use of such equipment as heart monitors, dye injectors, and cardiac catheters increases the threat of electrocution when used within the circulatory system. Infants are more susceptible to electric shock because of their smaller mass, and thus lower body resistance. The combination of factors for a patient like lowered body resistance, more electrical equipment, and conductors such as blood, urine, saline, and water makes it a challenge to increase electrical safety in a Hospital.

**Q: How does an IPS work?**
A: Typically we follow an TNS earthing System where neutral is grounded and the earth and neutral wire is different as shown in the below (Figure 1). As the neutral has an direct connection to earth, this path acts a least impedance path for the fault current to flow through. In this system when there is fault between phase & earth or neutral & earth, the leakage current will be limited based on impedance of the person who is in contact with the fault. The fault or the leakage current can be calculated based on the below formula

\[
\text{Voltage} \quad \text{Fault Current} = \frac{\text{Impedance of person + Impedance of the fault path}}{230V}
\]

\[
\begin{align*}
\text{Fault Current} &= \frac{230V}{1K\Omega + 0 \Omega} \\
&= 230 \text{ mA}
\end{align*}
\]
The fault of 230mA is too dangerous for human body and could result in the death of the person.

In order to provide safety to person, we have to limit the fault current. The best possible way to limit the fault current is to adapt an isolated earthing system (IT Earthing System) as shown below.

As seen above, the IT earthing system has no connection of neutral to earth and the output neutral is floating. As there is no physical connection between the neutral & earth, this system acts as high impedance path for the fault current and typically at 1,500 kΩ.

The fault or the leakage current can be calculated based on the below formula:

\[
\text{Fault Current} = \frac{\text{Voltage}}{\text{Impedance of person} + \text{Impedance of the fault path}}
\]
The system of IT earthing system will be used in an IPS, Isolated power supply to limit the leakage current and to protect the person who are in contact with the fault.

The IPS provides an isolated ungrounded system and must also have a method to check the system integrity. This function is provided by an insulation monitoring device that continuously checks the resistance (impedance) of the total isolated ungrounded system to ground. The insulation monitor must respond audibly and visibly when the impedance of the system degrades to the extent that 5 mA of current will flow through either conductor of the system to ground in a zero impedance fault. An activated alarm does not mean hazardous current is flowing. It only predicts that 5 mA of current could flow from one conductor of the isolated system to ground if a path for the current is provided. This requires a second fault or electric failure to be present in the system before a true hazardous condition exists. The alarm only warns that the potential problem must be corrected as soon as possible but there is no need to interrupt procedures being conducted when the alarm sounds.

**Q: Is there any standard which refers to the usage of IPS?**

**A:** Yes, IEC 60364-7-710(Electrical installations of buildings – requirements of special installations or locations – Medical locations refer to the usage of medical IT system based on classification of locations.

The classification of locations is as follows:

- Group 0: medical locations without applied parts
- Group 1: medical locations where applied parts are used externally or invasively to any part of the body, except for the locations described in group 2
- Group 2: medical locations where applied parts are used in applications such as intra cardiac procedures, operating theatres and vital treatments where discontinuity of the supply can cause danger to life

**Q: What is the application area of IPS as per the classification of IEC?**

**A:** As per IEC 60364-7-710, all group 2 locations like operation theatre, heart catheterization room, ICU, neonatal ICU etc.. requires a medical IT System which is simply called as IPS.

**Q: Do we have any Indian standard mandating the requirement of IPS?**

**A:** The hospital locations has been categorized as P0/1-P7 in National Electric code, Part-3, Section-4: Medical establishments. For categories of P5 installation, The National electric code has stated that it is recommended to have a medical IT system or IPS for such locations.
Extract of Table 1 Safety Provisions (Clause 6.1.1) from National electric code is as below

<table>
<thead>
<tr>
<th>Provisions</th>
<th>Principal Requirements</th>
<th>Installation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5</td>
<td>Continuity of the mains supply maintained in case of a first insulation fault to earth and currents to earth restricted</td>
<td>Isolated supply system with isolation monitoring</td>
</tr>
<tr>
<td>P6</td>
<td>Reduction of fault currents and touch voltages in case of a fault in the basic insulation</td>
<td>Medical isolating transformer supplying one individually piece of equipment</td>
</tr>
</tbody>
</table>

Q: Are there any other standard which needs to know?
A: Yes, the Medical grade isolation Transformers must be designed in accordance with IEC 61558-2-15 and the insulation monitoring device should meet the requirement of IEC 61557-8

Q: What are the major components in IPS?
A: The IPS has four major components which are
  1. Medical Grade Isolation Transformer
  2. Insulation Monitoring device
  3. Fault locator
  4. Remote Alarm panel

Q: Can we use a standard isolation transformer for IPS?
A: No, we can’t.
  - The isolation transformer used in IPS should have a leakage current of less than 0.5mA when the output winding is shorted to earth at rated voltage and rated frequency.
  - Single-phase transformers shall be used to form the medical IT systems for portable and fixed equipment and the rated output shall not be less than 0.5 kVA and shall not exceed 10 kVA.
  - If the supply of three-phase loads via an IT system is also required, a separate three-phase transformer shall be provided for this purpose with output line-to-line voltage not exceeding 250 V.
  - Monitoring of overload and high temperature for the medical IT transformer is required.

Q: What is an IMD?
A: IMD is an insulation monitoring device which monitors the insulation resistance between the Neutral and earth. Whenever the insulation resistance drops below 50kΩ, the IMD will show an insulation error which needs to corrected manually.
Q: What is a Remote Alarm Panel?
A: Remote Alarm panel is a remote indication device with provides an audio-visual alarm in the event of insulation fault, over temperature of transformer or overload of transformer. Generally, the remote alarm panel are installed in electrical maintenance room or in a nurse station for immediate action.

Illustration of IPS highlighting the major components of an IPS